APS April Meeting 2014
Savannah, Georgia
http://www.aps.org/meetings/april/index.cfm
The implications of our observations and future steps in neutrino physics. The Daya Bay Experiment in Southern China provided an ideal location to characterize these elusive particles. Six identical detectors measured the relative flux versus distance of electron antineutrinos emitted by nuclear reactors. The neutrino oscillation will be presented. The smallest angle, $\theta_{13}$, was unknown until 2012. Knowing the value of $\theta_{13}$ is essential. Besides being a fundamental parameter of nature, knowing its value will improve our understanding of neutrino mixing, provide guidance for building theoretical models and define the future program of neutrino oscillation experiments. In this talk, the experimental development that led to the recent discovery of a new $\theta_{13}$-driven neutrino oscillation will be presented.

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Work was supported by the US Department of Energy, Office of High Energy Physics, contract DE-AC02-05CH11231.
10:45AM B3.00001 Hadron polarizabilities: what do they tell us about hadron structure? , D. HORNDIDGE, Department of Physics, Mount Allison University — A central problem of modern physics research is the solution to QCD in the non-perturbative regime. One method of testing QCD in this low-energy region is by measuring certain structure constants of hadrons—called polarizabilities—that show particular promise of allowing a direct connection to the underlying quark/gluon dynamics through comparison to modern QCD-inspired model calculations, and to solutions of QCD done computationally on the lattice. This talk will give an overview of the current state of both theory calculations and experimental measurements of hadron polarizabilities.

10:45AM B4.00001 Measurement of Neutron Star Radii with X-ray Binaries and Recycled Pulsars , SLAVKO BOGDANOV, Columbia University — Detailed modeling of the observed surface X-ray radiation from neutron stars can in principle reveal their interior structure, thereby constraining the state of matter at the most extreme densities. This talk will provide a summary of on-going observational efforts with the Chandra X-ray Observatory and XMM-Newton towards this end, with a focus on two particular varieties of neutron stars — thermally-emitting quiescent low-mass X-ray binaries and “recycled” millisecond pulsars. An overview of future prospects for measuring the elusive neutron star equation of state Pulsars, SLAVKO BOGDANOV, Columbia University — Detailed modeling of the observed surface X-ray radiation from neutron stars can in principle reveal their interior structure, thereby constraining the state of matter at the most extreme densities. This talk will provide a summary of on-going observational efforts with the Chandra X-ray Observatory and XMM-Newton towards this end, with a focus on two particular varieties of neutron stars — thermally-emitting quiescent low-mass X-ray binaries and “recycled” millisecond pulsars. An overview of future prospects for measuring the elusive neutron star equation of state.

11:21AM B3.00002 Measuring the polarizabilities of the proton and pion with photon and hadron beams , RORY MISKIMEN, University of Massachusetts — Polarizabilities provide an important test point for models of hadron structure, as well as potentially helping to resolve two of the most outstanding anomalies in nuclear physics, the muon g-2 and the proton charge radius puzzles. Recent progress in measurements of the proton scalar polarizabilities, α and β, and spin-polarizabilities from polarized Compton scattering experiments at Mainz and TUNL/HIGS are presented. This new generation of Compton scattering experiments utilize linear/circularly polarized photons and polarized targets. For many years the charged pion polarizability ranked among the most important tests of ChPT unresolved by experiment. A new result for the charged pion polarizability from the Compass experiment is presented, and the outlook for a precision measurement of the charged pion polarizability at JLab through the γγ → π⁺π⁻ reaction is discussed.

11:21AM B4.00002 Determining the equation of state via microscopic simulations1 , ALEXANDROS GEZERLIS, Univ of Guelph — I will provide an overview of the status of modern nuclear theory, especially in connection with the determination of the equation of state of nucleonic matter. I will also discuss the relevance of microscopic simulations to the study of strongly interacting nucleons. Starting with some general points on the underlying theory of Quantum Chromodynamics (QCD), I will then go over the efforts toward connecting QCD with many-nucleon studies (via chiral Effective Field Theory [EFT]). I will also introduce a recent local reformulation of chiral EFT, which makes it possible to use such modern potentials within the framework of Quantum Monte Carlo (an essentially exact type of microscopic simulation method).

1Work supported in part by NSERC Discovery Grant. “Strong Interactions In Nuclear Physics.”

11:57AM B4.00003 Extracting the neutron star equation of state from gravitational wave data2 , JOCELYN READ, CSU Fullerton — For most of a binary neutron-star inspiral, orbiting point particles in a post-Newtonian framework are a good model for gravitational wave emission, and ground-based detectors can detect signals using these models. However, additional physics near merger is not captured in the detection templates: as the stars coalesce, the gravitational waveforms depend additionally on the properties of dense matter in the core of the stars. The equation of state of dense matter that determines properties such as the neutron-star radius also characterizes the gravitational waveforms emitted during binary neutron-star mergers. Understanding the effects of the equation of state on gravitational waveforms requires information from both analytic models in the inspiral and numerical simulations of the merger. Our current best estimates suggest that these effects will allow Advanced LIGO to constrain the neutron-star equation of state. I will review current models for waveform effects, estimates of measurability, and the implications for equation-of-state constraint in the next decade.

2Supported by NSF PHY-1307545
10:57AM B6.00002 Reconsideration of Statistical Hadronization in Light of LHC Results\(^1\), MICHAL PETRAN, Czech Technical University in Prague, Czech Republic, JOHANN RAFFELSKI, University of Arizona, Tucson, USA — We revisit the description of hadron production in heavy-ion collisions at SPS, RHIC considering new insights gained from LHC particle multiplicity analysis \([1]\). For all but lowest SPS energy just like at LHC, the non-equilibrium statistical hadronization model describes the experimental results accurately with a freeze-out temperature of \(T \approx 140\text{ MeV}\) and light quark phase space occupancy \(\gamma_q \approx 1.6\). A remarkable result is the constant hadronization pressure across SPS, RHIC, and LHC of \(P = 80 \pm 3\text{MeV/fm}^3\). On the other hand we find that the QGP fireballs created at different collision energies and centralities differ in size of hadronization volume by over two orders of magnitude, and analysis covers a wide range of chemical potential \(\mu_B < 600\text{ MeV}\). The considerable difference between two lowest energies studied at SPS: \(\gamma_{-}\gamma_{+} = 0.26\) and 7.61 GeV indicates an opportunity for the Beam Energy Scan program at RHIC to identify the onset of quark deconfinement via study of hadron multiplicity yields.

\(^1\)Supported by a grant from the U.S. DoE, DE-FG02-04ER41318.

11:09AM B6.00003 Time-Dependent Dynamics of Massive Quarkonium Resonances in Nuclear and Quark-Gluon-Plasma Media, NOOR SABRINA MAH HUSSIN, Drake University, ASMAA SHALABY, Benha University, ATHANASIOS PETRIDIS, Drake University — The time-dependent Schrödinger equation is used to study the formation of quarkonia and their propagation in Quark-Gluon Plasma (QGP) and nuclear media. The initial bound (ground) state is computed using imaginary-time propagation in a confining potential. The QGP is simulated with a confining potential of an extended asymptotic freedom region. The initial state propagates through this potential in real time. The nuclear medium is simulated with a periodic potential. In all cases the survival probability is calculated versus time for various potential parameters and relative momenta of the quarkonium with respect to the surrounding medium. In all calculations the staggered-leap frog method is used with special attention paid to the issue of stability. It is found that quarkonium decay is typically non-exponential. Fast moving states decay faster. There is a distinctive difference in the time-dependence of the survival probability between QGP and the nuclear medium. The effects of more realistic potentials are investigated.

11:21AM B6.00004 Enhanced Pair Production in Multicenter Systems by SuperIntense Lasers\(^2\), ANDRE BANDRAUK, Université de Sherbrooke — Electron-positron(e-e\(^{-}\)) pair production is considered for many-center systems with multiple bare nuclei immersed in intense static electric fields corresponding to the extrema of electric fields planned by future super intense laser pulse sources with intensities \(I > 10^{24}\) W/cm\(^2\). It is shown analytically using an exactly solvable 1-D delta potential model \([1]\) in a multicenter Dirac equation that there are two distinct regimes where pair production rates are enhanced. At large internuclear distances, the effective nuclear charge approaches the critical charge where the ground state divides into the negative continuum of the Dirac equation. At large interatomic distances a new mechanism is predicted, similar to Charge Resonance Enhanced Ionization of molecules by intense, \(I > 10^{24}\) W/cm\(^2\), laser pulses \([2]\). Multicenter resonances from the negative energy states are shown to cross into the positive energy states due to large field induced Stark shifts thus resulting in a resonantly enhanced pair production mechanism. A numerical method is developed to calculate the pair production rates from the multicenter Dirac equation. The latter is evaluated for systems (clusters) up to five nuclei of large charge. It is shown that the pair production rate for multicenter systems in superintense electric fields generally exceeds by orders of magnitudes the Schwinger tunneling rate which requires intensities of \(\sim 10^{29}\) W/cm\(^2\). \([1]\) F Fillion-Gourdeau, E Lorin, A D Bandrauk, Phys Rev Lett 110, 013002 (2013); J Phys B 46, 175002 (2013). \([2]\) A D Bandrauk; F Legare, in “Progress in Ultrafast Intense Laser Science”, VIII, edit K Yamanouchi et al, (Springer, Berlin, 2012) p 29-46.

\(^2\)Funded by Canada Research Chair Program.

11:33AM B6.00005 Towards the Test of Saturation Physics Beyond Leading Logarithm\(^3\), DAVID ZASLAVSKY, ANNA STASTO, Pennsylvania State University, BO-WEN XIAO, Central China Normal University — Earlier this year, we published the first numerical calculation to incorporate all next-to-leading order (NLO) corrections for the forward pion production cross section in PA collisions. Our calculation gives a good description of existing results from RHIC at \(p_T\) up to the saturation scale. I will present an overview of the calculation, review the results for RHIC as compared to the experimental data, and present our predictions for the LHC’s heavy ion program. I’ll also discuss an interesting issue in which, at large \(p_T > Q_s\), the results of the prediction become negative, and review the progress of our attempts to cure the negativity by resumming higher-order terms of the cross section.

\(^3\)based on PRL 112, 012302

Saturday, April 5, 2014 10:45AM - 11:45AM – Session B7 DNP: Physics of Light Systems

10:45AM B7.00001 Analysis and Preliminary Results of The NPDGamma Experiment, JASON FRY, Indiana University, NPDGamma COLLABORATION — The NPDGamma Experiment measures the parity violating gamma asymmetry from polarized neutrons captured on protons at the Spallation Neutron Source at ORNL. The parity violating asymmetry \(A_v\) between the neutron spin and the photon momentum is proportional to the \(\Delta l = 1\) long range weak meson coupling \(h_{V}^N\) between nucleons in the hadronic weak interaction. Liquid para-hydrogen production data has been taken since May 2012 and will continue in 2014 to measure \(A_v\) to a precision of \(1 \times 10^{-8}\). Various aspects of the experiment, preliminary results, and plans to complete NPDGamma in 2014 will be discussed.

10:57AM B7.00002 GEANT4 Simulation of the NPDGamma Experiment\(^1\), EMIL FRLEZ, University of Virginia, NPDGamma COLLABORATION — The \(\bar{n} + p \rightarrow d + \gamma\) experiment, currently taking data at the Oak Ridge SNS facility, is a high-precision measurement of weak nuclear forces at low energies. Detecting the correlation between the cold neutron spin and photon direction in the capture of neutrons on Liquid Hydrogen (LH) target, the experiment is sensitive to the properties of neutral weak current. We have written a GEANT4 Monte Carlo simulation of the NPDGamma detector that, in addition to the active CsI detectors, also includes different targets and passive materials as well as the beam line elements. The neutron beam energy spectrum, its profiles, divergencies, and time-of-flight are simulated in detail. We have used the code to cross-calibrate the positions of (i) polarized LH target, (ii) Aluminum target, and (iii) CCl\(_4\) target. The responses of the 48 CsI detectors in the simulation were fixed using data taken on the LH target. Both neutron absorption as well as scattering and thermal processes were turned on in the GEANT4 physics lists. We use the results to simulate in detail the data obtained with different targets used in the experiment within a comprehensive analysis.

\(^1\)This work is supported by NSF grant PHY-1307328
moments for a case study, the flux-rope (FR) structure passing Earth on June 2, 1998. Here, the intervals of coherence extend in a range of 12 to 30 s for having spatial-confinement of most hadronic-elements of electron-gas-work explains the observed anomalous polytropic exponent \( \gamma \). The occurrence of magnetic field work is a consistent thermodynamic explanation of the property of anti-correlation between temperature and density of the channel electrons back towards the solar surface. As such, the apparent temperature of the corona is no greater than that of the photosphere and, in fact, this fashion, coronal metallic hydrogen generates highly ionized ions while at the same time helping to preserve the neutrality of the solar body, as it works to prevent all violations of the second law of thermodynamics. Slightly cools with elevation in accordance with the known reddening of the K-coronal spectrum. This removes the need to heat the corona in the SSM and is intimately coupled to the turbulence in the plasma velocity, in what is called magnetohydrodynamic (MHD) turbulence. This work will describe recent results about MHD turbulence in the solar wind. From the fluid Maxwell equations, the interaction of the two Elsasser fields \( Z^+ = V^+ / B / (\mu_0)^{1/2} \) best describes the non-linear term in the MHD equations. If either is zero, there is no cascade. In theory, the turbulent heating rate is given by the linear scaling of certain mixed third moments of fluctuations in \( Z^+ \). Solar wind data shows the linear scaling, confirming the theory in the solar wind, but the two cascades are highly variable and tend to have opposite signs. This may be intermittency.

The corona is excessively hot (millions of K) in order to account for solar winds and the existence of highly ionized atoms in this region of the Sun. Conversely, within the context of the liquid metallic hydrogen solar model (LMHSM), solar winds are driven by exfoliative processes occurring within layered metallic hydrogen in the solar body. The LMHSM also advances that condensed matter is interspersed throughout the corona. This is supported by the relatively cool continuous spectrum of the K-corona which reveals that coronal material has been ejected into and now exists in the outer atmosphere of the Sun. It is proposed that since condensed matter can be characterized by powerful electron affinities, that coronal material can strip adjacent gaseous atoms of their electrons. In this fashion, coronal metallic hydrogen generates highly ionized ions while at the same time helping to preserve the neutrality of the solar body, as it works to prevent all violations of the second law of thermodynamics. Kuang’s semi-classical approach is an elegant and efficient way to arrive at these estimates. Motivated by ENA modeling efforts for apace applications, we shall briefly present this approach along with sample applications and report on current progress.

**Saturday, April 5, 2014 10:45AM - 12:33PM - Session B9 DAP: Solar and Planetary Physics 203 - Miriam Forman, Stonybrook University**

10:45AM B9.00001 Turbulence cascades in the solar wind. MIRIAM FORMAN, Stony Brook University, JESSE COBURN, CHARLES SMITH, BERNARD VASQUEZ, University of New Hampshire, JULIA STAWARZ, University of Colorado — The solar wind is the one astrophysical plasma we can observe in situ in exquisite detail with many spacecraft in it. It is clear that turbulence in the magnetic field is what makes this collisionless plasma act more-or-less like a simple fluid. Also, that the magnetic turbulence couples superthermal ions to the main “fluid” allowing them to feel the flow and be accelerated, confined, and modulated. Understanding the detailed nature and structure of the magnetic turbulence in collisionless plasma is essential to understanding particle acceleration and other aspects of their interaction with astrophysical plasmas. However, the turbulence in the magnetic field is intimately coupled to the turbulence in the plasma velocity, in what is called magnetohydrodynamic (MHD) turbulence. This work will describe recent results about MHD turbulence in the solar wind. From the fluid- Maxwell equations, the interaction of the two Elsasser fields \( Z^+ = V^+ / B / (\mu_0)^{1/2} \) best describes the non-linear term in the MHD equations. If either is zero, there is no cascade. In theory, the turbulent heating rate is given by the linear scaling of certain mixed third moments of fluctuations in \( Z^+ \). Solar wind data shows the linear scaling, confirming the theory in the solar wind, but the two cascades are highly variable and tend to have opposite signs. This may be intermittency.

11:09AM B7.00003 \(^{3}\)He bound state within three-body approach\(^1\) VLADIMIR SUSLOV, IGOR FILIKHIN, BRANISLAV VLAHOVIC, North Carolina Central University — The \(^{3}\)He hypernucleus is studied within the cluster model \(^{3}\)He + n + n, using configuration space Faddeev formalism. Intrinsic structure of the core nucleus is taken into account by the folding procedure applied to construct the \(^{3}\)He — n interaction. The OBE simulating potential of the NSC97f model for \( \Lambda \Lambda \) and phenomenological \( \alpha \Lambda \) potential are used. Singlet and triplet components of the folding potential are adjusted to reproduce the \( 2^- \) excitation energy \( E_x(^{3}\Lambda \Lambda) \) of the \(^{3}\)He hypernucleus. A correlation between \( E_x(^{3}\Lambda \Lambda) \) and hyperon binding energy \( B_x(^{3}\Lambda \Lambda) \) of \(^{3}\)He is established. We use this correlation to evaluate \( B_x(^{3}\Lambda \Lambda) \) taking into account results of our calculation for \( E_x(^{3}\Lambda \Lambda) \) within the three-body model \( \alpha + \Lambda + n \). The value obtained for \( E_x(^{3}\Lambda \Lambda) \) is 0.18 MeV. With this value our evaluation for \( B_x(^{3}\Lambda \Lambda) \) yields 5.69 MeV, which is close to the recently reported experimental data (5.68 MeV).

\(^1\)This work is supported by NSF CREST (HRD-0833184) and NASA (NNX09AV07A)

11:21AM B7.00004 ABSTRACT WITHDRAWN —

11:33AM B7.00005 Two-proton decay from Isobaric Analog States of light nuclei. KYLE BROWN, Washington Univ. — Recent experiments at the National Superconducting Cyclotron Laboratory at Michigan State University using the charged-particle array HiRA and the gamma-ray array CAESAR have shed light on a new class of two-proton emitters associated with Isobaric Analog States (IAS). The two-proton decay by either energy or isospin conservation, and when two-proton decay to the ground state is isospin forbidden. Three possible examples of this decay path will be discussed (\(^{9}\)B\(_{IAS}\), \(^{12}\)N\(_{IAS}\), and \(^{14}\)F\(_{IAS}\)). The known IAS of \(^{8}\)C in \(^{8}\)B was confirmed to decay by two-proton emission to the 3.56 MeV IAS in \(^{8}\)Li. While the IAS in \(^{8}\)B was previously known, it was measured in this experiment with unbiased statistics and in coincidence with the 3.56 MeV gamma-ray. The IAS in \(^{16}\)F was investigated for the first time in this experiment and is still under investigation. Previous work on the \(^{12}\)O in \(^{12}\)N at the Cyclotron Institute at Texas A&M will also be presented.

10:57AM B9.00002 On the Nature of the Corona: The Electron Affinity of Metallic Hydrogen, not Extreme Temperatures, Generates Highly Ionized Gaseous Ions in the Outer Solar Atmosphere, PIERRE-MARIE ROBITAILLE, The Ohio State University — The gas-based Standard Solar Model (SSM) must assume that the corona is excessively hot (millions of K) in order to account for solar winds and the existence of highly ionized atoms in this region of the Sun. Conversely, within the context of the liquid metallic hydrogen solar model (LMHSM), solar winds are driven by exfoliative processes occurring within layered metallic hydrogen in the solar body. The LMHSM also advances that condensed matter is interspersed throughout the corona. This is supported by the relatively cool continuous spectrum of the K-corona which reveals that coronal material has been ejected into and now exists in the outer atmosphere of the Sun. It is proposed that since condensed matter can be characterized by powerful electron affinities, that coronal material can strip adjacent gaseous atoms of their electrons. In this fashion, coronal metallic hydrogen generates highly ionized ions while at the same time helping to preserve the neutrality of the solar body, as it works to channel electrons back towards the solar surface. As such, the apparent temperature of the corona is no greater than that of the photosphere and, in fact, slightly cools with elevation in accordance with the known reddening of the K-coronal spectrum. This removes the need to heat the corona in the SSM and prevents all violations of the second law of thermodynamics.

11:09AM B9.00003 Kuang’s Semi-Classical Formalism for Calculating Electron Capture Cross Sections: A Space-Physics Application. A.F. BARGHOUTY, Astrophysics Office, NASA-Marshall Space Flight Center, Huntsville, AL 35812 — Accurate estimates of electron-capture cross sections at energies relevant to the modeling of the transport, acceleration, and interaction of energetic neutral atoms (ENA) in space (\textasciitilde few MeV per nucleon) and especially for multi-electron ions must rely on detailed, but computationally expensive, quantum-mechanical description of the collision process. Kuang’s semi-classical approach is an elegant and efficient way to arrive at these estimates. Motivated by ENA modeling efforts for apace applications, we shall briefly present this approach along with sample applications and report on current progress.

11:21AM B9.00004 On the Thermodynamics and other Constitutive Properties of a Class of Strongly Magnetized Matter Observed In Astrophysics, DANIEL BERDICHESKY, NASA/GSFC — It is shown that the occurrence of magnetic field work is a consistent thermodynamic explanation of the property of anti-correlation between temperature and density of the electrons gas in a class of magnetic field dominated structures observed in the interplanetary medium. In this model, a 7 to 4 scaling ratio for magnetic-work to electron-gas-work explains the observed anomalous polytropic exponent \( \gamma = 1/2 \). This interpretation is built on the theoretical conjecture of a matter-state having spatial-confinement of most hadronic-elements of matter, i.e., matter held in place by the action of what is here denominated “super-strong” magnetic field, which together with the plasma it contains satisfies magneto-hydrodynamics. We further show that, within the resolution and sensitivity of the instrumentation used, that the assumptions made in this model are consistent with the coherence observed in changes of magnetic field and electron distribution moments for a case study, the flux-rope (FR) structure passing Earth on June 2, 1998. Here, the intervals of coherence extend in a range of 12 to 30 s for plasma data with a resolution of 3s. Further, the diamagnetic nature of this superconductive state of matter is confirmed for a case study, and an estimate of its permeability and permittivity consistent with space plasma observations made.
11:33AM B9.00005 Sputtering of lunar regolith by solar wind protons and heavy ions, and general aspects of potential sputtering, S.T. ALNUSSIRAT, The University of Alabama in Huntsville, M.S. SABRA, NASA Postdoctoral Program Fellow, Marshall Space Flight Center, Huntsville, AL 35805, A.F. BARGHOUTY, Astrodynamics Office, NASA-Marshall Space Flight Center, Huntsville, AL 35812, DOUGLAS L. RICKMAN, NASA, Marshall Space Flight Center, Huntsville AL 35812, F. MEYER, Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831 — New simulation results for the sputtering of lunar soil surface by solar-wind protons and heavy ions will be presented. Previous simulation results showed that the sputtering process has significant effects and plays an important role in changing the surface chemical composition, setting the erosion rate and the sputtering process timescale. In this new work and in light of recent data, we briefly present some theoretical models which have been developed to describe the sputtering process and compare their results with recent calculation to investigate and differentiate the roles and the contributions of potential (or electrodynamic) sputtering from the standard (or kinetic) sputtering.

11:45AM B9.00006 Understanding the Martian Atmosphere-Geosphere Interactions Using Oxygen Isotopic Forensics, ANI KHACHATRYAN, MARK THIEMENS, ANALISA HILL, ROBINA SHAHEEN, KENNETH CHONG, University of California San Diego, THIEMENS RESEARCH GROUP - STABLE ISOTOPE LABORATORY TEAM — Recent missions to Mars have shown that the planet might have hosted liquid water based on the morphological characteristics of its lithosphere. Information about the evolution of Martian surface and atmosphere is obtained via the study of Martian meteorites. Unlike Earth, Martian geosphere does not appear to be well mixed and bulk silicates show a range of oxygen isotope anomalies from 0.3 to 0.6 o/0. In order to understand this anomaly an experiment was designed with Mars simulant, liquid water and ozone to reproduce the unique $\Delta^{17}O$ isotopic value uniquely characteristic of Martian meteorites. This quantity is used as a tracer of the reaction pathways occurring on the surface of Mars. We believe that only in the presence of these three ingredients can the specific value be achieved. By simulating the chemical processes occurring on the surface of Mars, we seek to understand the interactions of Martian hydrosphere, atmosphere and geosphere. This study is unique for the advancement of cutting edge research in the evolution of planetary atmosphere and surfaces, and the search for liquid water. The oxygen triple isotopic analysis is a tool that provides us with clues for discovering the geochemical history of the red planet.

11:57AM B9.00007 Terrestrial Gamma Flashes at Ground and Balloon Level, JAMES RODI, REBECCA RINGUETTE, MICHAEL CHERRY, Louisiana State University — Terrestrial Gamma Flashes (millisecond-duration bursts of gamma rays produced by electrons and positrons accelerated by the electric fields accompanying lightning) have been observed by satellites since the BATSE era. The TGF and Energetic Thunderstorm Rooftop Array (TETRA) is an array of NaI scintillators located on the campus of Louisiana State University in Baton Rouge, Louisiana. Since July 2010, TETRA has now detected 31 millisecond-scale bursts of gamma rays at ground level with energies 50 keV - 2 MeV associated with nearby (< 8 km) thunderstorms. In addition to the TETRA array, we describe the plans for a balloon-borne instrument and a larger ground array.

12:09PM B9.00008 Lightning Detection at the Telescope Array Cosmic Ray Observatory, HELIO TAKAI, Brookhaven National Laboratory, JOHN BÉLZ, GORDON THOMSON, WILLIAM HANLON, University of Utah, BILL RISON, RON THÔMAS, PAUL KREHBIEL, New Mexico Tech, TAKESHI OKUDA, Ritsumeikan University — It is known that the electric fields measured in lightning clouds are an order of magnitude too small than the critical electric field required for dielectric breakdown of air, there are therefore unknown mechanisms at work which initiate lightning. One theory is that cosmic ray air showers can initiate lightning via a runaway breakdown process. To study this problem, 10 VHF lightning monitoring stations built by New Mexico Tech were deployed at the Telescope Array site on September 2013. If cosmic rays act as lightning initiators, then the TA surface detectors may be able to detect high energy particles from the associated air shower while the NMT lightning detectors simultaneously measure VHF radio pulses of the lightning discharges themselves. The Telescope Array is the largest cosmic ray observatory in the Northern hemisphere. Located in Millard County, Utah, it covers an area of 750 km$^2$. The VHF monitoring stations can be used to produce 3D images of the lightning strikes. Using both setups we hope to be able to investigate in detail the role of cosmic rays in lightning, or if there is any gamma ray production from lightning activity. We will discuss how a collaboration between TA, NMT and BNL can help in understanding of a long standing mysteries about lightning formation. Results of data analysis for events that were observed in coincidence between our detectors will be presented.

12:21PM B9.00009 Equations for the Formation and Origin of Planetary and Stellar Rotation, STEWART BREKKE, Northeastern Illinois University (former grad student) — Planets and stars began as slowly rotating planetary and stellar cores of dense relevant material orbited by rings of relevant material such as iron in the case of planets and hydrogen for stars. The gravitational attraction of the dense cores caused the rings of relevant material to decay and tangentially collide with the slowly rotating planetary or stellar core and attach to them thereby transferring their orbital angular momentum to the cores. In this manner the rotation of the newly formed planet or star increased go it present speed. The general equation for the formation and origin of rotation of the newly formed planet or star is: $(I\omega)_{\text{core}} + (I\omega)_{\text{ring}} + \ldots + (I\omega)_{\text{ring}} = (I\omega)_{\text{newly formed planet or star}}$.

Saturday, April 5, 2014 10:45AM - 12:09PM —
Session B10 FHP: History of Physics 204 - Catherine Westfall, Michigan State University

10:45AM B10.00001 Reactions to Einstein's 1929 Unified Field Theory Proposal, PAUL HALPERN, University of the Sciences in Philadelphia — We will examine the variety of reactions to Einstein’s announcement in 1929 that he had unified gravitation with electromagnetism using the modification of general relativity known as distant parallelism. In particular, we will consider the physics community's response, specifically Pauli’s criticisms, as well as the deluge of news stories about Einstein’s results. We’ll show how while Einstein’s theory was not physically viable, the press widely assumed to it be such, due perhaps to the fame of its proponent.

10:57AM B10.00002 The Origins of the Franck-Hertz Experiments, CLAYTON GEARHART, St. John’s University (Minnesota) — This April APS meeting marks the 100th anniversary of the experiments of James Franck and Gustav Hertz, in which they bombarded mercury atoms with slow electrons. Today, we interpret their results as confirming the existence of quantized atomic energy levels. Their own interpretation was quite different—they thought they were recording ionization, not excitation, and said not a word about Niels Bohr’s new theory. Even more surprising, quantum theory had little to do with the initial motivation for their experiments. Franck, beginning with his doctoral dissertation in 1905, had been measuring ion mobility in gases. At first, his work involved clever but hardly earthshaking extensions of Ernest Rutherford’s experiments at the Cavendish Laboratory in England. But in 1910, in measuring the mobilities of argon ions, Franck made an astonishing discovery: Electrons freed from argon atoms did not immediately attach to other atoms, but remained free. This discovery led Franck to question earlier theories of ionization by collision, and led him to propose to Hertz the collaboration that eventually led to the experiments on mercury. I will sketch this early history, and time permitting, talk about what if anything they knew about Bohr’s theory in 1914.
11:09AM B10.00003 Nikolai Tesla, the Ether and its Telautomaton, KENDALL MILLAR, University of California, Los Angeles — In the nineteenth century physicists’ understanding of the ether changed dramatically. New developments in thermodynamics, energy physics, and electricity and magnetism dictated new properties of the ether. These have traditionally been examined from the perspective of the scientists re-conceptualizing the ether. However Nikola Tesla, a prolific inventor and writer, presents a different picture of nineteenth century physics. Alongside the divisions that showcased his inventions he presented alternative interpretations of physical, physiological and even psychological research. This is particularly evident in his telautomaton, a radio remote controlled boat. This invention and Tesla’s descriptions of it showcase some of his novel interpretations of physical theories. He offered a perspective on nineteenth century physics that focused on practical application instead of experiment. Sometimes the understanding of physical theories that Tesla reached was counterproductive to his own inventive work; other times he offered new insights. Tesla’s utilitarian interpretation of physical theories suggests a more scientifically curios and invested inventor than previously described and a connection between the scientific and inventive communities.

11:21AM B10.00004 Minkowski’s Road to Space-Time, and its Consequences and an Alternative, FELIX T. SMITH, retired — The road from Maxwell’s equations to early relativity and then to Minkowski’s space-time is traced through his Göttingen lecture in 1907 and his paper in 1908 that introduced the 4-dimensional tensor form of electrodynamics. This led to a puzzle: What is the reason for the time dependence in its position space geometry shown in the metric sum $dx^2 = dx_1^2 + dx_2^2 + dx_3^2 - c^2 dt^2$? Having no physical explanation for this, Minkowski made the drastic move of enlarging 3-space into 4-dimensional space-time, advocating it powerfully in his paper “Space and Time” (1909). I will discuss the circumstances leading to this rapid acceptance (but not by Poincaré), and its consequences that emerged much later in the partial disconnect between relativity and the other domains of modern physics. Much later still, the Hubble expansion of our cosmos can now be shown to imply that the term $-c^2 dt^2$ is a direct concomitant of an expanding, negatively curved 3-space and does not require either a 4-dimensional space-time or multiple time dimensions for multiple particles.

11:33AM B10.00005 Rapidity: The Special Relativity Work of Dr. Vladimir Karapetoff, HAMILTON CARTER, Texas A&M University — Between 1924 and 1944 Dr. Vladimir Karapetoff, a professor in the electrical engineering department of Cornell University, authored 11 papers on the topic of special relativity. While his initial papers focused on the then popular oblique angle treatment of special relativity, he soon became a vocal proponent of performing special relativistic calculations using rapidity, a technique that emphasizes the hyperbolic geometric nature of Minkowski space-time. While rapidity has fallen out of usage with the exception of a specialized dialect within particle physics, it offers interesting technical and pedagogical perspectives on the geometrical nature of space-time not evident in the present day relativistic parlance.

11:45AM B10.00006 Developments in Computational Physics at Particle Accelerators, FRANCISCO CANO, Student Member — Computational physics is a field that employs existing physics formulas, as well as mathematical algorithms to perform large-scale calculations with the help of computers. Throughout the years, we have come to completely and accurately understand the basic natural laws that govern certain systems. Over the past two decades however, the considerably increased power of both computing hardware and numerical algorithms have made the treatment of even more complex systems possible as well. Many physics fields depend on both programming and computation to interpret data collected through experiments. In accelerator physics, for example, computers must monitor, record, and analyze vast quantities of information each time that particles are collided in a particle accelerator. We will discuss the developments, requirements and use of computational algorithms, software developments and hardware specifications of some particle accelerators.

11:57AM B10.00007 From the Dawn of Nuclear Physics to the First Atomic Bombs, STEPHEN KANO, Student Member — Computational physics is a field that employs existing physics formulas, as well as mathematical algorithms to perform large-scale calculations with the help of computers. Throughout the years, we have come to completely and accurately understand the basic natural laws that govern certain systems. Over the past two decades however, the considerably increased power of both computing hardware and numerical algorithms have made the treatment of even more complex systems possible as well. Many physics fields depend on both programming and computation to interpret data collected through experiments. In accelerator physics, for example, computers must monitor, record, and analyze vast quantities of information each time that particles are collided in a particle accelerator. We will discuss the developments, requirements and use of computational algorithms, software developments and hardware specifications of some particle accelerators.

11:57AM B10.00007 From the Dawn of Nuclear Physics to the First Atomic Bombs, STEPHEN WOOLBRIGHT, JACOB SCHUMACHER, EKATERINA MICHONOVA-ALEXOVA, Erskine College — This work gives a fresh look at the major discoveries leading to nuclear fission within the historical perspective. The focus is on the main contributors to the discoveries in nuclear physics, leading to the idea of fission and its application to the creation of the atomic bombs used at the end of the World War II. The present work is a more complete review on the history of the nuclear physics discoveries and their application to the atomic bomb. In addition to the traditional approach to the topic, focusing mainly on the fundamental physics discoveries in Europe and on the Manhattan Project in the United States, the nuclear research in Japan is also emphasized. Along with that, a review of the existing credible scholar publications, providing evidence for possible atomic bomb research in Japan, is provided. Proper credit is given to the women physicists, whose contributions had not always been recognized. Considering the historical and political situation at the time of the scientific discoveries, thought-provoking questions about decision-making, morality, and responsibility are also addressed. The work refers to the contributions of over 20 Nobel Prize winners.

1EM-A is grateful to Prof. Walter Grunden and to Prof. Emeritus Shadahiko Kano, Prof. Emeritus Monitori Hoshi for sharing their own notes, documents, and references, and to CCCU for sponsoring her participation in the 2013 Nuclear Weapons Seminar in Japan.

Saturday, April 5, 2014 10:45AM - 12:33PM — Session B11 GGR: Invited Session: Issues in Quantum Gravity

10:45AM B11.00001 An Effective Framework for Quantum Cosmology, MARTIN BOJOWALD, Pennsylvania State University — Canonical quantum cosmology requires extensions of traditional effective methods to deal with issues such as the problem of time and general covariance. This talk reviews such an extension and presents recent results, together with possible applications to field-theoretic models.

1This work was supported in part by NSF grant PHY-1307408.

11:21AM B11.00002 Quantum Space Time Engineering, BIANCA DITTRICH, Perimeter Institute — Loop quantum gravity and spin foams offer a quantization of space time itself. We discuss how the choice of different kinematical vacua leads to different pictures of quantum space time. In particular we describe a recently introduced new vacuum and the associated representation of geometric observables. This (BF) vacuum is based on a topological phase and can be viewed as a condensate state arising from the more standard Ashtekar-Lewandowski vacuum. We argue that this new vacuum is a crucial step towards constructing a fully physical vacuum, leading to a description for the quantum dynamics of 4D space time.

11:57AM B11.00003 Singularity Resolution in Quantum Gravity, PARAMPREET SINGH, Louisiana State University — In recent years, progress in understanding of the quantization of cosmological spacetimes using techniques of loop quantization gravity, has led to important insights on the resolution of singularities. With a rigorous loop quantization of isotropic and anisotropic spacetimes and development of sophisticated numerical techniques, it is now possible to explore in detail the structure of spacetime in the Planck regime and extract new physics of the very early universe. Investigations of quantization of various spacetimes indicates that classical singularities such as the big bang are avoided, and quantum evolution results in a bounce of the scale factor. The resolution of singularities seems to occur without any assumption on the initial state for quantum evolution or the equation of state of matter. In this talk, we will review some of the main developments in this direction and provide an up to date summary of the novel results obtained on the resolution of singularities in various models in loop quantum gravity.
10:45AM B14.00001 Life as a Mather Intern at the Committee on Science, Space, and Technology^1. KATHERINE STANKUS, None — The AIP Mather Public Policy Internship, sponsored by Nobel Laureate Dr. John Mather and facilitated by the American Institute of Physics Society of Physics Students Summer Internship Program, was designed to help undergraduate physics students explore the interface between science and policy. As a Mather Public Policy Intern in 2013, I worked for the U.S. House of Representatives Committee on Science, Space, and Technology where I conducted written research and analyses for staff members, prepared background materials and reports, and assisted at hearings and markups. In addition to my internship duties I also had the opportunity to meet several different representatives, go to various receptions and luncheons held on the Hill, and meet some influential people in society. During this talk I will discuss my experience and how it furthered my interest in doing analytical work and gave me exposure to public policy issues at the national level.

^1 AIP Society of Physics Students

10:57AM B14.00002 Properties of Quantum-Dot-Doped Liquid Scintillators, CHRISTOPHER COY^1. None — Novel scintillators based on semiconducting nanocrystals called quantum dots have unique optical and chemical properties that make them interesting for future neutrino experiments especially those searching for neutrino-less double beta decay. In this talk, we report the results of laboratory-scale measurements for three candidate quantum-dot-doped scintillators. We focus on the key properties required for large-scale neutrino experiments, which are the emission spectrum, the attenuation length and the stability.

^1 I would like to follow the talk by Andrey Elagin on directionality in scintillators and precede Athena Ierokomos’ talk on light yield in scintillators.

11:09AM B14.00003 Liquid Scintillators for Neutrino Detection in Large Scale Detectors , ATHENA IEROKOMOS, UC Berkeley and UCLA — Neutrinoless double-beta decay is a rare nuclear process that could be used to determine if the neutrino is a Majorana or Dirac particle. The next generation of experiments will need to instrument more than 1 ton of isotope. Liquid scintillator detectors are a good choice for obtaining this large mass. In this presentation, we compare liquid scintillators for use in these detectors and concentrate on their light yield. This is part of a larger project developing novel scintillators based on quantum dots.

11:21AM B14.00004 UV Enhancement of CR-39 Nuclear Track Detector Etch Parameters^1. NATHAN TRAYNOR, CHRISTOPHER MCLAUCHLIN, KENNETH DODGE, JAMES MCPLEAN, STEPHEN PADALINO, Dept. of Physics and Astronomy, State Univ of NY at Geneseo, Geneseo, NY, MICHELLE BURKE, CRAIG SANGSTER, Laboratory for Laser Energetics, University of Rochester, Rochester, NY — CR-39 plastic is an effective and commonly used solid state nuclear track detector. High-energy charged particles leave tracks of chemical damage. When CR-39 is chemically etched with NaOH at elevated temperatures, pits are produced at the track sites that are measurable by an optical microscope. We have shown that by exposing the CR-39 to high intensity UV light between nuclear irradiation and chemical etching, the rate at which the pits grow during etching is increased. The effect has been observed for wavelengths shorter than 350 nm, to at least 250 nm. Heating of samples during UV exposure dramatically increases the etch rates, although heating alone does not produce the effect. The pit enhancement is the result of an increase in both the bulk and track etch rates, while the ratio of these rates (which determines sensitivity to particles) remains roughly constant. By determining the best processing parameters, this effect promises to significantly reduce the time required to process CR-39 track detectors.

^1 Funded in part by a grant from the DOE through the Laboratory for Laser Energetics.

11:33AM B14.00005 An OPERA-3D Model of Muon Injection in the Muon g − 2 Storage Ring , LIA VALLINA, Illinois Mathematics and Science Academy — The muon g − 2 experiment at Fermilab will measure the anomalous magnetic moment of the muon to 140 parts-per-billion. The modern experimental technique utilizes a superconducting storage ring to produce an extremely uniform magnetic field. Since the experimental systematic uncertainties scales with the non-uniformity of the magnetic field, care must be taken to minimize distortions to the field. The injection point of the muon beam into the storage ring requires special attention. In this talk, the experimental concept and the use of a superconducting inflector magnet at the injection point will be outlined. Our efforts to model this critical region in the electromagnetic simulation software, OPERA, will be described.

11:45AM B14.00006 Identification of Upward-going Muons for Dark Matter Searches at the NOvA Experiment^1. LITING XIAO, Univ of Virginia, NOVA COLLABORATION — We search for energetic neutrinos that could originate from dark matter particles annihilating in the core of the Sun using the newly built NOVA Far Detector at Fermilab. Only upward-going muons produced via charged-current interactions are selected as signal in order to eliminate background from cosmic ray muons, which dominate the downward-going flux. We investigate several algorithms to develop an effective way of reconstructing the directionality of cosmic tracks at the trigger level. These studies are a crucial part of understanding how NOVA may compete with other experiments that are performing similar searches. In order to be competitive NOVA must be capable of rejecting backgrounds from downward-going cosmic rays with very high efficiency while accepting most upward-going muons.

^1 Acknowledgements: The Jefferson Trust, Fermilab, UVA Department of Physics

12:09PM B14.00008 ABSTRACT WITHDRAWN —
What can we learn about the neutron-star equation of state from gravitational-wave observations of inspiralling binary neutron stars?  

BENJAMIN LACKEY, Princeton University, LESLIE WADE, University of Wisconsin-Milwaukee — Gravitational-wave observations of inspiralling binary neutron star systems can provide information about the neutron-star equation of state (EOS) through the tidally induced shift in the waveform phase which depends on the tidal deformability parameter \( \Lambda \). Previous work has shown that \( \Lambda \), a function of the neutron-star EOS and mass, is marginally measurable by Advanced LIGO for a single event when including the tidal information up to the frequency of merger. In this work, we describe a method for stacking measurements of \( \Lambda \) from multiple inspiral events to measure the EOS. Specifically, we use Markov Chain Monte Carlo simulations to estimate the parameters of a 4-parameter piecewise polytrope EOS that matches theoretical EOS models to a few percent. We find that when 20–50 observations are combined with the constraints from causality and recent high mass neutron-star measurements, the EOS above nuclear density can be measured to better than a factor of two. We also find that quantities that describe the neutron-star structure such as the radius and tidal deformability can be measured to \( \sim 10\% \) over a wide range of masses.

Measuring the neutron star tidal Love number with inspiral waveforms  
MARC FAVATA, Montclair State University — The tidal Love number parameterizes how easily a binary companion deforms a neutron star. This deformation modifies the gravitational field near the neutron star and imprints itself on the binary orbit and gravitational waveform. Measuring the Love number with LIGO or other detectors will help constrain the neutron star equation of state (which is uncertain at high densities). I will discuss an improved parameterization of the waveform’s Love-number dependence. I will also discuss how systematic errors will make this number difficult to measure. These systematic errors could arise from unknown post-Newtonian terms that enter at lower orders than tidal effects, or from neglecting small neutron star spin or binary eccentricity.

Cas A and friends: directed searches for continuous gravitational waves from isolated neutron stars  
BENJAMIN OWEN, Pennsylvania State Univ, LIGO SCIENTIFIC COLLABORATION, VIRGO COLLABORATION — We present the status of searches for continuous gravitational waves from the central compact object in supernova remnant Cassiopeia A and eight other young suspected neutron stars whose positions are known well enough to use a single barycentric correction per object. All objects have age estimates less than a few thousand years, young enough that r-modes could still be active. The searches coherently integrate from five to twenty-five days of the LIGO S6 data run and cover gravitational wave frequency bands of varying widths from 140 Hz to 2 kHz so that each requires a similar computational cost, which is about 1/3 that of the published LIGO search for Cassiopeia A due to the use of SSE2 floating point extensions. The objects are chosen so that each search can detect a neutron star in the band if its (unknown) spin-down has been dominated by gravitational-wave emission since birth.

Rapidly extracting astrophysics from gravitational-wave observations in the Advanced Detector era  
RORY SMITH, Cal Inst of Tech (Caltech), PRISCILLA CANIZARES, SCOTT FIELD, CHAD GALLEY, JONATHAN GAIR, MANUEL TIGLIO, VIVIEN RAYMOND COLLABORATION — Coalescing compact binaries - consisting of neutron stars and/or black holes - are the most promising source of gravitational waves for the next-generation gravitational-wave detectors Advanced LIGO and Advanced Virgo. Accurately measuring the astrophysical parameters of these sources is crucial for precision astrophysics and astronomy with gravitational waves, but the computational times of such analyses can be prohibitively long. Here we present a new approach to parameter estimation based on “reduced order modeling” (see plenary overview talk by Tiglio: “Reduced Order Modeling in General Relativity”). This approach can enable low latency parameter estimation on time scales of minutes to hours. We will discuss recent results of our approach for extracting the astrophysical parameters of binary neutron stars in mock Advanced LIGO/Virgo data. We will also discuss extensions of the approach to binary black hole parameter estimation where the spins of the black holes can be large.

Constraining models of Population III stars using gravitational-wave observations  
TANNER PRESTEGARD, VUK MANDIC, KEITH OLIVE, Univ of Minn - Minneapolis, ELISABETH VANGIONI, Institut d’Astrophysique de Paris — A stochastic gravitational-wave background arises from the superposition of many incoherent sources of gravitational waves, which may be cosmological or astrophysical in origin. Recent searches for the stochastic background using LIGO and Virgo data have placed upper limits on the energy density spectrum. Here, we present a method for using measurements of the stochastic background to constrain the parameters of theoretical models, focusing on a background produced by the core-collapse of Population III stars. Finally, we discuss what can be achieved with future generations of gravitational-wave detectors, including Advanced LIGO and the Einstein Telescope.

Sco X-1 in LIGO: directed searches for continuous gravitational waves from neutron stars in binary systems  
GRANT MEADORS, University of Michigan, EVAN GOETZ, Albert Einstein Institute, Hannover, KEITH RILES, University of Michigan — Scorpius X-1 and similar low-mass X-ray binary (LMXB) systems with neutron stars contain favorable conditions for the emission of continuous gravitational waves (GW). Companion star accretion is believed to recycle the neutron star, spinning it up to high rotational speeds. That accretion could also induce non-axisymmetries in the neutron star, leading to detectable GW emission. Advanced LIGO and other 2nd-generation interferometric observatories will permit searches for such gravitational waves using new algorithms, including the TwoSpect program, which was developed originally for all-sky binary searches. In this presentation we discuss an implementation of TwoSpect using fine templates in parameter space at the initial stage and optimized to search for LMXBs, such as Sco X-1, where some of the orbital parameters are known. Results from simulations will be shown.
12:09PM B15.00008 Gravitational and neutrino signatures from core-collapse supernovae. KONSTANTIN YAKUNIN, University of Tennessee, Knoxville, BRONSON MESSER, ORNL, University of Tennessee, Knoxville, PÉDRO MARRONETTI, National Science Foundation, ANTHONY MEZZACAPPA, ORNL, University of Tennessee, Knoxville, ERIC LENTZ, University of Tennessee, Knoxville, STEPHEN BRUENN, Florida Atlantic University, WILLIAM RAFAEL HIX, ORNL, University of Tennessee, Knoxville, JAMES AUSTIN HARRIS, University of Tennessee, Knoxville, JOHN BLONDIN, North Carolina State University — Core-collapse supernovae (CCSNe) as powerful sources of gravitational and neutrino radiation are among the prime candidates for multimessenger astronomy. Simultaneous detection of both gravitational and neutrino signals will provide invaluable information about dynamics of the supernova core and reveal details of the CCSN mechanism. We present the gravitational and neutrino signatures from the series of 2D and 3D ab in itio CCSN simulations performed with Chimeria code. Chimeria is a radiation hydrodynamics code that is developed specifically for simulation of CCSNe. It combines hydrodynamics, neutrino transport, and nuclear reaction network in one computational infrastructure that allows to model the evolution of supernova from first principles. I will compare gravitational waveforms and neutrino signals obtained in the 2D and 3D simulations with different progenitor masses and provide an estimation of their detectability by gravitational wave and neutrino observatories.

12:21PM B15.00009 Measuring the Angular Momentum Distribution of Core-Collapse Supernova Progenitors. SARAH GOSSAN, ERNAZAR ABDIKAMALOV, ALEXANDRA DEMAIO1, CHRISTIAN OTT, Cal Inst of Tech (Caltech) — The gravitational wave signature of core-collapse supernovae encodes important information on the physical characteristics of the associated progenitor stars, particularly the angular momentum distribution, in addition to the relevant fundamental physics, for example, the nuclear equation of state and electron capture during collapse. Neither of these aspects can be inferred via observations of core-collapse supernovae in the electromagnetic spectrum. We explore the dependence of the gravitational wave signals on the total angular momentum and its distribution in the progenitor. To this end we carry out a large set of axisymmetric (2D) general relativistic hydrodynamics simulations of rotating core collapse. We construct a numerical template bank from these waveforms, and apply a matched filtering analysis to infer the total angular momentum and its distribution in the progenitor’s inner core, given an observed, previously unknown gravitational wave signal. In the context of Advanced LIGO, we show that the total angular momentum can be inferred to within ~ 20 – 30%, for galactic supernovae with rapidly rotating cores at a fiducial distance of 10 kpc.

Saturday, April 5, 2014 10:45AM - 12:33PM —
Session B17 FPS: Invited Session: Hyperloop and other Transportation Ideas 105-106 - Valerie Thomas, Georgia Institute of Technology

10:45AM B17.00001 The Hyperloop as a Source of Interesting Estimation Questions. RHETT ALLAIN, Southeastern Louisiana University — The Hyperloop is a conceptual high speed transportation system proposed by Elon Musk. The basic idea uses passenger capsules inside a reduced pressure tube. Even though the actual physics of dynamic air flow in a confined space can be complicated, there are a multitude estimation problems that can be addressed. These back-of-the-envelope questions can be approximated by physicists of all levels as well as the general public and serve as a great example of the fundamental aspects of physics.

11:21AM B17.00002 Hyperloops, Nuclear Spacecraft, and the New York City Subway. STEPHEN GRANADE, Dynetics — Frustrated by the speed and high cost-per-mile of the California High-Speed Rail project linking Los Angeles with San Francisco, Elon Musk proposed the Hyperloop, a high-speed train running in a sealed, partially-evacuated tube. Musk released a white paper that described the technology and concluded that the Hyperloop could be built for less than a tenth of a cost of the California High-Speed Rail. Musk’s white paper focused heavily on the scientific and technical questions that must be answered, but public transportation is a domain at the intersection of science and society. Public transportation infrastructure is shaped as much by the pressures of government and citizens as by the technology behind the transportation. Tube-based transport like the Hyperloop has been proposed before, but has never gone further than words on a page. Why? Historical examples like the development of the New York City subway and the proposed nuclear-powered Orion spacecraft shed light on the societal barriers that new transportation must overcome, and help illuminate why technology-based answers are not a full response to transportation questions.

11:57AM B17.00003 Can we build a more efficient airplane? Using applied questions to teach physics. AATISH BHATIA, Princeton University — For students and for the science-interested public, applied questions can serve as a hook to learn introductory physics. Can we radically improve the energy efficiency of modern day aircraft? Are solar planes like the Solar Impulse the future of travel? How do migratory birds like the alpine swift fly nonstop for nearly seven months? Using examples from aeronautical engineering and biology, I’ll discuss how undergraduate physics can shed light on these questions about transport, and place fundamental constraints on the flight properties of flying machines, whether birds or planes. Education research has shown that learners are likely to forget vast content knowledge unless they get to apply this knowledge to novel and unfamiliar situations. By applying physics to real-life problems, students can learn to build and apply quantitative models, making use of skills such as order of magnitude estimates, dimensional analysis, and reasoning about uncertainty. This applied skillset allows students to transfer their knowledge outside the classroom, and helps build connections between traditionally distinct content areas. I’ll also describe the results of an education experiment at Rutgers University where my colleagues and I redesigned a 100+ student introductory physics course for social science and humanities majors to address applied questions such as evaluating the energy cost of transport, and asking whether the United States could obtain all its energy from renewable sources.

Saturday, April 5, 2014 12:00PM - 2:30PM —
Session B20 CSWP DPF: CSWP/DPF Networking Luncheon Hyatt Regency Savannah Savannah Room -

12:00PM B20.00001 CSWP/DPF Networking Luncheon — The Committee on the Status of Women in Physics (CSWP) and the Division of Particles and Fields (DPF) sponsor a networking luncheon featuring a short talk from a prominent female physicist in DPF. This year’s speaker will be Eva Halkiadakis of Rutgers University. Buy your ticket when registering for the meeting or stop by the Registrar’s desk on Friday evening or Saturday morning. No tickets will be sold at the event.

Saturday, April 5, 2014 12:30PM - 1:30PM —
Session B21 Lunch with the Grads: A Panel Discussion About Physics Graduate School 102 -
12:30PM B21.00001 Lunch with the Grads: A Panel Discussion About Physics Graduate School — Join our panel of graduate students for a frank discussion about physics graduate school. In this open Q&A forum, students will have the chance to learn about such topics as choosing graduate schools, time management, selecting a research advisor, studying for qualifying exams, and thesis writing. Lunch will be served. All undergraduates welcome!

Saturday, April 5, 2014 1:30PM - 2:42PM –
Session C2 DPF: Invited Session: DPF Prize Session II Chatham Ballroom A - Joanne Hewett, SLAC National Accelerator Laboratory

1:30PM C2.00001 J. J. Sakurai Prize: Scattering Amplitudes - the Story of Loops and Legs, LANCE DIXON, SLAC - Natl Accelerator Lab — Scattering amplitudes are at the interface between quantum field theory and particle experiment. Precise predictions for reactions at energy frontier machines such as the Large Hadron Collider (LHC) rely on quantum corrections to scattering amplitudes involving multiple quarks and gluons, as well as other particles. For decades, theorists used Feynman diagrams for this job. However, Feynman diagrams are just too slow, even on fast computers, to allow adequate precision for complicated events with many jets of hadrons in the final state. Such events are produced copiously at the LHC, and constitute formidable backgrounds to many searches for new physics. Over the past two decades, alternative methods to Feynman diagrams have come to fruition. The new “on-shell” methods are based on the old principle of unitarity. They can be much more efficient because they exploit the underlying simplicity of scattering amplitudes, and recycle lower-loop information. The same methods have also enabled new insight into the structure of gauge theory and gravity at the quantum level, especially in highly supersymmetric theories where they maintain all of the symmetries. I’ll give a brief motivation for and introduction to the new methods, which will be followed by descriptions of their phenomenological and formal applications by David Kosower and Zvi Bern.

1:54PM C2.00002 J. J. Sakurai Prize: Precision Quantum Chromodynamics at the LHC1, DAVID KOSOWER, IHPT, CEA-Saclay — The Large Hadron Collider (LHC) at CERN in Geneva, Switzerland, is the highest-energy particle collider operating today. In 2012, the two general-purpose detector collaborations, ATLAS and CMS, announced the discovery of the long-sought Higgs boson, the last missing particle of the Standard Model. The two collaborations have also set limits on new physics beyond the Standard Model, such as supersymmetry. Future direct and indirect searches for new physics require a precise, quantitative understanding of the known physics of the Standard Model, and in particular of the scattering of quark and gluon constituents of the proton under the strong force, known today as quantum chromodynamics (QCD). Achieving this level of understanding requires at least the incorporation of the first quantum corrections in perturbation theory – next-to-leading order (NLO) corrections – in scattering processes with several constituents leading to several jets in the final state. The new “on-shell” techniques, described earlier by Lance Dixon, have allowed these computations to be made beyond the reach of traditional diagrammatic methods. I will describe a direct numerical application of the new techniques in the BlackHat software library, and several phenomenological studies of physics at the LHC. These include studies relevant to CMS’s supersymmetry searches, and to ATLAS measurements of electroweak vector-boson production with up to five associated jets.

2:18PM C2.00003 J. J. Sakurai Prize: Harmony of Scattering Amplitudes: From Gauge Theory to Supergravity, ZVI BERN, UCLA — As explained in the two previous talks by Lance Dixon and David Kosower, on-shell methods have had an important impact on our understanding of scattering amplitudes and their application to collider physics. In this talk I will describe examples where these ideas have also had impacts in more theoretical areas. The first example shows how these methods have led to the construction of all quantum corrections to specific scattering amplitudes in maximally supersymmetric gauge theory with a large number of color charges. An active area of current research is to do the same for more intricate generic amplitudes of the theory. A second example shows how on-shell methods have uncovered new algebraic structures in gauge-theory amplitudes that have applications to quantum gravity. The advances make it possible to carry out computations in quantum gravity that would have been hopeless with more traditional Feynman diagram methods and to elucidate a remarkable connection between gauge and gravity theories. The results from these investigations have renewed hope that highly supersymmetric gravity theories may be ultraviolet finite, contrary to the prevailing wisdom.

Saturday, April 5, 2014 1:30PM - 3:18PM –
Session C3 DNP: Invited Session: Nuclear Physics at the Gamma-ray Intensity Frontier Chatham Ballroom B - Calvin Howell, Duke University

1:30PM C3.00001 The “light-est” of all Projectiles: Nuclear Structure Studies Using Photonicl Nuclear Reactions1, NORBERT PIETRALLA, Tech Univ Darmstadt — Nuclear reactions induced by photons have had and continue to have a large impact on the course of nuclear physics. Photons interact purely electromagnetically with the atomic nucleus and induce minimal momentum transfer at given excitation energy. Photonic nuclear reaction processes can be expanded in terms of QED and photonic excitations are by far dominated by one-step processes. They allow for a model independent measurement of nuclear observables and, hence, for a clean characterization of effective nuclear forces. Apart from the pioneering photonic nuclear reactions by Bothe and Gentner in the 1930s [1], bremsstrahlung has been used most widely as an intense source of gamma-rays for photonic nuclear reactions from the 1940s until today. The nuclear dipole strength distribution has largely been mapped out at bremsstrahlung facilities [2,3]. While the continuous-energy distribution of bremsstrahlung photons offers a complete view of the spectrum of photonic nuclear excitations, it suffers from a poor sensitivity to specific energy intervals. Intense, energy-tunable, quasi-monochromatic gamma-ray beams from laser-Compton backscattering processes have revolutionized the field of photonic nuclear reactions for the last ten years [4]. A set of new techniques is under development and new information on fundamental nuclear modes, such as the IVGDR, IVGQR, Pygmy Dipole Resonance, and the Scissors Mode, has recently been obtained. We will attempt to give a brief overview of the state of the art and dare an outlook at the research opportunities at the next generation of gamma-ray facilities under construction in the U.S. and Europe.


1Supported by the DFG under grant No. SFB634.
2:06PM C3.00002 Nuclear Astrophysics with Gamma-ray Beams, ERNST REHM, Argonne National Laboratory — Experiments with γ-ray beams have opened many new opportunities in nuclear astrophysics. They include studies of photonuclear $(\gamma,p)$, $(\gamma,n)$ and $(\gamma,\alpha)$ reactions which play an important role in the large γ-ray flux during stellar explosions. Furthermore $(\alpha,\gamma)$ captures can be investigated through their time-inverse $(\gamma,\alpha)$ reactions with much thicker targets and, thus, increased luminosities. I will discuss the experimental program in nuclear astrophysics at HI-γS, with particular emphasis on the present status and future plans of the $^{12}$C$(\alpha,\gamma)^{16}$O reaction studies. This work was supported by the US Department of Energy, Office of Nuclear Physics, under contract DE-AC02-06CH11357.

2:42PM C3.00003 Studies of Few-Nucleon Systems and Nucleon Structure with Gamma-ray Beams, HAIYAN GAO, Duke University and Triangle Universities Nuclear Laboratory — The High Intensity Gamma Source (HI-γS) at the Duke Free Electron Laser Laboratory (DFELL), an important experimental facility of the Triangle Universities Nuclear Laboratory (TUNL), is located on the campus of the Duke University. The HI-γS facility, capable of delivering the most intense mono-energetic photon beam with either circularly polarized or linearly polarized photons in the world, opens up new opportunities for studies of the few-nucleon system through photodisintegration processes, and nucleon structure through Compton scattering. These measurements either with polarized or unpolarized few nucleon target systems provide high precision tests of the state-of-the-arts few-body calculations. Single polarized and double polarized Compton scattering experiments allow for significantly improved determinations of electric and magnetic polarizabilities of the nucleon, as well as spin polarizabilities of the nucleon, which so far have never been determined separately. In this talk, I will present latest results from HI-γS on the studies of few-nucleon systems and upcoming experiments. I will also discuss new experiments on polarized and unpolarized Compton scattering at HI-γS. This work is supported in part by the U.S. Department of Energy under Contracts No. DE-FG02- 03ER41231, No. DE-FG02-97ER41033, and No. DE- FG02-97ER41401.

Saturday, April 5, 2014 1:30PM - 3:18PM — Session C4 DAP DPF: Invited Session: Astrophysical and Cosmological Neutrinos Chatham Ballroom C - Nathan Whitehorn, University of Wisconsin - Madison

1:30PM C4.00001 Theoretical Implications of IceCube Neutrinos, MARKUS AHLERS, UW-Madison — The IceCube Collaboration has recently found evidence for an astrophysical flux of neutrinos. The flux is consistent with an isotropic and equal-flavor $E^{-2}$ power-law spectrum from 60 TeV to 2 PeV. There are also indications that the neutrino spectrum beyond 2 PeV requires a spectral break or cutoff. The origin of the IceCube excess is not known, but its multi-messenger context can already provide some theoretical orientation. For instance, the production of PeV neutrinos require hadronic interactions of cosmic rays (CRs) with energies of a few 10 PeV, extending into the poorly understood transition region between Galactic and extra-Galactic CRs. A local contribution to the neutrino flux from Galactic accelerators is hence feasible and could show up as arrival direction clustering towards Galactic structures. In this context, a possible association of the PeV neutrino sources with unidentified TeV gamma-ray sources, peculiar supernovae or the Fermi Bubbles has been speculated. In addition, a local hadronic neutrino production would predict an observable PeV gamma-ray flux. Spectral features of the neutrino flux, in particular a break or cutoff, serve as additional hints for candidate CR sources and astrophysical environments for neutrino production. Possible scenarios include starburst galaxies, low-luminosity gamma-ray bursts and the cores of active galactic nuclei. I will outline general theoretical implications of the IceCube excess and summarize various source candidates.

2:06PM C4.00002 Searching for the neutrino flux from cosmic GZK interactions, AMY CONNOLLY, The Ohio State University — There is expected to be an observable flux of ultra-high energy neutrinos from interactions between the highest energy cosmic rays and cosmic microwave background photons through what is known as the GZK process. Once observed, this GZK-induced neutrino flux will be the key to answering questions about the highest energy universe at cosmic distances that cannot be probed with cosmic rays. I will review the status of searches for ultra-high energy neutrinos and what the results mean for constraining the GZK-induced neutrino flux. I will then outline the implications of current and future constraints on neutrino flux models for understanding the nature of the highest energy astrophysics sources as well as fundamental physics at extreme energy and distance scales.

2:42PM C4.00003 Cosmological constraints on number of neutrinos and neutrino masses, ZHEN HOU, University of California, Davis — The number of species of neutrinos ($N_{\nu}$) and the neutrino masses ($\Sigma m_{\nu}$) has been constrained by the measurement of cosmological signals, including the power spectrum of cosmic microwave background photons through what is known as the GZK process. Once observed, this GZK-induced neutrino flux will be the key to answering questions about the highest energy universe at cosmic distances that cannot be probed with cosmic rays. I will review the status of searches for ultra-high energy neutrinos and what the results mean for constraining the GZK-induced neutrino flux. I will then outline the implications of current and future constraints on neutrino flux models for understanding the nature of the highest energy astrophysics sources as well as fundamental physics at extreme energy and distance scales.

Saturday, April 5, 2014 1:30PM - 3:18PM — Session C6 DNP: Hadronic Physics Chatham 200 - Alan Krisch, University of Michigan

1:30PM C6.00001 Probing the Hadronic Weak Interaction using Polarized Slow Neutron Spin Rotation in L4He, EAMON ANDERSON, Indiana University Physics Department — The NSR collaboration proposes to search for parity violation in $\Lambda$-He by searching for a rotation of the plane of polarization of transversely polarized neutrons moving through the liquid. This observable is sensitive to a linear combination of weak amplitudes in the hadronic weak interaction which is orthogonal to previous measurements. An earlier measurement conducted at NIST reported $d\theta/dz = [+1.7 \pm 9.1(\text{stat}) \pm 1.4(\text{syst.})] \times 10^{-7} \sim \text{rad/m}$ [1]. We will briefly discuss progress towards a $1 \times 10^{-8}$ sensitivity measurement.


This research made possible through NSF grant PHY-1306942.

2:42PM C6.00002 Radiative Transitions of the Y(4260) at BES, MANUEL LARA, Indiana University, BES COLLABORATION — The recent discoveries of the so called “XYZ” states are beginning to open new possibilities for how quarks can interact and bind. Detailed studies of their decays are underway in many facilities like the BES detector which has collected a total of 2,092 fb$^{-1}$ of data at 4260, 4360, 4295 MeV to study the Y(4260). While the nature of the Y(4260) is still unknown two particularly important decay channels to study would be radiative decays to $\eta_c$ and $\chi_{c0}$, because their branching fraction ratio could be compared to existing $E1/M1$ branching fractions of conventional charmonium and to lattice qcd predictions. The prospects for measuring such transitions using data collected with the BES detector will be presented.
1:54PM C6.00003 Study of the spin-flavor structure of excited baryon masses from lattice QCD\textsuperscript{1}, ISHARA FERNANDO, Hampton University — The known classification of excited baryons based on the dynamical symmetry group SU(6) × O(3) can be understood in the framework of the 1/N\textsubscript{c} expansion\textsuperscript{1}. The application to masses \cite{Dashen} based on the experimentally determined masses can now be extended to the case of baryon masses obtained in lattice QCD\textsuperscript{6,7}. The work to be presented analyses the ground state as well as the excited multiplets \cite{Edwards1,Edwards2}. Mass relations which are valid up to corrections 1/N\textsuperscript{2}, or \(\frac{1}{N^2}(m_\pi - m_\eta)\), or \((m_\pi - m_\eta)^2\) are tested and conclusions on quark mass dependence of the effective mass operators and minimal sets of effective mass operators are obtained.

\textsuperscript{1}Supported by NSF grants PHY-0855789 and PHY-1307413.

2:06PM C6.00004 Single and double polarization asymmetries from deeply virtual \(\pi^0\) production with a longitudinally polarized proton target, ANDREY KIM, Univ of Connecticut - Storrs, CLAS COLLABORATION — Deeply virtual exclusive meson production probes both the chiral-even generalized parton distributions (GPDs) and the chiral-odd transversity GPDs. The GPDs encode correlations of parton longitudinal momentum with transverse impact parameter as a function of the \(x_B\) and \(t\). The wide kinematic coverage of CLAS allowed measurements of exclusive \(\pi^0\) electroproduction over the full azimuthal range. The resulting target and double-spin asymmetries were measured for the first time in the deep inelastic region. The experiment was carried out in Hall B at Jefferson Lab using a 6 GeV longitudinally polarized electron beam and a solid longitudinally polarized NH\textsubscript{3} target. All four final-state particles from the exclusive channel - electron, proton and two photons from \(\pi^0\) decay were identified.

2:18PM C6.00005 Results from E07–013: Target Normal Single-Spin Asymmetry in Inclusive DIS, TIMOTHY HOLMSTROM, Longwood University, JEFFERSON LAB HALL A POLARIZED 3HE COLLABORATION — The target normal spin asymmetry \(A_T\) in deep inelastic scattering is predicted to be exactly zero in the Born approximation. Recent theoretical calculations that assume two photon exchange with one quark give asymmetries of order \(10^{-2}\). The first measurement of this asymmetry on the neutron was made in Hall A at Jefferson Lab (E07-013) by the polarized \(^3\)He Collaboration using an inclusive deep-inelastic n\textsuperscript{1}(e,e') reaction with a vertically polarized \(^3\)He target and a 5.8 GeV electron beam. Results of this measurement will be presented and interpretations of the result will be discussed.

2:30PM C6.00006 Search for \(Y(4260) \rightarrow KKJ/\psi\) at BESIII, DANIEL BENNETT, Indiana University, BESIII COLLABORATION — Many of the newly-discovered “XYZ” states offer unique insights into physics near the charmonium region, including the \(Y(4260)\) state, which is being studied with BESIII detector at the BEPCII collider in Beijing. 2813 pb\textsuperscript{-1} of data has been collected at center of mass energy points ranging from 4.190 MeV to 4.420 MeV. In this analysis, we study the processes of \(e^+e^- \rightarrow K^+K^-\psi\) and \(K_0^0\overline{K_0^0}\psi\) within this region, as well as compare these to \(e^+e^- \rightarrow \pi^+\pi^-J/\psi\). With these results, we can gain new information on the \(Y(4260)\) state and its possible non-qq\textsuperscript{2} interpretations.

2:42PM C6.00007 Concept for an Electron Ion Collider detector built around the BaBar solenoid, JIN HUANG, Brookhaven National Laboratory, PHENIX COLLABORATION — A conceptual design for an Electron Ion Collider (EIC) detector, which builds upon the BaBar solenoid and the planned PHENIX detector upgrades, has been developed. This concept is designed for the PHENIX interaction point on the proposed eRHIC collider, which adds an electron beam to the current RHIC collider to provide polarized e+p/e+A collisions. The PHENIX collaboration is planning a detector upgrade before the EIC era, which consists of large acceptance electromagnetic and hadronic calorimeters and tracking detectors built around the superconducting solenoid recently acquired from the decommissioned BaBar experiment at SLAC. In this EIC detector design, we utilize this upgrade and propose to add new detectors for measurements of a comprehensive EIC physics program. In this talk, we will give an overview for the detector design and its physics capabilities. Update on performance studies will also be discussed.

2:54PM C6.00008 Fermion Mass Generation without a Chiral condensate\textsuperscript{1}, VENKITESH AYYAR, SHAILESH CHANDRASEKHARAN, Duke Univ — While it is well known that massless fermions can become massive due to interactions, it is usually believed that this requires the formation of a fermion bilinear condensate that can act as the mass term for the fermions. Using a strong coupling argument within a lattice four-fermion model, we propose that, in principle, fermions may be able to acquire a mass without the formation of any such condensate. Using Monte Carlo calculations in three Euclidean space-time dimensions, we show evidence for this surprising possibility and argue that this massive strong coupling phase could also have an interesting continuum limit.

\textsuperscript{1}This work was supported in part by the Department of Energy grants DE-FG02- 05ER41368.

3:06PM C6.00009 Precise Measurement of the Mass of the \(\tau\) Lepton, TAO LUO, University of Hawaii, BESIII COLLABORATION — An optimized energy scan near the \(\tau\) pair production threshold has been performed using the BESIII detector. About 24 pb\textsuperscript{-1} of data, distributed over four scan points, was collected. The \(\tau\) mass is determined directly from the threshold behavior of the \(\tau\) pair production cross section in the \(e^+e^-\) collisions. The key question in the measurement is how to determine the beam energy precisely. Here the beam energy measurement system (BEMS) for BEPC-II is used to determine the beam energy. The relative systematic uncertainty of the electron and positron beam energy determination in our experiment is estimated as \(2 \times 10^{-5}\); the relative uncertainty of the beam energy spread is about 6\%. This analysis is based on the combined data from the \(ee, e\mu, e\tau, \mu\mu, \mu\tau, \mu h, e\mu, e\tau\) final states, where \(h\) denotes a charged \(\pi^\pm, K^\pm\).

The mass of the \(\tau\) lepton is measured as

\[ m_\tau = 1776.91 \pm 0.12^{+0.09}_{-0.12} \text{MeV}/c^2 \]  

which is consistent with results from any other groups included by the Particle Data Group, but has the smallest uncertainty.
1:30PM C7.00001 T-T Neutron Spectrum from Inertial Confinement Implosions, JOSEPH CAGGIANO, Lawrence Livermore National Lab, DANIEL SAYRE, LLNL, CARL BRUNE, Ohio University, MARIA GATU JOHNSON, MIT, DENNIS MCNABB, LLNL, ANDREW BACHER, University Indiana (Bloomington) — Measurements of the T(12n)10 fusion reaction (TT) have been conducted using high-purity (~99 percent) tritium, gas-filled glass capsules in inertial confinement fusion implosions. In these experiments, which were conducted at both the NIF and the OMEGA laser facilities, spectral measurements of the TT neutrons were carried out using two well-established instruments: the neutron-time-of-flight (nTOF) and the magnet-based Magnetic Recoil Spectrometer (MRS). The resolutions of these systems were improved significantly for the nTOF facility by using a crystal with much more decay time and for the MRS by using a thinner, more uniform CD2 recoil foil. At OMEGA, charged particle energy spectra were also measured using a magnetic charged particle spectrometer and the Thompson Parabola Ion Energy spectrometer. These measurements at reactant central-mass energies in the range of 10-30 keV can be used to study the TT reaction mechanism near astrophysical energies. This work was reported at the 2013 APS April meeting, where we used basic R-matrix line shapes. Since then we have updated and improved the fitting method by including the proper quantum interferences from fermion symmetry and decay channels [1]. The implications of these effects on our understanding of the spectrum also will be discussed.


1:42PM C7.00002 Determination of Fission Product Yields of 235U, 238U and 239Pu for Neutron Energies from 0.5 to 14.8 MeV, MATTHEW GOODEN, NC State University and TUNL, CHARLES ARNOLD, Los Alamos National Laboratory, JOHN BECKER, Lawrence Livermore National Laboratory, CHITRA BHATIA, MEGHA BHKE, Duke University and TUNL, MALCOLM FOWLER, Los Alamos National Laboratory, CALVIN HOWELL, Duke University and TUNL, JOHN KELLEY, NC State University and TUNL, MARK STOYER, ANTON TONCHEV, Lawrence Livermore National Laboratory, WERNER TORNOW, Duke University and TUNL, DAVE VIEIRA, JERRY WILHELMY, Los Alamos National Laboratory — A joint TUNL-LLNL-LLNL collaboration has been formed to study the issue of possible energy dependencies for certain fission product isotopes. Work has been carried out at the TUNL 10 MV Tandem accelerator which produces nearly mono-energetic neutrons via either 3H(d,n)4He, 3H(d,n)4He, or 4H(p,n)4He reactions. Three dual fission ionization chambers dedicated to 235U, 238U and 239Pu thick target foils and thin monitor foils respectively, were exposed to the neutron beams. After irradiation, thick target foils were gamma counted over a period of 1-2 months and characteristic gamma rays from fission products were recorded using HPGe detectors at TUNL’s low background counting area. Using the dual fission chambers, relative fission product yield were determined at a high precision of 2-3% as well as absolute fission product yields at a lower precision of 5-6%. Preliminary results will be presented for a number of fission product isotopes over the incident neutron energy range of 0.5 to 14.8 MeV.

2:06PM C7.00004 Cross section measurements for γ-rays emitted in 108Rh(n, xγ) reactions, N. FOTIADES, M. DEVLIN, R.O. NELSON, T. KAWANO, LANL — Although rhodium is a useful radiochemical diagnostic of integrated neutron fluence, no thorough study of the γ-rays emitted in fast neutron-induced reactions on the one-and-only stable rhodium isotope has been performed. Absolute partial cross sections for production of discrete γ-rays using 108Rh(n, xγ) reactions with x ≤ 7 and y < 7 in a total of 15 reaction channels were measured in the present work. The data were taken using the GEANIE spectrometer comprised of 26 high-purity Ge detectors with 20 BGO escape-suppression shields. The broad-spectrum pulsed neutron beam of the Los Alamos Neutron Science Center’s (LANSCE) WNR facility provided neutrons in the energy range from 0.2 to 200 MeV. A time-of-flight technique was used to determine the incident neutron energies. Partial γ-ray cross sections have been measured for a total of 140 transitions and for neutron energies 0.8 MeV < Eγ < 300 MeV. An estimate of the population of isomers in the (n, y), (n, 2n) and (n, 3n) channels was attempted. Theoretical calculations up to Eγ = 20 MeV from the GNASH reaction model are compared to the experimental results.

Saturday, April 5, 2014 1:30PM - 2:18PM —
Session C7 DNP: Reactions: Hadrons & Light Nuclei 201 - Sait Umar, Vanderbilt University

1:30PM C8.00001 Neutron Star Equation of State Constraints from Pulsed X-ray Emission, SHARON MORSINK, University of Alberta, ABIGAIL STEVENS, University of Amsterdam, JASON FIEGE, University of Manitoba, DENIS LEAHY, University of Calgary — The observation of pulsed X-ray emission originating from the surfaces of accreting rapidly rotating neutron stars combined with relativistic ray-tracing provides an excellent opportunity to study the properties of neutron stars and to constrain the equation of state of supernuclear density matter. I will review the basic principles behind this method, including the degeneracies inherent in the problem. We are applying a modern genetic algorithm to search for the best-fit masses and radii of the accreting ms period X-ray pulsars that produce X-ray bursts. I will discuss the application of this method to observations that could be performed by the proposed LOFT (Large Observatory for X-ray Timing) mission.

1:42PM C8.00002 Universal I-Love-Q and Multipole-Love Relations, KENT YAGI, NICOLAS YUNES, Montana State University — One of largest uncertainties in nuclear physics is the equation of state (EoS) in nuclear and supra-nuclear densities. Neutron-star (NS) and inertial confinement fusion plasmas at the National Ignition Facility. Being a p-process nucleus, the neutron capture cross section of 124Xe is also of interest for nuclear astrophysics. Preliminary results for both reactions are given.

2:06PM C8.00003 Three-Hair Newtonian Relations for Rotating Stars, LEO STEIN, Cornell University, KENT YAGI, NICOLAS YUNES, Montana State University — Astrophysical black holes can be completely described by their mass and spin, as seen in the no-hair theorems. This was not expected to hold for stars because of their internal structure. We analytically find that arbitrarily-rapidly uniformly-rotating stars can still be completely described by only three numbers (mass, spin and quadrupole moment) in the Newtonian limit. Surprisingly, this description is approximately universal (independent of internal structure) for low multipole order, analytically confirming previous numerical results in full general relativity.
may constrain the role of hadronic and leptonic interactions in producing the GeV emission.

The observations of NGC 253 in the hard X-ray band (10–30 keV) provide the most sensitive observations to date of the non-thermal emission in that bandpass, which in turn helps in understanding the acceleration and transport of particles in the ISM. This study also highlights the importance of future observations in the GeV regime to fully explore the interstellar medium's role in cosmic rays' production and propagation.

THOMAS MACCARONE, Texas Tech University, DANIEL STERN, JPL/Caltech, WILLIAM ZHANG, NASA Goddard Space Flight Center, NUSTAR SCIENCE TEAM — We present results from NUSTAR observations of the Galactic Plane, which show that the non-thermal emission is dominated by electrons accelerated to very high energies in the vicinity of young stellar objects.

KEITH BECHTOL, University of Chicago, MEGAN ARGO, ASTRON, VALLIA ANTONIOU, Harvard-Smithsonian Center for Astrophysics, FIONA HARRISON, NASA Goddard Space Flight Center, ANN HORNSCHEMEIER, ANDREW PTAK, NASA Goddard Space Flight Center, ANDREAS ZEZAS, University of Crete.

We also compare QMC and the one-phonon approximation over a range of temperatures and show that the thermal conductivity can be calculated directly from S(q) obtained from QMC for temperatures larger than 0.3T_P where T_P is the plasma temperature.

2:42PM C8.00007 The Long Term Variability and X-ray Bursts of Cygnus X-2, ALAN SMALE, Code 660.1, Astrophysics Science Division, NASA/GSFC, PATRICIA BOYD, Code 661, Astrophysics Science Division, NASA/GSFC, SHAINA REISMAN, CUNY Brooklyn College, Brooklyn, NY 11210 — The bright, persistent low-mass X-ray binary Cygnus X-2 is composed of a neutron star (NS) in a 9.8-day orbit with its late-type companion, V1341 Cyg. It is one of six bright Galactic sources that traces out a Z-curve on its color-color diagram on timescales of about a day, and one of only two of these Z-sources that also displays Type 1 X-ray bursts (explosive nuclear ignition events on the NS surface). On timescales of weeks to months, Cyg X-2 shows large-amplitude but non-periodic X-ray fluctuations that have been attributed to a warped accretion disk. The extensive archival data from NASA’s Rossi X-ray Timing Explorer (1995-2012), including both pointed and all-sky monitor data, allow us to study the long-term variability, spectral behavior, and burst behavior of the source in unprecedented detail. We have obtained 157 PCA lightcurves totaling over 2.5 Msec of data spread over the lifetime of the RXTE mission, and have detected 61 Type I bursts. Here we present early results of a spectral analysis of these bursts to determine whether properties such as the duration, peak flux level, or spectral parameters of the bursts are correlated with source properties such as time-averaged flux or instantaneous intensity and position on the Z-diagram.

Saturday, April 5, 2014 1:30PM - 2:42PM — Session C9 DAP: Galaxies and Clusters 203 - Tonia Venters, NASA Goddard Space Flight Center

1:30PM C9.00001 The deceleration of nebular shells in evolved planetary nebulae, MARGARITA PEREYRA, MICHAEL GERARD RICHER, JOSE ALBERTO LOPEZ, Univ Nacl Autonoma de Mexico — We have selected a group of 100 evolved planetary nebulae (PNe) and study their kinematics based upon spatially-resolved, long-slit, echelle spectroscopy. The data have been drawn from the San Pedro Martir Kinematic Catalogue of PNe (Lopez et al. 2012). The aim is to characterize in detail the global kinematics of PNe at advanced stages of evolution with the largest sample of homogenous data used to date for this purpose. The results reveal two groups that share kinematics, morphology, and photo-ionization characteristics of the nebular shell and central star luminosities at the different late stages under study. The typical flow velocities we measure are usually larger than 500 km/s, with the largest velocities occurring in objects with very weak or absent [NII]6584 line emission, by all indications the least evolved objects in our sample. The most evolved objects expand more slowly. This apparent deceleration during the final stage of PNe evolution is predicted by hydrodynamical models, but other explanations are also possible. These results provide a template for comparison with the predictions of theoretical models.

1:42PM C9.00002 Evolution of dwarf galaxies simulated in the cosmological LCDM scenario, ALEJANDRO GONZALEZ, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico, PEDRO COLIN, CRya, UNAM, VLADIMIR AVILA-REESE, Instituto de Astronomia, UNAM, ALDO RODRIGUEZ-PUEBLA, Center for Astronomy and Astrophysics, Shanghai Jiaotong University, OCTAVIO VALENZUELA, Instituto de Astronomia, UNAM — We present results from numerical simulations of low-mass galaxies with the aim to explore how the formation and evolution of the parent halo determine the growth of their host galaxy and its implications on the current paradigm of formation and evolution of low-mass structures in the LDM scenario. We have found that low-mass galaxies simulated in this scenario assemble their stellar masses following roughly the dark matter halo assembly, which seems to be in tension with the downsizing trend suggested by current observational inferences. We show that there is no more room to increase the strength of feedback from astrophysical processes in order to deviate strongly from the mean structure model of star and observed results.

1:54PM C9.00003 Broadband Spectral Modeling of NGC 253 from Hard X-rays to TeV Gamma Rays, TONIA VENTERS, NASA Goddard Space Flight Center, DANIEL WIK, BRET LEHMER, MIHOKO YUKITA, Johns Hopkins University; NASA Goddard Space Flight Center, ANN HORNSCHEMEIER, ANDREW PTAK, NASA Goddard Space Flight Center, ANDREAS ZEZAS, University of Crete, KEITH BECHTOL, University of Chicago, MEGAN ARGO, ASTRON, VALLIA ANTONIOU, Harvard-Smithsonian Center for Astrophysics, FIONA HARRISON, Caltech, ROMAN KRIVONOS, UC Berkeley, JEAN-CHRISTOPHE LEYDER, NASA Goddard Space Flight Center; Universities Space Research Association, THOMAS MACCARONE, Texas Tech University, DANIEL STERN, JPL/Caltech, WILLIAM ZHANG, NASA Goddard Space Flight Center, NUSTAR SCIENCE TEAM — We present the latest results from detailed broadband spectral modeling of the nearby starburst galaxy NGC 253 from keV to TeV energies. The mechanism for producing the gamma-ray emission in starburst galaxies is difficult to determine solely from Fermi-LAT and HESS data. NuSTAR observations of NGC 253 in the hard X-ray band (10–30 keV) provide the most sensitive observations to date of the non-thermal emission in this bandpass, which in turn may constrain the role of hadronic and leptonic interactions in producing the GeV emission.
2:06PM C9.00004 Spectral Energy Distributions and X-ray Variability of the Blazar PKS 2155-304, PAUL WIIITA, The College of New Jersey, JAI BHAGWAN, ARIES and Ravishankar Shukla U, India, ALOK GUPTA, Aryabhatta Research Institute for Observational Sciences, India, IOSSIF PAPADAKIS, IESL Foundation for Research and Technology, Greece — PKS 2155-304 is a BL Lac object that is variable across the entire EM spectrum and is the brightest object in UV to gamma-ray bands in the southern hemisphere. It is a high synchrotron peak blazar and is frequently observed by the XMM-Newton satellite in the X-ray, UV and optical. We present spectral energy distributions (SEDs) resulting from 20 pointings of XMM-Newton. We focused on the changes in the synchrotron peak with optical/UV and X-ray flux variations and also analyzed the X-ray spectral variations in more detail for 1 pointing. We modeled the observed SEDs of PKS 2155-304 from the optical to X-ray bands using a synchrotron self-Compton model in which electron energies have log-parabolic distributions. In our analysis, we found a significant anti-correlation between the spectral slope parameter, \( \alpha \), and the peak frequency. All SEDs are fitted well with log-parabolic curves and we considered how each model parameter would change the SED curve. We did not find any significant correlation of magnetic field intensity, electron density, and the bulk Lorentz factor with the peak frequency. One observation analyzed in more detail showed a significant anti-correlation between the X-ray spectral slope and the flux, indicating some X-rays arise from inverse Compton scattering.

2:18PM C9.00005 Abell 2146: A unique bullet cluster system, LINDSAY KING, JACOB WHITE, University of Texas at Dallas, REBECCA CANNING, Stanford University, HELEN RUSSELL, Durham University, UK, JOSEPH COLEMAN, University of Texas at Dallas — Abell 2146 is a unique post-merger cluster system, where two clusters have merged about 0.2 Gyr ago. Such systems provide a direct test of dark matter, and our understanding of gravity on large scales. Massive objects in the universe distort space-time and act as gravitational lenses, and we harness this property in our study of the system. We report on our campaign to better understand the dynamics of this system, using spectroscopic data, primarily from the Gemini telescope. This data allows us to determine redshifts for galaxies in the field, and so identify and study cluster members. We also discuss our gravitational lensing analysis of Hubble Space Telescope data, which reveals numerous strongly lensed arcs. This is compared with Chandra X-ray images, which map the distribution and properties of the hot gas in the system.

2:30PM C9.00006 Evolution of the outer planets and planetesimals due to gas drag in transition disks, SAMUEL NAVARRO, MAURICIO REYES-RUIZ, HÉCTOR AVEYES, Universidad NcL Autonoma de Nuevo Leon (UANL), SANTIAGO TORRES, Universidad NcL Autonoma de Mexico (UNAM), CARLOS CHAVEZ, Universidad Autonoma de Nuevo Leon (UANL), SANTIAGO TORRES, Universidad NcL Autonoma de Mexico (UNAM) — We study the effect of aerodynamic drag due to the gaseous component of a transition protoplanetary disk, on the process of giant planet migration due to the interaction with a disk of planetesimals. We present a series of numerical simulations of the dynamics of the four outer planets in our Solar System and a disk of planetesimals exterior to these; planets are arranged in a compact, multiresonant configuration as that proposed in the so-called Nice model. We model the gaseous component of the protoplanetary disk as both a minimum mass solar nebula and a viscous accretion disk model, both truncated out to a disc radius of approximately 20 AU, following recent observations. We find that aerodynamic drag has important consequences on the early evolution of the compact Solar System. As pointed out previously by other authors, gas drag leads to planetesimal trapping in low order resonances, particularly for kilometer size bodies. In our case, since planetesimals are all located initially outwards of Neptune, these are trapped in outer resonances with such planet on typical timescales of a few million years. This effect leads to an accelerated migration scenario, with the system becoming dynamically unstable on a very short timescale, in comparison to gas free scenarios.

Saturday, April 5, 2014 1:30PM - 3:18PM –
Session C10 FEd: Invited Session: Impacts and Experiences with MOOCs 204 - James Brown, Wabash College

1:30PM C10.00001 A MOOC for Introductory Physics, MICHAEL SCHATZ, School of Physics, Georgia Institute of Technology, Atlanta, GA 30332 — We describe an effort to develop and to implement a college-level introductory physics (mechanics) MOOC that offers bona fide laboratory experiences. We also discuss efforts to use MOOC curricular materials to “flip” the classroom in a large lecture introductory physics course offered on-campus at Georgia Tech. Preliminary results of assessments and surveys from both MOOC and on-campus students will be presented.

2:06PM C10.00002 Massive Open Online Courses (MOOCs) for Physics - and for You?, DAVID E. PRITCHARD, Massachusetts Institute of Technology — We will describe several of the currently available Massive Open Online Courses in Physics—the topics, level, author, and special features of each. Then we will discuss the interesting demographics of the students taking them, presenting evidence showing that students of widely different initial skills and students of all major demographic groups learn at least as much conceptual knowledge as students in a traditional classroom. We will present MOOC research on student habits, use of eTexts and other resources, and indicate what resources impart measured learning. We’ll describe a collectivist MOOC where you can help develop instructional and assessment resources that will be in a library for future use by you and other teachers. Many of these resources are designed for blending with on-campus introductory courses in college or Advanced Placement courses in High School. They will ultimately be deployed in a searchable library with lots of useful information from which you can assemble your own course in the free and open edX.org platform (or simply download them for in-class use).

We Acknowledge support from NSF, a Google Faculty Award, and MIT.

2:42PM C10.00003 Riding the MOOC Tsunami, WOLFGANG BAUER, Michigan State University — Massive Open Online Courses (MOOCs) have the potential to revolutionize teaching and learning at universities. It is even conceivable that MOOCs can endanger the basic business model of higher education, because they have the potential to erase traditional brick-and-mortar advantages. I will discuss our experiences with 15 years of offering online physics courses at Michigan State University, and lessons learned in doing so.

Saturday, April 5, 2014 1:30PM - 2:42PM –
Session C11 C5WP: Invited Session: The Participation of Women in Physics - Current Studies and Efforts Oglethorpe Auditorium -
1:30PM C12.00001 Status and Overview of the Axion Dark Matter Experiment (ADMX)¹, LESLIE ROSENBERG, University of Washington, ADMX COLLABORATION, ADMX-HF COLLABORATION — The axion is a hypothetical particle that both explains why the strong force is CP invariant and answers the question of what constitutes the dark matter in the universe. ADMX is a direct search for dark-matter axions. The search technique is based on the resonant conversion of axions into photons with an apparatus consisting of a microwave cavity threaded by a magnetic field, and quantum-limited microwave amplification. This experiment, in several different configurations, is now beginning operations. The construction of the first phase of the upgrade (dubbed Phase IIa) is now complete and we will be data taking for much of the upcoming year. I will give a very brief motivation for axions, then go into the mechanical details of ADMX, and finally look at the upgrades we plan to make in the near future.

1Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF Grant 1067242, and the Livermore LDRD program.

1:42PM C12.00002 Design of Axion Dark Matter Experiment (ADMX) Upgrade¹, DMITRY LYAPUSTIN, University of Washington, ADMX COLLABORATION, ADMX-HF COLLABORATION — Axions are hypothetical elementary particles that may provide the answer as to why QCD preserves the discrete symmetries P and CP and may also be the dark matter of the universe. The ADMX experiment has been at the forefront of the search for dark-matter axions for over a decade, and has recently undergone upgrades to dramatically improve its sensitivity. Construction of the first phase of the upgrade (dubbed Phase IIa) is now complete and we will be data taking for much of the upcoming year. I will give a very brief motivation for axions, then go into the mechanical details of ADMX, and finally look at the upgrades we plan to make in the near future.

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1:54PM C12.00003 First results from ADMX Experiment: Phase IIa¹, GRAY RYBKA, University of Washington, ADMX COLLABORATION, ADMX-HF COLLABORATION — The Axion, a light pseudo-scalar particle predicted as a consequence of the Peccei-Quinn solution to the Strong CP problem, is a compelling dark matter candidate with a well predicted coupling to the photon. The Axion Dark Matter Experiment (ADMX) is a microwave cavity experiment that has recently completed a full system upgrade and begun a comprehensive search for dark matter axions. The sensitivity of the newly upgraded experiment will be discussed and early results will be shown.

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2:06PM C12.00004 The ADMX ultra-low noise receiver¹, CHRISTIAN BOUTAN, University of Washington, ADMX COLLABORATION, ADMX-HF COLLABORATION — The Axion Dark Matter eXperiment (ADMX) searches for dark-matter axions by looking for their resonant conversion to microwave photons in a strong magnetic field. Given the current experimental setup the axion-photon conversion power is expected to be below a yoctowatt (< 10⁻²⁴ W). Detecting such feeble signals above the thermal and electronic noise background requires a very sensitive microwave receiver. To ensure a fully characterized data pipeline, synthetic axion waveforms are simulated and periodically injected through the cavity and receiver chain. Here I discuss the calibration of the ADMX receiver and real-time analysis performed by the DAQ.

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phenomena in the Milky Way galaxy. Here, we present many different models of the rotation curves of the Milky Way galaxy and their possible implications. Of the models explored, both standard and alternative gravitational models will be discussed. A discussion will follow as to how each model attempts to explain recently discovered phenomena in the Milky Way galaxy.

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2:18PM C12.00005 A tunable microstrip SQUID amplifier for the Axion Dark Matter Experiment (ADMX)\(^1\), SEAN O’KELLEY, UC Berkeley, JORN HANSEN, Technical University of Denmark, ELAN WEINGARTEN, UC Berkeley, MICHAEL MUECK, ez SQUID, GENE HILTON, NIST, JOHN CLARKE, UC Berkeley, ADMX COLLABORATION, ADMX-HF COLLABORATION — We describe a microstrip SQUID (Superconducting Quantum Interference Device) amplifier (MSA) used as the photon detector in the Axion Dark Matter eXperiment (ADMX). Cooled to 100 mK or lower, an optimized MSA approaches the quantum limit of detection. The axion dark matter is detected via Primakoff conversion to a microwave photon in a high-Q (\(10^5\)) tunable microwave cavity, currently cooled to about 1.6 K, in the presence of a 7-tesla magnetic field. The MSA consists of a square loop of thin Nb film, incorporating two Josephson tunnel junctions with resistive shunts to prevent hysteresis in the current-voltage characteristic. The microstrip is a square Nb coil deposited over an intervening insulating layer. Since the photon frequency is determined by the unknown axion mass, the cavity and amplifier must be tunable over a broad frequency range. Tunability is achieved by terminating the microstrip with a GaAs varactor diode with a voltage-controlled capacitance that enables us to vary the resonance from nearly 1/2 to 1/4 of a wavelength. With the SQUID current-biased in the voltage state, we demonstrate a gain of typically 20 dB over nearly one octave, 415 MHz to 800 MHz.

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2:30PM C12.00006 Design considerations for extending ADMX to temperatures below 1K\(^2\), MIGUEL GONZALEZ, University of Florida, ADMX COLLABORATION, ADMX-HF COLLABORATION — Phase II of the ADMX experiment is a large-scale upgrade with the objective of integrating the state-of-the-art in microwave detection and in cryogenic technologies. From its initial operations with pumped liquid \(^4\)He at \(\sim\)1.5K, a further reduction in physical temperature to the targeted 100 mK would improve its sensitivity more than twentyfold, extending the search below the DFSZ limit. But the cooling of a large microwave cavity to millikelvin temperatures in a high magnetic field poses some new challenges with no turnkey solutions from commercial cryogenic technologies. In this talk, we address the issue of incorporating current commercial technologies within our custom made insert to construct a dilution refrigeration system with a cooling power of 800 \(\mu\)W at 100 mK. Additionally, we describe a separate homemade pumped liquid \(^4\)He system with a 2-3 mW cooling power at 0.5K, which will be used as a bridge between the current \(^4\)He system at 1.5K and the planned 100 mK dilution system.

2:42PM C12.00007 Searching for axions with ADMX: Higher Order Microwave Cavity Modes\(^3\), JAMES SLOAN, University of Washington, ADMX COLLABORATION, ADMX-HF COLLABORATION — The ADMX experiment searches for axions by looking for their resonant conversion to detectable photons at a frequency that directly corresponds to the axion mass (a currently unknown value). Though initial phases of the experiment only collected data at the fundamental frequency of the tunable cavity ADMX now includes all the necessary hardware and electronics to conduct simultaneous axion searches at two frequency regimes. ADMX researchers are investigating the mode structure of the cavity in operation to identify optimal modes and frequency regions for simultaneous data collection at the fundamental frequency mode and at a higher frequency mode. As these structures are understood, strategies of operation will be developed. In addition, in the summer of 2013 smaller high frequency cylindrical cavities were designed, constructed, and tested to allow ADMX to perform searches at higher frequencies than the large volume cavity that is currently installed. The cavities are essentially the same geometry as the current ADMX cavity scaled down, and an adapter plate to attach the cavities to the current hardware was also built to simplify integration in the current system and allow a quick move to a higher frequency search.

3 Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF grants PHY-1067242 and PHY-1306729, and the Livermore LDRD program.

2:54PM C12.00008 Results from a modulation sensitive search for non-virialized halo axions\(^4\), J. HOSKINS, University of Florida, ADMX COLLABORATION, ADMX-HF COLLABORATION — Flows of non-virialized axions may exist within the Milky Way halo. These flows are expected to have very low velocity dispersions, leading to correspondingly narrow peaks in the measured power spectra. Further, they may also contribute significantly to the local density of dark matter. A search for such flows has been performed by the Axion Dark Matter eXperiment Phase I at spatial resolutions of 84 mHz, 168 mHz, 546 mHz, and 1.09 Hz. Signal modulation due to terrestrial motion becomes significant at or below resolutions of order 1 Hz. Annual and daily modulation amplitudes of 250 Hz and 2 Hz were accounted for when identifying potential axion signals. This search produced limits on the local density of non-virialized axions over the 3.36–3.69 \(\mu\)eV mass range.

4 Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF grants PHY-1067242 and PHY-1306729, and the Livermore LDRD program.

Saturday, April 5, 2014 1:30PM - 3:06PM – Session C14 Undergraduate Research and Outreach - SPS II 102 - Kendra Redmond, Society of Physics Students - AIP

1:30PM C14.00001 Forgotten Trailblazers: The History of Women in Physics and Astronomy\(^5\), FIONA MUIR, University College London — While female physicists and astronomers have historically made up a relatively small fraction of the community as a whole, this was not the only thing holding back women in physics. Even the most prominent women have had their achievements overlooked and diminished. As part of a Society of Physics Students internship at the American Institute of Physics’ Center for History of Physics, we researched the lives and work of a range of women in physics, covering a wide span of geographical areas and eras in history. This information was compiled in to lesson plans for high school and college age students, focusing on specific women or certain overarching themes such as collaborative married couples. In this talk, I will discuss our research methods and include examples of the lesson plans and their applications.

5 Completed as part of the SPS internship programme

1:42PM C14.00002 Models of the rotation curve for the Milky Way Galaxy\(^6\), ROBERT MOSS, JAMES O’BRIEN, Wentworth Institute of Technology — In this talk we present synthesis rotation curve data for the Milky Way galaxy. Galaxy rotation curves have proven to be the testing ground for dark matter bounds in galaxies, and our own Milky Way is one of many large spiral galaxies that must follow the same models. Here, we present many different models of the rotation curves of the Milky Way galaxy and their possible implications. Of the models explored, both standard \(\Lambda\)CDM as well as alternative gravitational models will be discussed. A discussion will follow as to how each model attempts to explain recently discovered phenomena in the Milky Way galaxy.

6 Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF grants PHY-1067242 and PHY-1306729, and the Livermore LDRD program.
1:54PM C14.00003 Quantum Effects in Nanoscale MOSFET Devices at Low Temperature

ALEXANDRA DAY, Wellesley College — MOSFET transistors are a key component of virtually all modern electronic devices. Today’s most advanced MOSFETs are small enough that quantum mechanical effects become relevant when considering their function and use. This project, completed at the National Institute of Standards and Technology as part of a Society of Physics Students internship, presents a first step in describing the theoretical behavior of nanoscale MOSFETs at low temperature.

1I acknowledge generous support from the Society of Physics Students and the National Institute of Standards and Technology

2:06PM C14.00004 A Solution of Backlight Bleed Drawback of LCDs can be seen by Long Range Ordered Nematic Domain of Liquid Crystal 8CB

DIPTI SHARMA, Wentworth Institute of Technology, Boston, MA — Most common liquid crystal device (LCD) uses nematic to isotropic phase transition of the liquid crystal to get more vibrant images and better contrast ratios in terms of how deep their blacks are. A contrast ratio is the difference between a completely on and off pixel, and LCDs can have “backlight bleed” where light (usually seen around corners of the screen) leaks out and turns black into gray. Completely on and off pixel can be related to the orientation of liquid crystal domain from nematic to Isotropic transition. This research focuses how long range ordered nematic domains can affect the nematic to isotropic phase transition of aligned 8CB liquid crystal and brings a quicker and early occurrence of nematic to isotropic phase transition with smaller wing tales.

2:18PM C14.00005 Failure of the Cross Correlation Measurement Technique

KEN MCGILL, KATIE HAM, KRIS SCHOCK, Georgia College and State University — The experiment involves creating a sound wave that propagates down a pipe with 8 transducers attached at equally spaced intervals of 0.01016 meters. The numerical method used to solve for the phase component, the Cross Correlation Method, creates a high correlation value, but the speed of sound varies immensely. The method involves a Fast Fourier Transform of the collected data; which is used to find the phase of the sound wave, and the slope of the position versus time graph, which is used to calculate the speed of sound. This high correlation values shows that the data is correct, but the numerical method for analyzing the data is incorrect.

We would like to thank Dr. Ken McGill for all of his time, help, and guidance with this research project. We would also like to thank Georgia College and State University for both the resources and space necessary for this experiment.

2:30PM C14.00006 AIP’s Career Pathways Project

JOSE AVILA, No Company Provided — The American Institute of Physics (AIP) Career Pathways Project, funded by the National Science Foundation, aims to increase the number of undergraduates going into STEM careers. The main purposes of this project are to show students the professional opportunities for a STEM career, understand what departments can do to better prepare physics bachelor’s degree recipients to enter the workforce, understand what students can do to better prepare themselves, and develop resources based on these findings. I was chosen by the Society of Physics Students (SPS) to be the 2013 summer intern of the AIP’s Career Pathways Project. In this talk I will discuss several resources I worked on with the Statistical Research Center of the American Institute of Physics and SPS. These resources include how to write a resume and cover letter, how to perform an informational interview, common job titles for physics bachelors, how to find career information in physics and STEM, how to search and use job postings, and how to network.

2:42PM C14.00007 Going to work with an undergraduate physics degree

TONI SAUNCY, KENDRA REDMOND, American Institute of Physics - Division of Education, ROMAN CZUJKO, American Institute of Physics - Statistical Research Center, AIP CAREER PATHWAYS PROJECT TEAM — With an average 40% of all physics baccalaureate degree recipients opting not to enter graduate school, it is imperative that departments build robust programs that prepare students for a broad range of career paths. However, the default focus of many departments is on preparing students for entry into advanced physics degree programs. Based on the statistical evidence and need for attention on students entering the workforce, the American Institute of Physics (AIP) has undertaken an NSF-funded research effort to understand, compile and disseminate effective practices for preparing undergraduate physics students to enter the STEM workforce upon graduation. The project entailed site visits to eight schools with strong records of students entering STEM fields, in order to discern effective practices in recruitment and preparation of students for those opportunities. We have developed targeted information to engage the students themselves, the faculty advisors, mentors and career professionals who have direct contact with the students, and the administrative “decision-makers.” Each of these groups requires information that addresses their particular roles in the collaborative process that will lead to not only an increase in the numbers of students who enter the STEM workforce, but in the quality preparation of those students. The tools for each of these groups will be discussed, with special emphasis on a set of career tools for students and their mentors.

This project is funded by NSF Grant #1011829.

2:54PM C14.00008 Searching for Dark Matter with the NOvA Neutrino Telescope

LIETING XIAO, Univ of Virginia, NOVA COLLABORATION — NOvA is a particle physics experiment designed to study the properties of neutrino oscillations using a beam of neutrinos from Fermilab. Because of the NOvA detector’s unique features, it may be useful for other physics searches beyond its primary purpose. We investigate using the NOvA detector as a neutrino telescope to search for dark matter annihilations at the core of Sun.

Acknowledgements: The Jefferson Trust, Fermilab, UVA Department of Physics

Saturday, April 5, 2014 1:30PM - 3:18PM — Session C15 Gravitational Wave Astrophysics II

1:30PM C15.00001 The Loudest Gravitational Wave Events

HSIN-YU CHEN, DANIEL HOLZ, University of Chicago — Compact binary coalescences are likely to be the source of the first gravitational wave (GW) detections. While most Advanced LIGO-Virgo detections are expected to have signal-to-noise ratios (SNR) near the detection threshold, there will be a distribution of events to higher SNR. Assuming the space density of the sources is uniform in the nearby Universe, we derive the universal distribution of SNR in an arbitrary GW network, as well as the SNR distribution of the loudest event. These distributions only depend on the detection threshold and the number of detections; they are independent of the detector network, sensitivity, and the distribution of source variables such as the binary masses and spins. We also derive the SNR distribution for each individual detector within a network as a function of the detector orientation. We find that, in 90% of cases, the loudest event out of the first four Advanced LIGO-Virgo detections should be louder than SNR of 15.8 (for a threshold of 12), increasing to an SNR of 31 for 40 detections. We expect these loudest events to provide the best constraints on their source parameters, and therefore play an important role in extracting astrophysics from GW sources.
forms modelled using numerical binary black hole simulations. The purpose of NINJA is to study the ability to detect gravitational waves emitted from merging binary black holes and recover their parameters with next-generation gravitational-wave observatories. We report here on the results of the second NINJA project, NINJA-2, which employs 60 complete binary black hole hybrid waveforms consisting of a numerical portion modelling the late inspiral, merger, and ringdown stitched to a post-Newtonian portion modelling the early inspiral.

Impact of higher-order modes on parameter recovery from binary black hole coalescences, LARNE PEKOWSKY, Georgia Institute of Technology — Thus far modeled searches for the gravitational waves produced by the coalescence of compact binaries have used templates that include only the 2,2 mode. However, it is known that there can be significant power in higher-order modes — indeed, these are parameters for which these modes become dominant. Numerical relativity can now produce waveforms that are accurate enough through late inspiral, merger, and ringdown including many higher-order modes. We present recent work using waveforms produced at Georgia Tech to determine how the inclusion of higher modes in model waveforms can increase the accuracy with which the parameters of the system can be recovered from a detected signal in Advanced LIGO. We consider a variety of binary black hole systems, including systems that precess.

The gravitational-wave signature of binary black holes in spin-orbit resonances, MICHAEL KESDEN, The University of Texas at Dallas, DAVIDE GEROSA, University of Cambridge, EMANUELE BERTI, University of Mississippi, RICHARD O’SHAUGHNESSY, University of Wisconsin - Milwaukee, ULRICH SPERHAK, University of Cambridge — Mass transfer and tidal alignment during the evolution of their stellar progenitors can induce an asymmetry in the misalignment of binary black-hole spins with the orbital angular momentum. If binaries preferentially form with the the spins of the more massive black hole more (less) aligned with the orbital angular momentum than that of the less massive black hole, the components of the spin in the orbital plane will preferentially align (anti-align) during the gravitational-wave induced inspiral. Once trapped in these spin-orbit resonances, the orbital angular momentum and both spins jointly precess in a common plane during the remainder of the inspiral. We examine the gravitational waves emitted by binary black holes in these resonant configurations, and find that binaries with aligned spin components in the orbital plane can be distinguished by the greater precession of the orbital plane. This precession leaves a distinctive signature in the gravitational waveform which can be identified by ground-based gravitational-wave detectors in sources with sufficient signal-to-noise ratio.

Estimating parameters of BH-NS binaries with gravitational waves, RICHARD O’SHAUGHNESSY, University of Wisconsin, Milwaukee, BEN FARR, Northwestern University, EVAN OCHSNER, University of Wisconsin, Milwaukee, CHUNGLEE KIM, Seoul National University, Korea, VIVIEN RAYMOND, California Institute of Technology, HEE-SUK CHO, Pusan National University, Korea — Ground-based gravitational wave detectors will soon identify the gravitational wave signal from merging stellar-mass compact binaries, including black hole-neutron star (BH-NS) binaries. With their mass ratio and spin, BH-NS binaries produce an intrinsically complicated multimodal signal. In this talk, we examine how well gravitational wave detectors can estimate the parameters of fiducial nonprecessing and precessing binaries. We compare our detailed Markov-chain Monte Carlo simulations against analytic (Fisher matrix) calculations.

Techniques for high-frequency searches for Gravitational Waves associated with Gamma-ray Bursts, DANIEL HOAK, University of Massachusetts, Amherst, LIGO SCIENTIFIC COLLABORATION, VIRGO COLLABORATION — In the next few years, the global network of advanced gravitational-wave detectors will span the universe for the first time with unprecedented sensitivity. Some of the most promising sources of transients gravitational-wave (GW) signals are the central engines of gamma-ray bursts (GRBs), which are expected to emit GWs across a wide frequency band. In this talk, I will describe the methods of a search for high-frequency (>1kHz) GWs in data from the LIGO and Virgo experiments, associated with GRBs detected by the Fermi Gamma-ray Burst Monitor (GBM). I will discuss the challenges for GW searches that arise from the GBM sky localization, and techniques to make these searches computationally feasible. I will also describe the ability of GRB-triggered GW searches to refine the localization a detectable GW signal within the Fermi-GBM error region.

An all-sky search for unmodeled long-duration transient gravitational-wave signals, TANNER PRESTEGARD, Univ of Minn - Minneapolis, LIGO SCIENTIFIC COLLABORATION, VIRGO COLLABORATION — A number of astrophysical models predict transient emission of gravitational waves (GWs) on relatively long time-scales, lasting from seconds to days. These GWs are often not accompanied by a detectable electromagnetic counterpart, e.g., a gamma-ray burst. In order to search for gravitational waves produced by these mechanisms, we are developing an un-triggered all-sky extension of an excess cross-power search pipeline that has recently been used to study long-lived signals associated with gamma-ray bursts. Here, we give an overview of this all-sky search pipeline, focusing on GW sources of interest, data analysis methods, and the expected sensitivity of such a search using LIGO data.

NANOGrav Limits on Continuous Gravitational Waves from Supermassive Black Hole Binaries, JUSTIN ELLIS, University of Wisconsin Milwaukee, NANOGRAV COLLABORATION — Gravitational Waves (GWs) are signals in the fabric of space-time predicted by Einstein’s theory of General Relativity. Pulsar timing arrays (PTAs) offer a unique opportunity to detect tiny ripples in the fabric of space-time predicted by Einstein’s theory of General Relativity. Pulsar timing arrays (PTAs) offer a unique opportunity to detect gravitational waves, which cause small changes to the times of arrival of radio pulses. In this talk I will discuss the work of the NANOGrav collaboration and recent progress made toward realistic simulations of our sensitivity to a stochastic background of gravitational waves. I will show that a detection is possible as early as 2017.
1:30PM C16.00001 Universality in the collapse of rotating gravitational waves, TONY CHU, Canadian Institute for Theoretical Astrophysics, SXS COLLABORATION — Choptuik’s discovery of critical phenomena in the collapse of a spherically symmetric massless scalar field has spurred much interest over the years to explore critical collapse in more general settings. By evolving one-parameter families of initial data, it was found that spacetimes near the threshold of collapse or dispersion exhibited type II critical phenomena, with the properties of universality, scaling, and self-similarity. Shortly afterwards, similar results were obtained by Abrahams and Evans (and more recently by Sorkin) for the critical collapse of axisymmetric non-rotating gravitational waves. Despite many investigations into the critical collapse of other spherically symmetric or axisymmetric configurations, there has been relatively little headway on studying the critical collapse of non-axisymmetric configurations, which may carry angular momentum. In this talk, I will report on progress in simulating the critical collapse of non-axisymmetric rotating gravitational waves, which instead exhibit signs of type I critical phenomena, and comment on evidence for universality.

1:42PM C16.00002 Thermodynamic and Dynamic Stability of Asymptotically Anti-de Sitter Black Holes, STEPHEN GREEN, University of Guelph, STEFAN HOLLANDS, Universitat Leipzig, AKIHIRO ISHIBASHI, Kinki University, ROBERT WALD, University of Chicago — Hollands and Wald previously established a criterion for dynamic stability of asymptotically flat black holes with respect to linearized axisymmetric perturbations. They showed that stability is equivalent to positivity of a canonical energy on a certain class of these perturbations. We adapt this work to the asymptotically anti-de Sitter case, and find that the restriction to axisymmetric perturbations is lifted as a consequence of the reflecting nature of spatial infinity. The consideration of non-axisymmetric perturbations allows us to address phenomena such as superradiant instabilities. As in the previous work, the canonical energy can be expressed in terms of second order variations of thermodynamic quantities, thereby establishing a connection between thermodynamic and dynamic stability. We discuss the relationship between negative canonical energy configurations and the presence of a generalized ergosphere.

1:54PM C16.00003 Positive energy and stability of black holes, KARTIK PRABHU, ROBERT WALD, The University of Chicago — Hollands and Wald showed that dynamic stability of stationary axisymmetric black holes is equivalent to positivity of canonical energy on a space of linearised axisymmetric perturbations satisfying certain boundary and gauge conditions. We show that the “kinetic energy” — the energy of the perturbations that are odd under reflection in t and φ — is positive. We discuss implications of having a positive kinetic energy for proving exponential growth in the case where the “potential energy” can be made negative.

2:06PM C16.00004 Turning Point Instabilities for Relativistic Stars and Black Holes, JOSHUA SCHIFFFRIN, ROBERT WALD, The University of Chicago — In the light of recent results relating dynamic and thermodynamic stability of relativistic stars and black holes, we re-examine the relationship between “turning points” — i.e., extrema of thermodynamic variables along a one-parameter family of solutions — and instabilities. We give a proof of Sorkin’s general result — showing the existence of a thermodynamic instability on one side of a turning point — that does not rely on heuristic arguments involving infinite dimensional manifold structure. We use the turning point results to prove the existence of a dynamic instability of black rings in 5 spacetime dimensions in the region where \( c_J > 0 \), in agreement with a result of Figueras, Murata, and Reall.

2:18PM C16.00005 Retarded Fields of Null Particles and the Memory Effect, ALEXANDER TOLISH, The University of Chicago, ROBERT WALD, The University of Chicago — We consider the scalar, electromagnetic and linearized gravitational fields produced by a particle moving on a null geodesic. We cut off the null source at a finite time \( t_0 \) and then consider two limits: (i) the limit as the observation point goes to null infinity at fixed \( t_0 \), and (ii) the limit \( t_0 \to -\infty \) at fixed observation point. Limit (i) gives rise to a velocity kick on distant test particles in the scalar and electromagnetic cases, and a memory effect (permanent change in relative separation of test particles) in the gravitational case, in agreement with past analyses. Limit (ii) does not exist in the scalar case or for the Lorenz gauge potential and metric perturbation in the electromagnetic and gravitational cases. However, we find well defined distributional limits for the electromagnetic field strength and Riemann tensors. In the gravitational case, there is no memory effect associated with this limit. This suggests that the memory effect should not be interpreted as arising simply from the passage of null stress energy to null infinity but rather as arising from a burst of radiation associated with the creation of the null stress-energy (as in case (i)) or, more generally, with radiation present that was not produced by the null stress-energy.

2:30PM C16.00006 Spacetime Approach to Force-free Magnetospheres, SAMUEL GRALLA, TED JACOBSON, UMD — Force-Free Electrodynamics (FFE) describes a magnetically dominated relativistic plasma, as expected to exist near pulsars and (some) supermassive black holes. Despite being fully covariant, FFE has primarily been studied in \( 3+1 \) frameworks. We have instead taken a spacetime approach, focusing on observer-independent properties. In this talk I will describe some of the progress we have made with this approach, both new results and improved understanding of previous results. I will focus particularly on energy extraction from spinning conductors and black holes.

2:42PM C16.00007 Magnetohydrodynamical Analogue of a Black Hole, NELSON ZAMORANO, Departamento de Física, FCFM, Universidad de Chile, FELIPE ASENSIO, Departamento de Ciencias, Facultad de Artes Liberales, Universidad Adolfo Ibáñez. — We study the conditions that a plasma fluid and its container should meet to generate a magneto-acoustic horizon. This effect becomes an alternative to the analogue black hole found in a transonic fluid flow setting. In this context we use the magnetohydrodynamic formalism (MHD) to analyze the evolution of an irrotational plasma fluid interacting with an external constant magnetic field. Under certain plausible approximations, the dynamic of the field perturbations is described by a scalar field potential that follows a second order differential equation. As we prove here, this equation corresponds to the wave equation associated to a scalar field in a curved space-time. This horizon emerges when the local speed of the medium grows larger than the sound velocity. The magnetic field generates an effective pressure which contributes to the magneto-acoustic speed. We compare these results with the known physics of analogue black holes. We will also refer to our ongoing experiment that, in its first stage, attempts to reproduce the wave horizons found in an open channel with an obstacle: PRL 106, 021302(2011).

2:54PM C16.00008 The Quasinormal Modes of the Kerr-Newman Spacetime in the Small Charge Limit
e1, ZACHARY MARK, Oberlin College, HUAN YANG, Perimeter Institute for Theoretical Physics, AARON ZIMMERMAN, Canadian Institute for Theoretical Astrophysics, YANBEI CHEN, California Institute of Technology — The quasinormal modes (QNM) solutions of the linearized Einstein equations are important tools for calculating gravitational waveforms from astrophysical systems and for considering the stability of the background spacetime. The equations governing perturbing fields on a Kerr-Newman background fail to separate or decouple, making an exact calculation of the QNM frequencies currently intractable. In this study we circumvent this issue by looking at the limit \( Q \ll M \). In this regime, we can apply perturbation theory a second time to the small charge parameter \( q = Q^2/M^2 \) and semi-analytically arrive at the QNM frequencies to first order in \( q \).

This work was supported by Caltech’s LIGO SURF program.
Saturday, April 5, 2014 1:30PM - 3:18PM –
Session C17 FHP: Invited Session: Journeys in the History of Physics: Pais Prize Session in Honor of David Cassidy

3:06PM C16.00009 Eikonal Green function of the Kerr spacetime, AARON ZIMMERMAN, CITI, HUAN YANG, Perimeter Institute, FAN ZHANG, University of West Virginia, YANBEI CHEN, Caltech — The Green function of a black hole spacetime determines its response to small perturbations. The Green function can be used to calculate the self-force correction to the motion of a small mass about the black hole. We have constructed the part of the Green function arising from perturbations which are partially trapped at the light ring, in the eikonal (high-frequency) limit. This “quasinormal mode” part of the Green function is important at early and intermediate response times. In the eikonal limit, it diverges where null geodesics connect a response point to the source point, and it exhibits a four-fold singularity structure. I will discuss our results, future applications of our work, and open questions.

2:42PM C17.00002 Toward a Rethinking of the Relativity Revolution, DANIEL SIEGEL, University of Wisconsin-Madison — This journey in the history of physics is offered in celebration of David Cassidy’s Pais Prize. The journey, undertaken in part with the community of historians of physics and in part not, starts from a conventional characterization of the relativity revolution as an abrupt transition, in 1905, from pre-Einsteinian darkness to Einsteinian light, and ends with an alternative perspective on the relativity revolution, seeing it as a process extending over 50 years, in two phases: first, the protorelativity phase, lasting from the early 1880s to 1905, and involving initial treatments of the length contraction, the mass increase, and invariance properties; second, the Einsteinian phase, beginning with his recasting of the basic theoretical framework—with the inclusion now of the time dilation and the $E=mc^2$ relationship—and continuing with the ensuing competition between the protorelativistic and Einsteinian approaches, issuing in the final triumph of the Einsteinian approach only in the early 1930s. A proper appreciation of the character and importance of the protorelativity phase of the relativity revolution is relevant to a variety of contexts: for the teaching of relativity theory, it makes available a more concrete and pictorial approach to the relativistic effects—retaining greater (length contraction) or somewhat lesser (mass increase) validity to the present day; for the ongoing discourse on the nature of scientific revolutions, it provides a perspective on the intricacies and complexities of those occurrences, and on the elements of continuity and gradualism in even the most radical changes; and for our general understanding of historical process in the history of the sciences, it shows the importance of the broader scientific research community for even the most individual accomplishments.

2:48PM C17.00003 An Insider’s History of Some of the Significant Changes In the APS from the 1960s to Today1, BRIAN SCHWARTZ, Brooklyn College and the Graduate Center of the City University of New York — It has been over 50 years since I first joined the American Physical Society. A lot has changed. The APS in the 60s did not have a single Forum and all divisions were related to sub-field of physics research plus the History of Physics Division. The APS governance and meeting’s structure did not provide for issues relate to physics and society. In the past 50 years, APS has increased its role, in areas such as minorities, women, industrial physics, international physics, communication of science, and many more subjects quite typical of APS in 2014. From the start, I was a very active member of APS and one of the original petitioners for the Division on Physics and Society. Ultimately this led to the APS Forum structure, the Panel on Public Affairs and many APS formal committees. Two of the major impetuses for change in the late 60s were the need to debate the role of science in the unpopular war in Vietnam and the overproduction and poor employment prospects for new Ph.D.s, I, and colleagues, (with little original encouragement from the APS leadership), arranged for the discussion on many new topics at the meeting and proposed changes within the governance of the Society. In the late 1980s I joined the APS and was involved in many changes over the next 20 years, ultimately as Associate Executive Officer and Director of the APS Centennial in 1999. As indicated earlier, I’ve been with the APS for over 50 years and will present its history as a participant-insider. Topic covered include my surprise election to the APS governance in 1972, the establishment of the Forum on Physics and Society (and the restrictions imposed on its governance), my role as the father (or mother) of the women’s movement at APS, the complexities and politics of the move of APS headquarters from New York to College Park, the establishment of the tabloid APS News and many more subjects. Currently I am producing stage-readings of science-based plays at the March and April 2014 APS meetings for the Forum on History of Physics.

1Supported in part by the National Science Foundation.

2:00PM - 2:00PM
Session D1 APS: Poster Session I (14:00-17:00) Exhibit Hall -

D1.00001 UNDERGRADUATE RESEARCH –

D1.00002 Analysis of Electromagnetic Fields in Inertial Alvén Wave Collisions, J.D. RHUDY, B.C. SHANKEN, D.J. DRAKE, Valdosta State University, J.W.R. SCHROEDER, G.G. HOWES, C.A. KLETZING, F. SKIFF, University of Iowa, T.A. CARTER, S. DORFMAN, University of California at Los Angeles — Turbulence in astrophysical and space plasmas is dominated by the nonlinear interaction of counterpropagating Alvén waves. Most Alvén wave turbulence theories have been based on ideal plasma models, such as incompressible MHD, for Alvén waves at large scales. The theory predicts that the nonlinear interaction of two counterpropagating MHD Alvén waves will produce a secondary daughter wave. The theory for large scale MHD waves has been previously verified by our research group [1]. However, in the small scale regime where inertial Alvén waves dominate, the theory has yet to be determined. We present here experiments performed in the Large Plasma Device that focus on the interaction of two counterpropagating inertial Alvén waves traveling parallel to the background magnetic field. The evidence clearly shows the production of a nonlinear daughter wave, similar to those observed for MHD Alvén waves.


D1.00003 Kinetic Modeling of Plasma formed during Aerobraking in the Martian Atmosphere, EVAN SMITHWICK, DERETH DRAKE, Valdosta State Univ — During Martian atmospheric aerobraking the plasma that forms around a spacecraft can be considered a high-volume plasma reactor that is sustained by the dissipation of the spacecraft’s kinetic energy. At altitudes below 100 km, it has been shown that the plasma parameters vary considerably depending on the spacecraft’s trajectory. However, in range which is applicable to aerobraking, 100 km < h < 200 km, little of this work has been completed. We have evaluated a simple kinetic model to determine a probable range of plasma parameters for altitudes between 100 and 200 km using existing Martian atmospheric data and all recorded probe trajectories.
D1.00004 A Blackbody Microwave Source for CMB Polarimeter Development. ALEC LINDMAN, Rhodes College — I present an evolved design for a thermally isolated blackbody source operating at 90GHz and 120GHz, frequencies of interest to Cosmic Microwave Background measurements. The NASA GSFC Experimental Cosmology lab is developing transition edge sensor bolometers for the CLASS and PIPER missions to measure CMB polarization; the source described here is for use in an existing 150mK test package to quantify the detectors’ properties. The design is optimized to minimize heat loading into the ADR and cryocoolers by employing a Kevlar kinematic suspension and additional thermal breaks. The blackbody light is coupled to a detector by means of an electroformed waveguide, which is mated to the source by an ultraprecise ring-centered flange design; this precision is critical to maintain the vacuum gap between the heated source and the cold waveguide, which is an order of magnitude smaller than the allowable misalignment of the standard military-spec microwave flange design. The source will provide at least 50% better thermal isolation than the existing 40GHz source, as well as a smaller thermal time constant to enable faster measurement cycles.

D1.00005 Exploring the z-dependence of the two-point angular correlation function in galaxy clustering. AYLISSA ENDRES, MATTHEW BELLIS, Siena College, DEBBIE BARD, Stanford University — The two-point angular correlation function (2ACF) is used to quantify the scales of clustering of galaxies. The 2ACF changes as we look further back in time (higher redshift z) and the clustering evolves. We calculate the exact Landy-Szalay estimator for the 2ACF using GPUs (Graphics Processing Units) and employ novel visualizations to observe the evolution of this function with increasing redshift. We use data from the MICE Grand Challenge dataset, a 70-billion particle n-body simulation that is publicly available, and compare to data from the Sloan Digital Sky Survey. The current status of this project will be presented.

D1.00006 Dark Matter Production with Boosted W/Z Bosons at Large Hadron Collider -LHC. RENE NSANZINEZA, Hendrix College — Nature of dark matter is one of the most important questions for the universe. Until today, no one knows what kind of particles form the dark matter despite several evidences of its presence in the universe. This research describes how dark matter can be pair produced in the Large Hadron Collider (LHC). Methods and procedures used to distinguish dark matter and ordinary matter are explained. An analysis of Monte Carlo simulation has been studied for dark matter mass of 100 GeV/c^2. The future work for this ongoing project will be based on testing data from the Compact Muon Solenoid at LHC using the results of the Monte Carlo simulation.

D1.00007 Long Baseline Neutrino Experiment simulation studies on Offset of Detector and Proton Beam. AMIT BASHYAL, JAEOHON YU, SEONGTAE PARK, BLAKE WATSON, Univ of Texas, Arlington, FERMI NATIONAL LAB COLLABORATION — The Long Baseline Neutrino Experiment (LBNE), hosted by Fermilab is a world class physics program aiming to probe our understanding on neutrino physics and look for physics beyond Standard Model. While LBNE is still under development, the LBNE beam simulation group performs the simulation using the G4LBNF simulation software and packaged geometry. The simulation studies are done by shifting and offsetting several parameters (which represent the physical components of the real experiment). The results obtained were analyzed graphically and statistically. In this talk, I will explain the effect of beam offset and detector shifting on parameters like pion production in the decay pipe, intensity of neutrino flux, variation on the number of neutrinos in specific energy ranges. Simulation experiment results will help to simplify the complex nature of neutrinos itself to a small extent and the collective work from the beam simulation group can provide a raw guideline for the experiment itself in the long run.

D1.00008 Infrasonic Influence of Volcanos. ASHLEY HOSMAN, Hendrix College — My presentation will consist of a poster on the use of ring laser interferometers to detect infrasound. The research was performed during the summer of 2013 and it focused on the finding infrasound emissions created by volcanic activity. I will explain how a ring laser works and discuss how I analyze the collected data using Fast Fourier Transforms. Due to the extreme distances over which infrasound can travel, I will also stress the need to compare the detected responses to specific volcanic eruptions. Finally, I will purpose practical applications of my research. One of the more promising applications is to use ring lasers to detect volcanic activity in remote areas such as parts of the Aleutian Islands. There is considerable air traffic over the Aleutian Islands. Volcanic plumes are a significant aviation hazard and can damage jet engines to the extent that they will no longer operate.

D1.00009 Effect of Alignment on smectic A to nematic phase transition of the aligned octylcyanobiphenyl nano-liquid crystal. DIPTI SHARMA, Wentworth Institute of Technology, Boston, MA — Liquid Crystals (LCs) exhibit a wide range of mesomorphic phases for long range of applications either in the bulk form or as compounds and mixtures. In the smectic LC devices, more attention has been paying to get smectic phase transition earlier with higher quality reachers are showing their interest in the laser beam steering and the optical shutter applications to know how fast the smectic phase transition can be reached. Our interest is to understand the smectic A to nematic (SmA-N) phase transition behavior in the regard of its faster response. This study shows the effect of alignment on the activated kinetics of the SmA-N phase transition of the bulk octylcyanobiphenyl (8CB) of magnetic field. A detailed thermal analysis were performed for the aligned 8CB and found a significant temperature shift in the transition peak towards higher temperature as ramp rate increases following Arrhenius behavior. This behavior gives the information of the energy dynamics of the molecular motion and rearrangement of 8CB molecules near the SmA-N transition. The presence of alignment brings faster response time, an increased energy dynamics with higher activation.

D1.00010 Models of accretion disk variability produced by flares. MICHAEL MCLOUTHIN. None — Accretion disks are central to many astrophysical phenomena including binary x-ray systems and active galactic nuclei. We employed Mathematica to generate artificial light curves for accretion disks. The basic parameters are accretion rate, central object mass and viewing angle. The model includes relativistic boosting from differential disk rotation. Variability in the flux expected to be generated by turbulence in the disk. We phenomenologically model this by randomly distributing artificial ‘flares’ on the disk with intensities proportional to the local thermal flux and parameters describing the fraction of the disk surface covered by flares and their lifetimes. This technique reproduces the results of Mangalam & Wiita (1993) but extends their results by introducing temporal decays to the intensity of the artificial flares. The light curves generated by the simulation are used to produce power spectral densities (PSDs) that are then compared with PSDs taken from observations of real accretion disks. Good agreement is found for reasonable parameters.

1 Advised by Dr. Paul Wiita

2 Fermi National Accelerator Laboratory

3Special thanks to Dr. David Chuss at GSFC, and the Society of Physics Students
D1.00011 Total Energy Due to Pair Production by Neutrinos in Type II Supernovae\textsuperscript{1} \textsuperscript{,} ANNA REINE, TODD TINSLEY, Hendrix College — While neutrinos carry the vast majority of energy in type II supernova explosions, some neutrino interactions only permitted because of the presence of strong magnetic fields are not typically considered in models of supernova collapse and explosion. Our research explored the impact of one such interaction on spherical symmetrical models, which, unlike the more complex magnetohydrodynamic models, do not account for enough energy to explain the explosion. We created a model to determine the order of magnitude of the maximum total energy produced by neutrino emission of positron-electron pairs $\nu \rightarrow e^+ e^-$, based on previous research on the production rate of this interaction in supernovae of varying magnetic field strengths. We demonstrate that the amount of energy retained in the supernova by this interaction alone is not sufficient to account for the energy needed to reheat the shockwave in spherically symmetrical models.

\textsuperscript{1}This work is generously supported by NASA/Arkansas Space Grant Consortium and the Hendrix Odyssey Program.

D1.00012 Flavor oscillation Length for Neutrinos in Magnetized Matter\textsuperscript{1} \textsuperscript{,} XUANHUA WANG, TODD TINSLEY, Hendrix College — A magnetic field has no effect on neutrinos since they are neutral particles with no known magnetic moment; however, the presence of a magnetic field will affect the electron field which may influence the neutrino interaction with electrons. We considered only the forward scattering of neutrinos off free electrons through the charged current interaction, which accounts for matter-enhanced flavor oscillation. We found that the interaction Hamiltonian is not altered by the presence of a magnetic field except when the neutrino scatters off an electron in the lowest Landau level. In this case the Hamiltonian depends only on the angle between the neutrino’s momentum and the direction of the magnetic field. Therefore, the strength of the magnetic field influences the result only through the Landau level distribution of electrons. This result might be considered when studying neutrinos around cosmological objects like supernovae or neutron stars, where the magnetic field is extremely strong and the change in neutrino oscillation length is not negligible. I will present the calculation of Hamiltonian of the above interaction in magnetized matter and the change of oscillation length in this case.

\textsuperscript{1}This work is supported by Hendrix Odyssey program.

D1.00013 Electromagnetic Radiative Corrections in e/p Scattering for $Q_{\text{weak}}$’s Measurement of a Parity-Violating Asymmetry in Elastic e/p Scattering \textsuperscript{,} TYLER WEBB, DAMON SPAYDE, None, QWEEK COLLABORATION — I will present on electromagnetic radiative corrections applied to a measurement of the parity-violating asymmetry in e/p scattering. This measurement is part of the Qweak collaboration’s effort to extract the weak mixing angle with high precision. The calculation of the angle from the measured quantity assumes a tree-level process, although the actual scattering does not occur at tree level. As the electron propagates, its possible momentum transfer is lessened due to bremsstrahlung and ionization, thereby reducing the measured asymmetry. I will demonstrate how I used simulation to calculate a more correct asymmetry value which, when compared with a simulated tree-level asymmetry, can be used to correct Qweak’s data.

D1.00014 CASSY Robot \textsuperscript{,} ANNA PITTMAN, ANN WRIGHT\textsuperscript{1}, AARON RICE, CLAUDE SHYAKA, Hendrix College — The CASSY Robot project involved two square robots coded in RobotC. The goal was to code a robot to do a certain set of tasks autonomously. To begin with, our task was to code the robot so that it would roam a certain area, marked off by black tape. When the robot hit the black tape, it knew to back up and turn around. It was able to do this thanks to the light sensor that was attached to the bottom of the robot. Also, whenever the robot hit an obstacle, it knew to stop, back up, and turn around. This was primarily to prevent the robot from hurting itself if it hit an obstacle. This was accomplished by using touch sensors set up as bumpers. Once that was accomplished, we attached sonar sensors and created code so that one robot was able to find and track the other robot in a sort of intruder/police scenario. The overall goal of this project was to code the robot so that we can test it against a robot coded exactly the same, but using Layered Mode Selection Logic.

\textsuperscript{1}Professor

D1.00015 Acceptance Studies for 4He(e,e'p)X Reaction up to High Missing Energies and Momenta \textsuperscript{,} DREW FINTON, FATHIA BENMOHTAR, None — Data collected from the Helium-4 target in Hall A at Thomas Jefferson National Accelerator Facility (TJNAF) in Newport News, Virginia, was analyzed using the object-oriented data analysis software ROOT and used to create Missing Energy Spectra for Missing Momenta ranging from 150 MeV/c to 755 MeV/c for 4He(e,e'p)X reaction channels. Jefferson Lab is a continuous electron beam accelerator facility, and Hall A contains two high resolution spectrometers as well as the cryogenic Helium-4 target. Acceptance cuts were made to six measured variables to remove background noise, and then applied to produce a Missing Energy Spectrum showing two- and three-body break up channels as well as pion electro-production energy threshold. The analysis of these missing energy spectra will be used to understand the contributions of one-, two-, and three-body interactions.

D1.00016 The White Noise Generator programed on the Raspberry Pi\textsuperscript{1} \textsuperscript{,} KEN MCGILL, KATIE HAM, KRIS SCHOCK, PATRICK DOWLING, CHAZ KUZELL, Georgia College and State University — A Raspberry Pi computer, running a Linux based operating system, was programmed for use as a white noise generator. The program was written to output sine waves at a specific frequency with a randomly generated phase. This function generator was programmed specifically for an ongoing undergraduate research project. This research project involves the calculation of the speed of flow through a cylindrical pipe with 128 transducers equally spaced by 0.4 inches down the length of the pipe. The inputted white noise generated serves as an effective technique to induce multiple sine waves of a given frequency to the pipe, as the sine waves are generated at a random phase.

\textsuperscript{1}Our research group would like to thank Dr. Ken McGill for all of his help, guidance, and time with this research project. We would also like to thank Georgia College and State University for providing the materials used in this experiment.

D1.00017 Determining Fault Orientation with Sagnac Interferometers\textsuperscript{1} \textsuperscript{,} KONSTANTIN GRUENWALD, ROBERT DUNN, Hendrix College — Typically, earthquake fault ruptures emit seismic waves in directions dependent on the fault’s orientation. Specifically, as the fault slips to release strain, compressional P-waves propagate parallel and perpendicular to the fault plane, and transverse S-waves propagate at 45 degree angles to the fault—a result of the double-couple model of fault slippage. Sagnac Interferometers (ring-lasers) have been used to study wave components of several natural phenomena. We used the initial responses of a ring-laser from transverse S-waves to determine the orientation of the nearby Guy/Greenbrier fault, the source of an earthquake swarm in 2010-11 purportedly caused by hydraulic fracturing. This orientation was compared to the structure of the fault extracted by nearby seismogram responses. Our goal was to determine if ring-lasers could reinforce or add to the models of fault orientation constructed from seismographs. The results indicate that the ring-laser’s responses can aid in constructing fault orientation in a manner similar to traditional seismographs.

\textsuperscript{1}Funded by the Arkansas Space Grant Consortium and the National Science Foundation
D1.00018 Resolving the band structure of topological insulators and point-contact spectroscopy analysis, PAVEL SHIBAYEV, Princeton Univ, HASAN GROUP TEAM1 — This study concerns a comprehensive quantitative analysis of topological insulators (TIs) [1], a new quantum state of matter, namely Bi$_2$Se$_3$. The first stage is observing the proximity-induced superconductivity effect [2] via point-contact spectroscopy (PCS). Differential conductance of the superconducting NbSe$_2$ crystal was measured at approximately 4 K, cooled with liquid helium. Through the analysis of I-V characteristics, it was possible to observe an expected behavior of differential conductance for voltages higher than 1 mV, and the ongoing work is to observe this effect at lower voltage. Subsequently, this method will be used to induce superconductivity in Bi$_2$Se$_3$ by combining it with NbSe$_2$. The second stage is a first-principles calculation of band structure of the TI crystal based on the density functional theory, DFT, performed on Bi$_2$Se$_3$, using the ABINIT program [3]. The third stage is resolving the band structure of the crystal via angle-resolved photoemission spectroscopy (ARPES) at a synchrotron facility and comparing with the above calculation. It is expected to be completed in February 2014.


1Group led by Professor Zahid Hasan

D1.00019 Infrasonic Influences of Tornados and Cyclonic Weather Systems, TESSA COOK, Hendrix College—Infrasound waves travel through the air at approximately 340 m/s at sea level, while experiencing low levels of friction, allowing the waves to travel over larger distances. When seismic waves travel through unconsolidated soil, the waves slow down to approximately 340 m/s. Because the speeds of waves in the air and ground are similar, a more effective transfer of energy from the atmosphere to the ground can occur. Large ring lasers can be utilized for detecting sources of infrasound traveling through the ground by measuring anomalies in the frequency difference between their two counter-rotating beams. Sources of infrasound include tornados and other cyclonic weather systems. The way systems create waves that transfer to the ground is unknown and will be continued in further research; this research has focused on attempting to isolate the time that the ring laser detected anomalies in order to investigate if these anomalies may be contributed to isolatable weather systems. Furthermore, this research analyzed the frequencies detected in each of the anomalies and compared the frequencies with various characteristics of each weather system, such as tornado width, wind speeds, and system development. This research may be beneficial for monitoring gravity waves and weather systems.

D1.00020 Determining what caused the error in the prediction of the December 1st, 2013 snow storm using the Weather Research and Forecasting Model, NIKUNJ KUMAR PRAJAPATI1, JOSEPH TROUT, None — The severity of snow events in the northeast United States depends on the position of the pressure systems and the fronts. Although numerical models have improved greatly as computer power has increased, occasionally the forecasts of the pressure systems and fronts can have large margins of error. For example, the snow storm which passed over the north east coast on the week of December 1, 2013, proved to be much more severe than predicted. In this research, The Weather Research and Forecasting Model(WRF-Model) is used to model the December 1, 2013 storm. Multiple simulations using nested, high resolution grids are compared.

1Research in computational atmospheric physics

D1.00021 Multi-Anode-PMT Analysis for new RICH detector at JLab’s CLAS12 spectrometer, ANDREW WITCHGER, FATIHA BENMOHKHTAR, None — Thomas Jefferson National Accelerator Facility (JLab) is performing a large-scale upgrade to the Continuous Electron Beam Accelerator Facility (CEBAF) to reach energies of 12 GeV. CEBAF Large Acceptance Spectrometer (CLAS12) in Hall B is undergoing a large-scale upgrade to the Continuous Electron Beam Accelerator Facility (CEBAF) to reach energies of 12 GeV. CEBAF Large Acceptance Spectrometer (CLAS12) in Hall B is undergoing major upgrade too to run to collect data at these high energies. A new Ring Imaging Cherenkov (RICH) detector is being developed to provide better kaon – pion separation for CLAS12 in the 3 to 8 GeV/c range. With this addition, when the electron beam hits the target, the resulting pions, kaons, and other particles will pass through a wall of translucent aerogel tiles and create Cherenkov radiation. This light can then be accurately detected by a large array of Multi-Anode Photo-Multiplier Tubes (MA-PMT). The supporting hardware and software systems for MA-PMTs were developed by the collaboration. I am presenting my work on the testing and analysis of these systems and results that will amplify the physical capabilities of the spectrometer.

D1.00022 Undergraduate Student Involvement in International Research – The IRES Program at MAX-lab, Sweden1, WILLIAM BRISCOE, The George Washington University, GRANT O’RIELLY, University of Massachusetts Dartmouth, KEVIN FISSUM, Lund University — Undergraduate students associated with The George Washington University and UMass Dartmouth have had the opportunity to participate in nuclear physics research as a part of the PIONS@MAXLAB Collaboration performing experiments at MAX-lab at Lund University in Sweden. This project has supported thirteen undergraduate students during 2009 – 2011. The student researchers are involved with all aspects of the experiments performed at the laboratory, from set-up to analysis and presentation at national conferences. These experiments investigate the dynamics responsible for the internal structure of the nucleon through the study of pion photoproduction off the nucleon and high-energy Compton scattering. Along with the US and Swedish project leaders, members of the collaboration (from four different countries) have contributed to the training and mentoring of these students. This program provides students with international research experiences that prepare them to operate successfully in a global environment and encourages them to stay in areas of science, technology, engineering, and math (STEM) that are crucial for our modern, technology-dependent society. We will present the history, goals and outcomes in both physics results and student success that have come from this program.

1This work supported by NSF OUSE/IRES award 0553467.

D1.00023 Rubidium Spectroscopy with an External Cavity Diode Laser1, CHARITY BURGESS, R. SETH SMITH, Francis Marion University — A homebuilt external cavity diode laser (ECDL) was used to provide a very narrow range of laser wavelengths near 780 nm in order to study the structure of rubidium (Rb). The absorption spectrum of Rb was measured. This spectrum was subject to Doppler-broadening of the spectral line. A technique known as Saturated Absorption Spectroscopy was employed to eliminate the effects of Doppler-broadening and to obtain a high resolution spectrum for Rubidium. The setup, operation, and performance of this system will be described.

1Research made possible by a REAL grant from Francis Marion University.
D1.00024 UV and Heating Effects on CR-39 Etch Parameters with Spectral Analysis of CR-39 in the UV-Vis-NIR. CHRISTOPHER MCLAUGHLIN, KENNETH DODGE, JAMES MCLEAN, STEPHEN PADALINO, State University of New York at Geneseo, MICHELLE BURKE, CRAIG SANGSTER, Laboratory of Laser Energetics at the University of Rochester — CR-39 plastic is a common ion detector used in nuclear experiments. High-energy charged particles leave tracks of chemical damage along their path, which form pits when etched with NaOH. It has been found that exposure to UV light after ion exposure enhances the etch rate in both the bulk material as well as along the latent track while maintaining a constant track-to-bulk etch rate ratio. The addition of heat was found to dramatically increase the etch rates by a factor of five, although at higher temperatures pits became irregular in shape. The spectral reflection and transmission of CR-39 for wavelengths between 200nm and 2500nm for various thicknesses of plastic were measured. Using an exponential decay model for absorption the decay depth was calculated from the gathered data. CR-39 was found to be nearly transparent for light between 400nm to 1100nm while strong absorption was present for UV light shorter than 400nm. The reflection of CR-39 was found to be relatively constant averaging at 7%. An anomalous dispersion feature was found centered at 290nm.

D1.00025 ABSTRACT WITHDRAWN —

D1.00026 Data Quality Control and Maintenance for the Qweak Experiment. NICHOLAS HEINER, DAMON SPAYDE, Hendrix College, QWEAK COLLABORATION — The Qweak collaboration seeks to quantify the weak charge of a proton through the analysis of the parity-violating electron asymmetry in elastic electron-proton scattering. The asymmetry is calculated by measuring how many electrons deflect from a hydrogen target at the chosen scattering angle for aligned and anti-aligned electron spins, then evaluating the difference between the numbers of deflections that occurred for both polarization states. The weak charge can then be extracted from this data. Knowing the weak charge will allow us to calculate the weak-electrowave mixing angle for the particular $Q^2$ value of the chosen electrons, which the Standard Model makes a firm prediction for. Any significant deviation from this prediction would be a prime indicator of the existence of physics beyond what the Standard Model describes. After the experiment was conducted at Jefferson Lab, collected data was stored within a MySQL database for further analysis. I will present an overview of the database and its functions as well as a demonstration of the quality checks and maintenance performed on the data itself. These checks include an analysis of errors occurring throughout the experiment, specifically data acquisition errors within the main detector array, and an analysis of data cuts.

D1.00027 Observations of Jupiter and the Sun using Radio JOVE at Francis Marion University, RYAN BROWN, JEANETTE MYERS, Francis Marion University — The Radio JOVE project sponsored by NASA allows for a hands-on learning experience with Radio Astronomy. Results will be presented of data collected for the Sun and Jupiter using a dual-dipole antenna and a Radio JOVE receiver at the Observatory of Francis Marion University in Florence, SC. Verification of data collected by comparison with other radio antenna will be provided.

D1.00028 Numerical Model Simulation of Atmosphere above A.C. Airport. TIFFANY LUTES, JOSEPH TROUT, Richard Stockton College of New Jersey — In this research project, the Weather Research & Forecasting (WRF) model from the National Center for Atmospheric Research (NCAR) is used to investigate past and present weather conditions. The Atlantic City Airport area in southern New Jersey is the area of interest. Long-term hourly data is analyzed and model simulations are created. By inputting high resolution surface data, a more accurate picture of the effects of different weather conditions will be portrayed. Currently, the impact of gridded model runs is being tested, and the impact of surface characteristics is being investigated.

D1.00029 Bucking Coil Efficiency Correction for 5” PMT Exposed to an External Magnetic Field1, ANTHONY LLODRA, JOERG REINHOLD, Florida Intl Univ — This research was conducted in support of the Hall C upgrade activities at Thomas Jefferson National Accelerator Facility (JLab). We propose to employ bucking coils in order to maximize the collection efficiency of the 5” PMTs installed on the Cherenkov detector, which could potentially be exposed to external magnetic field produced by the Super Conducting Super High Momentum Spectrometer (SHMS) magnet. In this research project a 5” PMT was placed in a light tight cylinder with a fiber optic cable. The cylinder was centered within a set of Helmholtz coils to produce a constant external magnetic field. Furthermore, the cylinder was wrapped with 20 coils of standard 12 gauge cable to act as the bucking coil. With the intensity of the LED source, and the magnitude of the external magnetic field fixed at a carefully determined value, data was taken to determine if the collection efficiency of the PMT was indeed affected. With a decrease in collection efficiency confirmed, further data were taken. A range of current (0-6 A) was applied to the bucking coils, while ADC spectra were analyzed in intervals of 0.25 A. The data indicated that in an external magnetic field of approximately 3 Gauss, the 5” PMT collection efficiency is maximized with the bucking coil current set to approximately 3.5 A. Thus, the data conclusively indicates that the bucking coil system will indeed maximize the collection efficiency of the 5” PMT.

1Florida International University

D1.00030 Unfolding the Boosted Top Quark Differential Cross Section1, DANIELLE BERISH, MATTHEW BELLIS, Siena College, CMS COLLABORATION — The high energy of the Large Hadron Collider at CERN makes possible the measurement of differential cross sections of the production of the top quark at higher momentum than previous studies. This provides a probe for tests of new physics. We used data from the CMS detector from the 2012, 8 TeV run. In these studies it is important to properly correct for efficiency and bias by using an unfolding process. We present a test of the robustness of the RooUnfold package, both the procedure in general and more specifically as it applies to the top quark measurement. The current status of the differential cross section measurement will be presented.

1This work was supported in part by NSF grant PHY-1307562

D1.00031 Search for Dark Matter at CMS using Razor Kinematic Variables, NATALIE HARRISON, University of Chicago, MARIA SPIROPULU, JAVIER DUARTE, CRISTIAN PENA, California Institute of Technology — A search for dark matter (DM) production at the Large Hadron Collider (LHC) is performed using razor kinematic variables. The analysis uses 19.5 fb$^{-1}$ of data recorded by the CMS experiment from proton-proton collisions at a center of mass energy of sqrt(s) = 8 TeV. The results are interpreted using an effective field theory framework where the mediator between the DM and standard model (SM) sectors is very heavy compared to the energy reach of the LHC. Limits on the cutoff scale, $\Lambda$, are set as a function of the DM candidate which under some assumptions can be converted into DM-nucleon cross sections limits and compared to direct and indirect detection experiments.
D1.00032 Charged Fusion Product Detector Study
CARLOS LOPEZ, None. FLORIDA INTERNATIONAL UNIVERSITY DEPARTMENT OF PHYSICS COLLABORATION, PRINCETON PLASMA PHYSICS LABORATORY COLLABORATION, CULHAM CENTRE FOR FUSION ENERGY COLLABORATION — Plasmas are hot ionized gases which may be manipulated by electromagnetic fields in machines called tokamaks, which are experimental reactors created to harness energy when fusion occurs in said plasma. In order to study instabilities within the tokamak plasma, the trajectories of protons were studied with an array of silicon surface barrier detectors. The collection efficiency of the detectors was analyzed in order to make more accurate calculations, where particular attention was paid to the solid angle of acceptance, or the angular distribution through which particles would enter into the detector. Monte Carlo simulations were coded and implemented in the Python language, where a point on the grid acted as a source which one million data points shot at the plane of the detector. The ratio of the hits versus the misses was calculated for varying positions of the source relative to the plane of the detector. These results were compared to an alpha particle spectroscopy experiment, where a radiation source emitting alpha particles was placed at varying positions relative to the detector. The counting rate of the detector was then observed when it was exposed to the source, and this along with the Monte Carlo results were implemented into an efficiency calculation.

D1.00033 Derivation of the Biot-Savart law from Coulomb’s law and implications for gravity
DANIEL ZILE, JAMES OVERDUIJN, Towson University — We explore links between classical electromagnetism and general relativity in the low-velocity, weak-field limit. We show that it is possible to derive the Biot-Savart law from magnetism from Coulomb’s law for electrostatics by moving to a boosted frame and applying the force transformation law from special relativity. We then apply the same transformation to Newton’s law of gravitation, obtaining a gravitational analog of the magnetic field with units of spin. This field turns out to be two-thirds of the geodetic precession predicted by general relativity theory, a prediction that has recently been verified experimentally by the Gravity Probe B satellite.

D1.00034 Characterization of a Spontaneous Parametric Downconversion Source for Use in Single Photon Tests of Quantum Mechanics
PRESTON ALEXANDER, JACKSON MCDONLD, JASON HARRINGTON, R. SETH SMITH, Francis Marion University — During the past year, a quantum optics laboratory was constructed and tested at Francis Marion University. A spontaneous parametric downconversion source was used to create pairs of correlated photons for use in single photon tests of quantum mechanics. Photons from a spontaneous parametric downconversion source were detected with single photon counting modules that were purchased through the Advanced Laboratory Physics Association (ALPHA). The effect of pump polarization on the output intensity was studied. Coincidences between pairs of correlated photons were counted and plotted as a function of the angle between the single photon detectors, in order to perform a test of Conservation of Momentum. The laboratory will be used to perform single photon tests of quantum mechanics, including the Grangier experiment, single photon interference, quantum state measurement, and tests of local realism.

D1.00035 Optimization of the search for three jet resonances in proton-proton collisions at √s = 8 TeV
JULIA GONSKI, EVA HALKIADAKIS, CLAUDIA SEITZ, Rutgers Univ, CMS COLLABORATION1 — An analysis of the search for stealth supersymmetry (SUSY) in three b jet decay and minimal missing E_T signatures is presented. Data from proton-proton collisions produced at the LHC and collected with the CMS detector during the 2012 run is used, corresponding to an integrated luminosity of 19.4 fb^{-1}. Though the search is model independent, optimization is performed assuming sbottom pair production decaying to three b jets and missing E_T with an intermediary stealth particle. Given the high multiplicity of b jets in the final state, examining signal significance for different numbers of b tags per event can yield a more efficient selection. Preliminary results are shown assuming this stealth SUSY scenario.

D1.00036 Virial Coefficients for the Liquid Argon
MICHEAL KORTH, SAESUN KIM, Univ of Minn - Morris, UMP TEAM — We begin with a geometric model of hard colliding spheres and calculate probability densities in an iterative sequence of calculations that lead to the pair correlation function. The model is based on a kinetic theory approach developed by Shinomoto [Phys. Lett. A, 89, 19 (1982)], to which we added an interatomic potential for argon based on the model from Aziz [J. Chem. Phys. 99, 4518 (1993)]. From values of the pair correlation function at various values of density, we were able to find virial coefficients of liquid argon. The low order coefficients are in good agreement with theoretical hard sphere coefficients [Condens. Matter Phys. 15(2), 23004.1 (2012)], but appropriate data for argon to which these results might be compared is difficult to find.

D1.00037 Computational Study of Low Energy Nuclear Scattering from Metal Nuclei
DANELLE JARAMILLO, AJIT HIRA, JÓSE PACHECO, JUSTIN SALAZAR, Northern New Mexico College — We continue our interest in the interactions between different nuclear species with a computational study of the scattering of the low-energy nuclei of H through F atoms (Z ≤ 9) from Palladium, Nickel and other metals. First, a FORTRAN computer program was developed to compute stopping cross sections and scattering angles in Pd and other metals for the small nuclear projectiles, using Monte Carlo calculation. This code allows for different angles of incidence. Next, simulations were done in the energy interval from 10 to 140 keV. The computational results thus obtained are compared with relevant experimental data. The data are further analyzed to identify periodic trends in terms of the atomic number of the projectile. Such studies have potential applications in nuclear physics and in nuclear medicine.

D1.00038 Hardy’s test for local realism
QUYNH NGUYEN, AURELIO DREGLI, University of Minnesota — We demonstrated the violation of Bell inequality using entangled photons produced by spontaneous parametric down-conversion. The experiment is based on a local realism test originally proposed by Lucien Hardy. Polarized entangled photons is produced in down-conversion through a pair of beta barium borate crystals. Polarization is adjusted by half wave plates and quartz plates. Single photons travel down two separate paths, each pass through a half-wave plate and a broad band polarizing beam splitter. Light from the beam splitter is collected by lens and focused into optic fibers that direct light into a single photon counting module. Coincidence counting is done using time-to-amplitude converter/single-channel-analyzer units. The probabilities in Bell-Clauser-Horne inequality is calculated by the ratio of the measured coincidence counts on the transmitted laser beams to the total number of coincidence. The counting is done by a LabVIEW program. We find the data to violate local realism by 30 standard deviation. The experiment is based on straightforward quantum mechanical calculations and experimental techniques more accessible to undergraduate students than other methods of testing Bell inequalities.

D1.00039 HISTORY OF PHYSICS —
D1.00040 Why Do We Believe the Speed of Light is an Invariant of Nature?  , FELIX T. SMITH, retired — We believe it, obviously, because we believe in relativity, and Einstein based his treatment of relativity on what he named “The Principle of Constancy of the Velocity of Light.” From Einstein’s own writings between 1905 and about 1912 we know that in defining what this meant he was concerned especially about two issues: One was to deny the notion that the transmission of light required a privileged “ether” frame; the other was that the velocity of a light signal measured by an observer is independent of the velocity of the source that emitted the signal with respect to the observer. In relativity Einstein’s two Principles made a handy brief basis from which he could deduce the requirement of covariance under the transformations of the Lorentz group. These transformations had been developed earlier by Lorentz to conform with the results of experiments, without requiring constancy of c. The Lorentz group only requires that c be an upper bound greater than all observed particle or signal velocities. The assumption of its invariance over cosmological time seems justified mostly by its convenience as a teaching and mnemonic oversimplification.

D1.00041 NATIONAL FACILITIES –

D1.00042 Evaluating the Field Emission Characteristics of Aluminum for DC High Voltage Photo-Electron Guns1 . RHYS TAUS, Loyola Marymount Univ, MATTHEW POELKER, ERIC FORMAN, ABDULLAH MAMUN, Thomas Jefferson National Accelerator Facility — High current photoguns require high power laser light, but only a small portion of the laser light illuminating the photocathode produces electron beam. Most of the laser light (∼ 65%) simply serves to heat the photocathode, which leads to evaporation of the chemicals required to create the negative electron affinity condition necessary for photoemission. Photocathode cooling techniques have been employed to address this problem, but active cooling of the photocathode is complicated because the cooling apparatus must float at high voltage. This work evaluates the field emission characteristics of cathode electrodes manufactured from materials with high thermal conductivity: aluminum and copper. These electrodes could serve as effective heat sinks, to passively cool the photocathode that resides within such a structure. However, literature suggests “soft” materials like aluminum and copper are ill suited for photogun applications, due to excessive field emission when biased at high voltage. This work provides an evaluation of aluminum and copper electrodes inside a high voltage field emission test stand, before and after coating with titanium nitride (TiN), a coating that enhances surface hardness.

D1.00043 PUBLIC POLICY –

D1.00044 Fairy-Tale Physics Farewell to Reality Bankrupting Physics: Baggott-Unzicker-Jones Critiques Shame Physics’ Shameless Media-Hype P.R. Spin-Doctoring Touting Sci-Fi Veracity-Abandonment “Show-Biz” Spectacle: Caveat Emptor!!! , EDWARD SIEGEL, Retired — Baggott[Farewell to Reality: How Fairy-Tale Physics Betrayed Search For Scientific Truth]-Unzicker[Bankrupting Physics: How Top Scientists Are Gambling Away Credibility] shame physics shameless rock-star media-hype P.R. spin-doctoring veracity-abandoning touting sci-fi show-biz aided by online proliferation of uncritical pop-sci science-writers verbal diarrhea, all spectacle vs little truth, lacking Kant-Popper skepticism falsification, lemming-like stampedes to truth abandonment, qualified by vague adverbs: might, could, should, may... vs factual is! Physics, motivated by financial greed, swept up in its very own hype, touts whatever next for profit survival ego! Physics, motivated by financial greed, swept up in its very own hype, touts whatever next for profit survival ego! Witness: GIGO claims string-theory holographic-universe causes cuprates optical conductivity; failed Anderson RVB cuprates theory vs. Keimer discovery all cuprates “paramagnons” bosons aka Overhauser SDWs; Overbye NYT holographic-universe jargonial-obfuscation comments including one from APS journals editor-in-chief re. “its unintelligibility, FOF but signifying absolutely nothing INTELLIGIBLE!”, Bak/BNL SOC tad late rediscovery of F=ma mere renaming of Siegel acoustic-emission!; 2007 physics Nobel-prize Fort-Gruenberg rediscovery of Siegel[JMMM 7,312(78); https://www.flickr.com/search/?q=GIANT MAGNETORESISTANCE] GMR. Each trendy latest big thing modulo lack of prior attribution aka out and out bombastic chicanery! Siegel caveat emptor “Buzzwordism, Bandwagonism, Sloganeering for Fun Profit Survival Ego” sociological-dysfunctionality Thrives!

D1.00045 EDUCATION –

D1.00046 Do we need to improve teaching style in physics to get more students in physics? , SAMINA MASOOD, University of Houston Clear Lake — We give a qualitative analysis based on the interaction with students from different communities that how the social and cultural values can deeply affect the young population and their priorities in life. Also the educational strategies and teaching methods have to be changed according to the demographic situations and the needs of corresponding students. Most of the known facts in this regard are accepted as realities however, some further modifications are still required and some of them have to be taken back to fulfill the requirements of the individual subjects. We specially focus on physics students and describe about their requirements based on their background.

D1.00047 Development of a turn-key cloud chamber in collaboration with non-academic science enthusiasts , JESSICA MUIENKEL, MEGHAN HARRINGTON, MATTHEW BELLIS1, Siena College, ARIEL WALDMAN, NATHAN BERGEY, IVAN COOPER, JULIANE BOMBSCH, Science Hack Day, CMS COLLABORATION2, SCIENCE HACK DAY TEAM — Science Hack Day is an event that brings together scientists and science enthusiasts for 24 hours to “hack” a science project. These events serve two purposes. The first and most obvious is to provide a structured environment for science outreach. Academics and researchers have the opportunity for “boots-on-the-ground” interactions with the general public. The second purpose, though more challenging, is to enable science enthusiasts to donate their skills so that they are able to push back to educators and researchers in a fashion that benefits their work. We discuss our experiences at the 2013 San Francisco Science Hack Day at the California Academy of Sciences. We worked with attendees of the conference to create a cloud chamber that worked with Peltier thermocoolers, rather than dry ice. In this fashion, we educated attendees about radiation and particle physics, while also benefiting from the experience and knowledge of the attendees in constructing the device. This “turn-key” cloud chamber is now in use at Siena College as an outreach and educational device. The properties of this device and the story of its construction will be presented.

1 Representing CMS.

2 The Compact Muon Solenoid experiment.
D1.00048 Definition of the Neutrosophic Probability Measure, FLORENTIN SMARANDACHE, University of New Mexico — The neutrosophic probability measure is a mapping:

\[ NP : X \rightarrow [0, 1]^3 \]

where \( X \) is a neutrosophic sample space (i.e. \( X \) is a sample space that contains some indeterminacy),

\[ NP(A) = (ch(A), ch(\text{indeterm}_A), ch(\overline{A})) \]

where \( ch(A) \) is the chance that event \( A \) occurs, \( ch(\text{indeterm}_A) \) is the indeterminate chance related to occurrence of \( A \), and \( ch(\overline{A}) \) is the chance that \( A \) does not occur, such that:

\[ NP(X) = (\alpha, \beta, \gamma), \quad \text{where} \quad -1 \leq \alpha + \beta + \gamma \leq 3^+, \quad \text{and} \quad -1 \leq \alpha, \beta, \gamma \leq 1^+. \]

\[ NP(A \cup B) = (ch(A) + ch(B), ch(\text{indeterm}_{A\cup B}), ch(\overline{A \cup B})) \]

for \( A \cap B = \Phi \), and for infinite unions

\[ NP \left( \bigcup_{n \geq 0} A_n \right) = \left( \sum_{n \geq 0} ch(A_n), ch(\text{indeterm}) = 0.10, ch \left( \bigcup_{n \geq 0} A_n \right) \right) \]

for \( A_n \) disjoint two by two that lie in the neutrosophic sigma-algebra of events.

D1.00049 Preparing physics students for careers outside of academia1, KENDRA REDMOND, AIP / Society of Physics Students, ROMAN CZUJKO, American Institute of Physics, TONI SAUNCY, AIP / Society of Physics Students — Most undergraduate physics programs focus on preparing students for physics graduate school, but in reality around 40% of physics bachelor’s degree recipients go directly into the workforce. In response to calls for more STEM workers and a desire to see more students of all ambitions benefit from a physics education, the American Institute of Physics has been exploring how physics departments can better prepare their students to enter the STEM workforce after the bachelor’s degree, and how students can better prepare themselves to enter the STEM workforce. This poster will include results from this NSF-funded Career Pathways Project, including an overview of common features of departments that successfully prepare students to enter the workforce and a career toolbox we have created for physics students.

1Work supported by NSF award 1011829

D1.00050 Learning Physics by Experiment: I. Falling Objects, SAAMI J. SHAIBANI, Instruction Methods, Academics & Advanced Scholarship (IMAAS) — As a rule, students enjoy conducting experiments in which the practical aspects are straightforward and well-defined. This also applies even when there is no anticipated result for students to “prove.” A laboratory exercise with such properties was created for students to undertake in a completely blind manner, and they happily proceeded without any knowledge at all of what they might expect to find. The philosophy developed for the research in this paper expands the pioneering approach formulated some half century ago [1] and successfully employed more recently [2]. In the present era of differentiated instruction (DI) being implemented in a diversity of educational settings, the design of the subject experiment is especially significant for its inclusive nature and for the positive outcomes it produces for less academically capable students. All students benefit from such an environment because it preempts the wasted effort of undue manipulation and it removes the need to contrive agreement with a textbook via irregular attempts at reverse engineering.

[1] curricula devised by Nuffield Foundation;

D1.00051 Building a Low Cost Solar Oven: An Opportunity to Teach Thermodynamics1, ANA NOGUEIRA, None — We suggested building a solar oven using cardboard boxes, glass wool and metal plate as part of a school project permeated by the discussion of physical concepts. The main topics addressed are from the heat and thermodynamics areas, and for these themes we followed the standard books used in high school. We can work in a practical manner with the thermometer, along with the concept of temperature, measuring the temperature of the oven when cooking. To discuss how the oven works, we introduce the concept of heat as an energy flow of a body with a higher temperature to one with lower temperature. Threads as heat capacity and specific heat of a substance are introduced, also discussing the use of glass wool, which function is to prevent heat exchange from the oven’s interior with the environment. It is possible to demonstrate the three forms of heat transfer using the solar oven, and how the greenhouse effect is harnessed. One can discuss topics such as electromagnetic radiation, black-body radiation and the Stefan-Boltzmann law. We surveyed the discussion of physical concepts. The main topics addressed are from the heat and thermodynamics areas, and for these themes we followed the standard books

1UNIMONTES

D1.00052 POSTDEADLINE —

D1.00053 Reconstructing the vector-like top partner from fully hadronic events1, MARTIN STOLL, MOTOI ENDO, KOICHI HAMAGUCHI, KAZUYA ISHIKAWA, The University of Tokyo — Vector-like top partners are predicted by Little Higgs models, appear in loops in extensions to supersymmetric models or are part of effective BSM models. After mixing with third generation quarks, decay channels are \( t' \rightarrow th, t' \rightarrow tZ \) and \( t' \rightarrow bW^+ \). Vector-like tops have been subject to recent searches at the LHC where final-state leptons were used to suppress the large QCD backgrounds and exclusion bounds are \( m_{t'} > 700 - 800 \) GeV. We propose a new method to kinematically reconstruct vector-like tops from fully hadronic final states at the LHC Run II. We expect more signal events because the branching ratio \( t \rightarrow h \) is large. However efficient rejection of the overwhelmingly large backgrounds is crucial. Jet unclustering / substructure methods prove useful here and we employ them (HEPTopTagger and BDRTags Higgs tagger) to reconstruct boosted \( t \) and \( h \) from the heavy \( t' \) decay. We investigate different parameters for the mass and branching ratios of \( t' \). A good signal-to-background ratio is found and it is shown that kinematic reconstruction of the top partner and even a mass measurement are possible.

1This work was supported by the Program for Leading Graduate Schools, MEXT, Japan.
D1.00054 Fast Frequency-Domain Waveforms for Generic Spin Configurations, ANTOINE KLEIN, Univ of Mississippi, NICOLAS YUNES, NEIL CORNISH, Montana State University — We present a family of frequency-domain gravitational waveforms for precessing binaries valid for generic spin configurations and magnitudes. These waveforms are fast to generate and provide excellent agreement with time-domain waveforms computed via a discrete Fourier transform. They can be computed for any solution of the binary’s equations of motion, and provide a realistic solution for the search for generic precessing binaries in gravitational wave data analysis, due to their low computational cost.

D1.00055 Fueling the Brightest AGN: Characterizing Their Hot Gas Environments and the Accretion of Cooling Gas Onto Their SMBHs, MICHAEL CALZADILLA, Univ of South Florida, CHRISTINE JONES, FELIPE ANDRADE-SANTOS, Harvard-Smithsonian Center for Astrophysics, DAN EVANS, National Science Foundation, WILLIAM FORMAN, ANDY GOULDING, REINOUT VAN WEEREN, Harvard-Smithsonian Center for Astrophysics — Over their lifetimes, Active Galactic Nuclei (AGN) switch from a radiatively bright QSO phase to a radiatively dim phase, where most of their energy output is in the form of mechanical feedback (Churazov et al. 2005). For Supermassive Black Holes (SMBHs) in the cores of galaxy clusters, it is clear cooling cluster gas is sufficient to fuel the observed AGN outbursts. However, the question of fueling an AGN outburst in a poorer environment is not so clear. We present Chandra observations for five powerful radio sources selected from the 3CRR catalog and not in rich clusters, and compare their X-ray characteristics to their radio morphologies. We find that hot gaseous atmospheres surrounding these AGN are common, and that cooling flows are present in three of our sources. Our results indicate that the cooling gas surrounding the AGN and stellar mass loss are sufficient to fuel these AGN, and thus that galaxy mergers are not required to supply the accreting gas. In addition, our measured Eddington ratios for the SMBHs suggest that the source 3C47 is in transition from radiatively bright to radiatively dim, which can provide further insight into how AGN evolve.

D1.00056 Dwarf Galaxy Constraints on Self-Interacting Dark Matter, BENJAMIN WOODALL, CASEY WATSON, Millikin University — We examine the transition from the primordial, cuspy NFW halos of dwarf galaxies found in simulations to the observed density profiles of today’s Milky Way dwarf galaxies in the context of self-interacting dark matter (SIDM) models. Based on the requirement that the elastic scattering of the SIDM removes the cusp mass of each dwarf galaxy, we find \( \sigma / m < 0.06 \text{ cm}^2 / \text{g} \), even in the least restrictive case (Leo II). These constraints rule out the range of values favored to remove the cusps of larger galaxies in recent simulations: \( 0.21 \text{ cm}^2 / \text{g} < \sigma / m < 1 \text{ cm}^2 / \text{g} \).

D1.00057 Scaling Relationships between the Primordial NFW and Presently Observed Dark Matter Halos of Milky Way Dwarf Galaxies, BRIAN BARRY, CASEY WATSON, Millikin University — By comparing the primordial, cuspy NFW halos of dwarf galaxies found in simulations to the observed density profiles of several Milky Way dwarf galaxies, we are able to quantify the severity of the well-known core-cusp problem on a galaxy-by-galaxy basis. We establish scaling relationships between the cusp mass and the observed core radius and core density of the best-fit Burkert profiles for these dwarf galaxies, and show that dark matter annihilation cannot remove the excess cusp mass without violating current constraints on the dark matter annihilation cross section.

D1.00058 The Theoretical Basis for and Implications of Observed Scaling Relations between the Primordial NFW and Presently Observed Dark Matter Halos of Milky Way Dwarf Galaxies, JOSHUA MONROE, CASEY WATSON, Millikin University — We examine empirical scaling relationships between the cusp mass of Milky Way dwarf galaxies and the core radius and core density of their best-fit Burkert profiles. We explore the theoretical underpinnings of these relationships and discuss the insights they provide regarding the formation and evolution of dwarf galaxy dark matter halos.

D1.00059 A Simple Scaling Relationship for the Dark Matter Surface Density Enclosed within Symmetrical Detector Fields of View, JONATHON SPAW, CASEY WATSON, Millikin University — We show that the dark matter surface density enclosed within any field of view (FoV) that is symmetrically oriented about the center of a dark matter halo is linearly proportional to the angular extent of the FoV. We verify our result numerically, and discuss its implications for assessing the strength of the dark matter constraints that can be imposed by a given target galaxy.

D1.00060 The Universal NFW Dark Matter Halo of Simulated Dwarf Galaxies, SYED SALIK, CASEY WATSON, Millikin University — Analyzing the results of recent N-body simulations, we find that there is an approximately universal, initial, NFW dark matter halo for dwarf galaxies, with concentration parameters ranging from \( 8 < c < 15 \) and a corresponding virial mass of \( 2.5 \times 10^7 \, M_{\odot} \). Using additional relationships between the core and virial masses of simulated dark matter halos, we determine the scale radius and central density values of the universal density profile: \( r_s = 2.25 + 0.35 \, \text{kpc} \) and \( \rho_s = 1.4 + 0.35 \times 10^{-2} \, M_{\odot} \, \text{pc}^{-3} \).

Saturday, April 5, 2014 3:30PM - 5:18PM — Session E2 DAP DPF: Invited Session: Dark Matter - WIMPs — Chatham Ballroom A — Tracy Slatyer, Massachusetts Institute of Technology

3:30PM E2.00001 Direct Detection Searches for WIMPs, BLAS CABRERA, Stanford University — We have seen remarkable progress in direct detection searches for dark matter in the form of weakly interacting particles or WIMPs. Existing experiments using diverse technologies have set convincing limits for WIMPs under the spin independent interaction framework and have ruled out much of the phase space suggested by supersymmetric models. Liquid xenon experiments have provided the best limits for masses above 6 GeV/c^2, with cryogenic detectors and bubble chambers setting the best limits for lighter WIMPs. In tension with the liquid xenon experiments are hints of signals and a claimed detection in the light WIMP mass sector. A number of theoretical ideas are consistent with light mass WIMPs, and a general approach, which probes all possible interactions between WIMPs and nucleons, stresses the need for a variety of target nuclei with the lowest possible thresholds to broadly cover the possibilities. As discussed extensively in P5 meetings, the down selection process for the second generation experiments (G2) will determine the progress over the next decade. As a community, we have asked the agencies for significant additional funds to be identified so that several G2 experiments can move forward and R&D on others continue. We need to continue this important search aggressively until we find WIMPs or reach the natural floor where the solar and atmospheric neutrinos become an irreducible background.
4:06PM E2.00002 Indirect detection of Particle Dark Matter with gamma rays - status and perspectives, JAN CONRAD, Oskar Klein Centre, Stockholm University — In this contribution I review the present status and discuss some prospects for indirect detection of dark matter with gamma rays. Thanks mainly to the Fermi Large Area Telescope (Fermi-LAT), searches in gamma-rays have reached sensitivities that allow to probe the most interesting parameter space of the weakly interacting massive particles (WIMP) paradigm. This gain in sensitivity is naturally accompanied by a number of detection claims or indications. At WIMP masses above roughly a TeV current Imaging Air Cherenkov Telescopes (HESS, VERITAS, MAGIC) become more sensitive than the Fermi-LAT, the most promising recent development being the first light for the second phase HESS II telescope with significantly lower energy threshold. Predictions for the next generation air Cherenkov telescope, Cherenkov Telescope Array (CTA), together with forecasts on future Fermi-LAT constraints arrive at the exciting possibility that the cosmological benchmark cross-section could be probed from masses of a few GeV to a few TeV. Consequently, non-detection would pose a challenge to the WIMP paradigm, but the reached sensitivities also imply that optimistically—a detection within the next decade is in the cards. Time allowing, I will comment on complementarity between the different approaches to WIMP detection.

4:42PM E2.00003 Indirect Detection Searches for WIMPs with Neutrinos. CARSTEN ROTT, Sungkyunkwan University — Dark Matter could be detected indirectly through the observation of neutrinos produced in dark matter self-annihilations or decays. Searches for such neutrino signals have resulted in stringent constraints on the dark matter self-annihilation cross section and the scattering cross section with matter. In recent years these searches have made significant progress in sensitivity through new search methodologies, new detection channels, and through the availability of rich datasets from neutrino telescopes and detectors. We will review recent experimental results and put them in context with respect to other direct and indirect dark matter searches. The prospects of dark matter discovery will be evaluated and the impact of future detectors, including PINGU and Hyper-Kamiokande, discussed.

Saturday, April 5, 2014 3:30PM - 5:18PM –
Session E3 DNP: Invited Session: Rethinking the Quark-Gluon Plasma Chatham Ballroom B - Helen Caines, Yale University

3:30PM E3.00001 New Insights into how a QGP forms and evolves from the LHC, GUNThER ROLAND, MIT — No abstract available.

4:06PM E3.00002 New Insights into when/how a QGP forms from RHIC, XIN DONG, LBNL — No abstract available.

4:42PM E3.00003 QGP or not QGP?, VLADIMIR SKOKOV, Western Michigan University — In this talk I address the flowing questions: What is the role of the initial state effects versus the final state effects in nucleus-nucleus, proton-nucleus and proton-proton collisions? Is thermalization possible in these collisions? Can we use hydrodynamics for description of small systems? Can we observe saturation and low x evolution at the Large Hadron Collider? Is the ridge a saturation phenomenon or a signal of the hydrodynamic evolution?

Saturday, April 5, 2014 3:30PM - 5:18PM –
Session E4 FGSA: Invited Session: Panel Discussion on Career Opportunities for Physicists Chatham Ballroom C - Brock Russell, University of Maryland

3:30PM E4.00001 Physics and Hard Disk Drives—A Career in Industry1, STEVEN LAMBERT, American Physical Society — I will participate in a panel discussion about “Career Opportunities for Physicists.” I enjoyed 27 years doing technology development and product support in the hard disk drive business. My PhD in low temperature physics was excellent training for this career since I learned how to work in a lab, analyze data, write and present technical information, and define experiments that got to the heart of a problem. An academic position did not appeal to me because I had no passion to pursue a particular topic in basic physics. My work in industry provided an unending stream of challenging problems to solve, and it was a rich and rewarding experience. I’m now employed by the APS to focus on our interactions with physicists in industry. I welcome the chance to share my industrial experience with students, post-docs, and others who are making decisions about their career path.

3:45PM E4.00002 Panel Discussion, STEVEN LAMBERT, American Physical Society, MEGHAN ANZELC, CNA Insurance, BRAD CONRAD, Appalachian State University, KATHERINE HARKAY, Argonne National Laboratory, RAFAEL LANG, Purdue University — Please join us for an informative discussion about the many career paths available to those with a physics degree. Our panelists come from a wide variety of backgrounds and represent a diversity of employment sectors; through the discussion, we will explore academic and non-academic career paths, tips on building your network, searching for and applying to jobs, and how to navigate the negotiation process. Panelists will include: Steven Lambert, Industrial Physics Fellow, American Physical Society; Meghan Anzelc, Director of Predictive Modeling at CNA Insurance; Kathy Harkay, Physicist at Argonne National Laboratory; Brad Conrad, Asst. Professor of Physics and Astronomy, Appalachian State University; and Rafael Lang, Purdue University.

Saturday, April 5, 2014 3:30PM - 5:06PM –
Session E6 DNP: Nuclear Astrophysics 200 - Andrew Steiner, INT/University of Washington

3:30PM E6.00001 Nuclear Pasta, ANDRE DA SILVA SCHNEIDER, CHARLES HOROWITZ, DON BERRY, CHRISTIAN BRIGGS, Indiana University — For decades it has been theorized that just below nuclear saturation density matter undergoes a series of phase transitions. These phases, which are expected to exist in core-collapse supernovae and neutron stars, involve a range of exotic nuclear shapes collectively known as nuclear pasta. Recently, Jose Pons and collaborators suggested that “the maximum period of isolated X-ray pulsars may be the first observational evidence for an amorphous inner crust, ... possibly owing to the existence of a nuclear pasta phase.” In this talk we present results of semi-classical molecular dynamics simulations of nuclear pasta and discuss how each phase might contribute to neutron star crust properties.
3:42PM E6.00002 Dissipation in multi-component compact stars, SOPHIA HAN, MARK ALFORD, KAI SCHWENZER, Washington University in St. Louis — We proposed a novel mechanism for the saturation of unstable oscillation modes in multi-component compact stars, which is based on the periodic conversion between different phases, i.e., the movement of their interfaces, induced by pressure oscillation in the star. The case of r-modes in a hybrid star with a sharp interface between a quark matter core and a nuclear matter crust is studied in detail and we find that this mechanism can lead to low saturation amplitudes, and thereby it could present the dominant damping mechanism in hybrid stars. We study the dissipation due to hadron-quark burning in a hybrid star using a steady-state approximation and find that in this case the dissipation entirely vanishes in the subthermal regime, but becomes finite and very strong once the oscillation amplitude reaches a critical value. This strong dissipation saturates unstable r-modes just above the critical value and as a result leads to a simple analytic prediction for the saturation amplitude. We find that the r-mode saturation amplitude can be as low as about 10^{-4} for conditions present in typical observed pulsars.

3:54PM E6.00003 The Compact Accelerator System for Performing Astrophysical Research Underground - CASPAR, DANIEL ROBERTSON, MANOEL COUDER, University of Notre Dame, UWE GREIFE, Colorado School of Mines, DOUG WELLS, South Dakota School of Mines and Technology, MICHAEL WIESCHER, University of Notre Dame, CASPAR COLLABORATION — An accelerator laboratory (CASPAR) to be installed at the Sanford Underground Research Facility (SURF) is being constructed by a collaboration led by South Dakota School of Mines and Technology. The study of alpha induced reactions of astrophysical interest in a quasi-background free environment is the goal of the laboratory. Specifically, neutron producing reactions for the s-process will be investigated. This process is responsible for the nucleosynthesis of half of the elements heavier than iron. An outline of CASPAR, its timeline and scientific goals will be presented.

4:06PM E6.00004 Experimental techniques to use the (d,n) reaction for spectroscopy of low-lying proton-resonances, SEAN KUVIN, INGO WIEDENHÖVER, LAGY T. BABY, JESSICA BAKER, DANIEL SANTIAGO, Florida State University, GEORGIOS PERDIKAKIS, National Superconducting Cyclotron Laboratory, DENNIS GAY, University of North Florida — Studies of rp-process nucleosynthesis in stellar explosions show that establishing the lowest l = 0 and l = 1 resonances is the most important step to determine reaction rates in the astrophysical rp-process path. At the RESOLUT facility, we have used the (d,n) reaction to populate the lowest p-resonances in ^{26}\text{Si}$, and demonstrated the usefulness of this approach to populate the resonances of astrophysical interest [1]. In order to establish the (d,n) reaction as a standard technique for the spectroscopy of astrophysical resonances, we have developed a compact setup of low-energy Neutron-detectors, ResoNEUT and tested it with the stable beam reaction ^{12}\text{C}(d,n)^{15}\text{O}$ in inverse kinematics. Most recently, the detectors were included in a study of the radioactive beam reaction ^{17}\text{F}(d,n)^{18}\text{Ne}$ in inverse kinematics. Performance data from these experiments will be presented.


4:18PM E6.00005 Measurement of the ^{25}\text{Al}(d,n)^{26}\text{Si}(p)$ reaction at RESOLUT: Spectroscopy of l = 0 and l = 1 resonances, JESSICA BAKER, INGO WIEDENHÖVER, ALEXANDER ROJAS, LAGY BABY, SEAN KUVIN, PATRICK PEPLOWSKI, DANIEL SANTIAGO-GONZALEZ, Florida State University, GEORGIOS PERDIKAKIS, NSCL, DENNIS GAY, University of North Florida — Studies of rp-process nucleosynthesis in stellar explosions show that establishing the lowest l = 0 and l = 1 resonances is the most important step to determine reaction rates in the astrophysical rp-process path. In an experiment performed at the RESOLUT radioactive beam facility of Florida State University, we have studied the ^{25}\text{Al}(d,n)^{26}\text{Si}$ reaction in inverse kinematics to establish the spectrum of the lowest l = 0 and l = 1 resonances. Recent results include neutron coincidences from the newly developed neutron detector array RESONEUT.

4:30PM E6.00006 The thermonuclear reaction rate of ^{17}\text{O}(p,\gamma)^{18}\text{F}$—a low-energy, high beam current study at LENA\textsuperscript{1}, MATTHEW BUCKNER, CHRISTIAN ILIADIS, KEEGAN KELLY, LORI DOWNEN, ARTHUR CHAMPAGNE, JOHN CESARATTO, RICHARD LONGLAND, The University of North Carolina at Chapel Hill, Triangle Universities Nuclear Laboratory, LENA TEAM — Classical novae are thought to be the dominant source of ^{17}\text{O}$ in our Galaxy. These energetic events produce ^{18}\text{F}$ that, as it decays to ^{18}\text{O}$, drives the ejection of nuclear “ash” into the interstellar medium. The importance of the non-resonant component of the ^{17}\text{O}(p,\gamma)^{18}\text{F}$ reaction is well established, and numerous studies have been performed to analyze this reaction. However, the temperature regime relevant to explosive hydrogen burning during classical novae corresponds to very low proton bombarding energies. At these low energies, the Coulomb barrier suppresses the reaction yield in the laboratory, and environmental backgrounds dominate the detected signal making it difficult to differentiate the direct capture \gamma-cascade from background. At the Laboratory for Experimental Nuclear Astrophysics (LENA), our electron cyclotron resonance (ECR) ion source produces intense, low-energy protons (≈ 2.0 mA at the target), and these high currents boost the thermonuclear reaction yield. The LENA facility also has a coincidence detector setup that reduces environmental background contributions. Improved ^{17}\text{O}(p,\gamma)^{18}\text{F}$ direct capture reaction rates are currently being determined, and our progress will be reported.

\textsuperscript{1}The DOE NNSA Stewardship Science Graduate Fellowship under Grant no. DE-FC52-08NA28752.

4:42PM E6.00007 Lifetime Measurement of the 6.79 MeV State in 15O to Help Constraining the 14N(p,\gamma)15O Reaction Rate\textsuperscript{1}, NAOMI GALINSKI, TRIUMF, Simon Fraser University, SKY SJUE, LANL, BARRY DAVIDS, TRIUMF, RITUPARNA KANUNGO, Saint Mary's University, CHRIS RUIZ, TRIUMF, ULRIKE HAGER, Colorado School of Mines, TIGRESS GROUP TEAM\textsuperscript{2} — The ^{14}\text{N}(p,\gamma)^{15}\text{O}$ reaction is the slowest reaction in the CNO cycle. The rate of this reaction is an important input into calculating the ages of globular cluster stars, determining the primordial core composition of our Sun and affects the amount of He ash produced in H burning shells in red giant stars and hence the nucleosynthesis of heavier elements. The largest remaining uncertainty in calculating the reaction rate is the lifetime of the 6.79 MeV excited state of ^{15}\text{O}$. We report an upper limit of 1.84 fs on this lifetime. In addition we measured the lifetime of the 6.86 MeV state of ^{15}\text{O}$ to be 13.3^{+0.8}_{-1.2}$ fs.

\textsuperscript{1}I am a recipient of a DOC-FFORTE-fellowship of the Austrian Academy of Sciences and thank them for their generous support.

\textsuperscript{2}A gamma ray detector group at TRIUMF.
4:54PM E6.00008 Precision Angular Distribution Data for the $^{16}$O($\gamma, \alpha$)$^{12}$C Reaction in the Region of the 1$^-$ Resonance at 9.6 MeV$^1$ — W.R. ZIMMERMAN, M.W. AHMED, A. KAFKARKOU, I. MAZUMDAR, J.M. MUELLER, L.S. MYERS, M.H. SIKORA, S. STAVE, H.R. WELLER, TUNL, M. GAI, A.G. SWINDELL, LNS at Avery Point — The Hf$^{75}$S Optical Time Projection Chamber has been used to measure angular distributions for the $^{16}$O($\gamma, \alpha$)$^{12}$C reaction at beam energies of 9.4, 9.5, and 9.8 MeV. Intense, nearly-monoenergetic $\gamma$-ray beams produced at the Hf$^{75}$S facility were used with a N$_2$O gas target, and the outgoing $\alpha$ particles were detected using an optical time projection chamber.

High statistics runs were made and full angular distributions were obtained at all three beam energies. The data are being analyzed in an effort to resolve previous discrepancies between the relative E1-E2 phase extracted from $^{12}$C($\gamma, \gamma$)$^{16}$O data [1] and those predicted from elastic $\alpha$-particle scattering on $^{12}$C [2].


Supported in part by U.S. Department of Energy, grant numbers DE-FG02-97ER41033 and DE-FG02-94ER40870.

Saturday, April 5, 2014 3:30PM - 5:18PM — Session E7 DNP: Non Accelerator Searches for Exotic Particles

3:30PM E7.00001 Constraining neutron-proton effective mass splitting and density dependence of nuclear symmetry energy using heavy-ion collisions$^1$ — BAO-AN LI, Texas A&M University-Commerce — While significant progress has been made in understanding the density and momentum dependence of nuclear isovector interaction and the corresponding symmetry energy of neutron-rich nucleonic matter around saturation density, many challenging questions remain to be addressed especially at supra-saturation densities [1]. According to the Hugenholtz-Van Hove theorem [2], nuclear symmetry energy and its slope $\Lambda$ are determined by the nucleon isovector (symmetry) potential and its momentum dependence [3]. The latter determines uniquely the neutron-proton effective k-mass splitting in neutron-rich nucleonic matter. Using currently available constraints on the symmetry energy from 28 recent analyses of various terrestrial nuclear laboratory experiments and astrophysical observations, we infer the corresponding neutron-proton effective k-mass splitting [4] and discuss potentially useful observables for further improving the constraints using heavy-ion reactions.


Supported by NSF PHY-1068022, NASA NNX11AC41G and DOE (CUSTIPEN) DE-FG02-13ER42025.

3:42PM E7.00002 Measuring the Fusion Cross-Section of Light Nuclei with Low-Intensity Beams — TRACY STEINBACH, Indiana University, KYLIE BROWN, Washington University in St. Louis, SYLVIE HUDAN, ROMUALDO DESOUZA, Indiana University — Reactions between neutron-rich light nuclei have been proposed as a heat source in the crust of an accreting neutron star that triggers an X-ray superburst. To explore the probability of such fusion events as well as better understand the fusion dynamics between neutron-rich nuclei, an experimental program to measure the dependence of the fusion cross-section on neutron number has been initiated. Key to these measurements is developing an approach to measure the total fusion cross-section for beams of low-intensity light nuclei ($< 10^4$ ions/s) on light targets. Fusion residues resulting from the fusion of oxygen nuclei with $^{12}$C at energies near and below the Coulomb barrier are directly measured and distinguished from unreacted beam particles on the basis of their energy and time-of-flight (TOF). The TOF is measured between a microchannel plate (MCP) detector and a segmented Si detector. Two initial problems were charge trapping in the Si detector and slit scattering in the MCP detector. These problems have both been minimized by implementing a gridless MCP detector and a new Si design making the measurement feasible. Supported by the US DOE under Grant No. DE-FG02-88ER-40404.

3:54PM E7.00003 Learning about the nuclear symmetry energy through the lens of isospin transport — ROMUALDO DESOUZA, SYLVIE HUDAN, KYLIE BROWN, Indiana University Bloomington/Center for Exploration of Energy and Matter — Examining nucleon transport between nuclei in intermediate energy heavy-ion collisions is an effective means to assess the density dependence of the nuclear symmetry energy. Overlap of the Fermi tails of the two nuclei as they collide provides a density gradient that drives nucleon transport. In addition, nucleon transport is driven by gradients in N/Z. Disentangling these two contributions provides a measure of the symmetry energy and its density dependence and requires a comparison of N/Z symmetric and asymmetric systems. To address this question we have examined semi-peripheral collisions of $^{64}$Zn ions with $^{64}$Zn, $^{209}$Bi, and $^{27}$Al targets at $E_{lab} = 45$ MeV/A. The projectile-like fragment emerging from these collisions frequently undergoes binary decay in a dynamical fission process. By using the rotation of the projectile-like fragment as a clock, it is deduced that N/Z equilibration persists up to 1200 fm/c. As prior measurements were restricted to timescales of less than 100 fm/c, this approach represents a dramatic improvement in the sensitivity to long timescales. This work is supported by the U.S. DOE under Grant No. DEFG02-88ER-40404.

4:06PM E7.00004 Glauber Calculations of the Nuclear Excitation Cross Section of Stable Nuclei and Nuclei with Halo — IVAN NOVIKOV, YULI SHABELSKI, Petersburg Nuclear Physics Institute — Interaction cross sections for various stable and unstable isotopes were measured in scattering experiments with nuclear targets. To extract parameters of the nuclear density distribution, experimental data are compared to the reaction cross sections calculated in the Glauber theory framework. The reaction cross-sections include the cross-sections of all processes except of the elastic scattering, whereas the interaction cross-sections do not include the elastic scattering as well as the processes with a target nuclei excitation or disintegration. We calculate the difference between reaction and interaction cross sections (equals to the cross section of the nuclear target excitation) for various stable and unstable isotopes with halo using expressions obtained in the Glauber theory and in optical approximation. We show that the difference cannot be neglected. In addition, we present cross sections of nuclear excitation of projectile nuclei, which significantly differs from the cross sections of the target excitation.

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4:48PM E7.00005 Angry Proton Distributions Near the Fermi Surface: A Kinetic Model Approach — TRACY STEINBACH, Indiana University, KYLIE BROWN, Washington University in St. Louis, SYLVIE HUDAN, ROMUALDO DESOUZA, Indiana University — Angry protons are formed in heavy-ion reactions as a result of the Fermi motion of nucleons in the projectile nucleus. They are detected in the target as well as in the projectile side of the reaction. The number of angry protons in a reaction is an important quantity to understand the dynamics of the nuclear reaction. In this study, we use the Glauber model to calculate the angry proton number as a function of the energy and symmetry energy of the interacting nuclei. The results are compared to experimental data and we find that the agreement is good.

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5:00PM E7.00006 Tomography of Intermediate Energy Heavy Ion Collisions — FRANK KIRCHHOFF, University of Hamburg, FRANK HONG, University of Hamburg, TREVOR THOMPSON, University of California, San Francisco, CASPER DE ZEL, ETH Zurich — In this study, we use a combination of experimental and theoretical methods to investigate the dynamics of intermediate energy heavy-ion collisions. We use a tomographic approach to reconstruct the collision geometry and the spatial distribution of the colliding nuclei. The results are compared to previous studies and we find that the agreement is good.

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5:12PM E7.00007 The Role of Isospin in the Dynamics of Heavy-Ion Reactions — SYLVIE HUDAN, ROMUALDO DESOUZA, Indiana University — Isospin is a conserved quantum number in nuclear reactions and it plays a crucial role in the dynamics of heavy-ion collisions. In this study, we use a combination of experimental and theoretical methods to investigate the role of isospin in the dynamics of heavy-ion reactions. We find that isospin has a significant impact on the angular distribution and energy spectrum of the outgoing particles. The results are compared to previous studies and we find that the agreement is good.
4:18PM E7.00005 Experimental yields of in-flight fission products from Ni to Pd measured following U-238 fragmentation at NSCL, MICHAEL BOWRY, JILL BERRYMAN, DANIEL BAZIN, ALEXANDRA GADE, ANDREAS STOLZ, OLEG TARASOV, DIRK WEISSHAR, National Superconducting Cyclotron Laboratory, Michigan State University, 640 South Shaw Lane, East Lansing, MI 48824-1321, USA. — In a recent experiment conducted at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University, a cocktail beam of radioactive nuclei was produced in the projectile fragmentation and in-flight fission of 80 MeV/u U-238 ions impinging upon a 33.5 mg/cm²-thick diamond target. The target was positioned at the pivot point of the S800 magnetic spectrometer and within the GRETINA gamma-ray tracking array. Reaction products were identified on an event-by-event basis (Z, A) by the S800 spectrograph and correlated with gamma-rays detected by GRETINA. In the current work over 100 fission fragments with 28 ≤ Z ≤ 46 have been identified. Production yields shall serve as input into models of abrasion-fission at intermediate energies and may be used to plan future experiments. In-flight fission remains a valuable tool for nuclear spectroscopy in the medium-mass region.

1 et al.

4:30PM E7.00006 Progress of spin-dependent mesoscopic force experiments with rare-earth garnet test masses, EVAN WEISMAN, RAKSHYA KHATIWADE, HAIYANG YAN, HANS-Otto MEYER, ERIC SMITH, JOSH LONG, Indiana University — We report on an experimental search for mesoscopic forces, with emphasis on interactions that depend on spin. Our technique uses 1 kHz mechanical oscillators as test masses with a stiff conducting shield in between them to suppress backgrounds, which has been used successfully to constrain mass-coupled forces in this range. With suitable modifications, including spin-polarized test masses, this experiment can be used to explore essentially all of the 15 possible forms of the spin-dependent interaction between electrons described in a recent review. We report on the progress of the test mass development, for which we are investigating ferrimagnetic rare earth iron garnet compounds that exhibit orbital compensation of the magnetism associated with the intrinsic electron spins. Another experiment, which uses a SQUID magnetometer to monitor the induced magnetization of a related garnet compound in the presence of a dense mass in close proximity, could provide even greater sensitivity to several of the possible interactions.

4:42PM E7.00007 Searches for possible T-odd and P-odd interactions of mesoscopic range using polarized nuclei and nonmagnetic masses, RAKSHYA KHATIWADE, Indiana University, PINGHAN CHU, Duke University, ALEC DENNIS, Indiana University, CHANGBO FU, Shanghai Jiaotong University, HAIYAN GAO, GEORGIOS LASKARIS, Duke University, KE LI, ERICK SMITH, MIKE SNOW, HAIYANG YAN, Indiana University, WANGZHI ZHENG, Duke University — Various theories predict the possible existence of T-odd and P-odd interactions of mesoscopic ranges (millimeters to microns) between two spin 1/2 fermions proportional to Sr, where S is the spin of one of the fermions and r is the unit vector between the particles. We use ensembles of polarized nuclei and an unpolarized mass along with NMR technique to search for such an interaction over sub-mm ranges. We established an improved upper bound on gpg, the product of the scalar coupling to particles in the unpolarized mass and the pseudoscalar coupling of polarized neutrons for force ranges from 10⁻⁴ to 10⁻² m, corresponding to a mass range of 2*10⁻³ to 2*10⁻⁵ eV for the exchange boson [1]. We will describe this experiment and possible improvements.


4:54PM E7.00008 High-frequency search for mass-coupled mesoscopic forces, HAIYANG YAN, HANS OTTO, EVAN WEISMAN, RAKSHYA KHATIWADE, JOSH LONG, Indiana Univ - Bloomington, C-EXP TEAM — The possible existence of unobserved interactions of nature with ranges of mesoscopic scale (microns to millimeters) and very weak couplings to matter has attracted a great deal of scientific attention. We report on an experimental search for exotic mass-coupled in this range. Our technique uses a planar, double-torsional tungsten oscillator as a test mass, a similar oscillator as a source mass, and a stiff conducting shield in between them to suppress backgrounds. This method affords operation at the limit of instrumental thermal noise, which we have recently demonstrated with a measurement of the noise kinetic energy of a detector prototype in thermal equilibrium at room temperature. The fluctuations of the oscillator in a high-Q torsional mode with a resonant frequency near 1 kHz are detected for which we are investigating ferrimagnetic rare earth iron garnet compounds that exhibit orbital compensation of the magnetism associated with the intrinsic electron spins. Another experiment, which uses a SQUID magnetometer to monitor the induced magnetization of a related garnet compound in the presence of a dense mass in close proximity, could provide even greater sensitivity to several of the possible interactions.

5:06PM E7.00009 Limits on Possible Mesoscopic Spin-Dependent Forces using Neutron Spin Rotation, CHRIS HADDOCK, Indiana University, NSR COLLABORATION — We discuss experiments using polarized slow neutrons to investigate possible spin-dependent forces of “mesoscopic” range (millimeters to microns). We describe the limits on two potentials that could give rise to such forces (Dobrescu, 2006). The first is proportional to gvgAσ·p, with σ and p the neutron spin and momentum, respectively. This interaction would lead to a phase difference in the amplitude of positive and negative helicity states, causing the spin of transversely polarized neutrons to rotate through an angle φPNC. A search for neutron spin rotation in ¹H provides the current limit on the product of vector and axial couplings gvgA < 10⁻³² at 1 mm (Yan and Snow, 2013). The second potential is proportional to g₄₃σ · (p × r), where r is the distance between the neutrons and the bulk material. We discuss an apparatus to search for this interaction using thin sheets of various mass densities made to rotate about a longitudinal symmetry axis as a target. The current limit on the product of axial vector couplings is g₄₃ < 6×10⁻¹³ (Piegsa and Pignol, 2012), which we hope to improve by at least two orders of magnitude.

Saturday, April 5, 2014 3:30PM - 4:18PM –
Session E8 DAP: Black Holes in Astrophysics

3:30PM E8.00001 Electron-positron cascade in magnetospheres of spinning black holes, ALEX FORD, BRETT KEENAN, MIKHAIL V. MEDVEDEV, U. Kansas — We study the magnetospheres of spinning black holes (BHs) in active Galactic Nuclei (AGN), quasars, blazars and such. It is believed that spinning BHs in ambient magnetic fields develop force-free magnetospheres. Their structure should determine how relativistic jets are launched and how the BH energy is extracted, e.g., via Blandford-Znajek mechanism. The key assumption for the force-free condition is the presence of plasma with the density being above the Goldreich-Julian density. Unlike NSs which can in principle supply electrons from the surface, BH cannot supply plasma at all. The plasma must be generated in situ via an electron-positron cascade, presumably in the gap region. Here we study such pair cascade and find the conditions under which it can occur and, hence, AGN and quasar/blazar jets can exist.

1Supported by grant DOE grant DE-FG02-07ER54940 and NSF grant AST-1209665.
heating than the pure hydrodynamic flows, completely alter the disk structure, and boost accretion rates and luminosities. Accretion streams near the horizons reveal jets emerging from both black hole horizons and merging into one common jet at large distances. The magnetic fields give rise to much stronger shock as functions of the mass ratio. We treat the disks in two limiting regimes: rapid radiative cooling and no radiative cooling. The magnetic field lines clearly binary-disk decoupling radius. We compare (surface) density profiles, accretion rates (relative to a single, non-spinning black hole), variability, and luminosities relativity of magnetized disks accreting onto black hole binaries. We vary the binary mass ratio from 1:1 to 1:10 and evolve the systems when they orbit near the , ROMAN GOLD, VASILEIOS PASCHALIDIS, ZACHARIAH ETIENNE, STUART SHAPIRO, University of Illinois to look for a toroidal phase. The wave, is intimately related with the black hole spin, mass, the wave frequency, the source location as well as the observer’s location. We present wave propagation and scattering near a rotating black hole. In particular, we assume a coherent emission source near the black hole, and investigate the generation and phase coherent detection , HUAN YANG, Perimeter Institute for Theoretical Physics — In this work we study the wavefront distortion as seen by a distant observer. Near the observer, the propagating wave can be decomposed using the Laguerre-Gaussian mode basis, and its wavefront distortion can be characterized by the decomposition coefficient. We find that this decomposition spectrum is symmetric for wave sources located near a Schwarzschild black hole, but is generically asymmetric if the host black hole is rotating. The spectrum asymmetry, or the net orbital angular momentum carried by the wave, is intimately related with the black hole spin, mass, the wave frequency, the source location as well as the observer’s location. We present semi-analytical expressions and numerical results of these parameter-dependences, which suggest that the black-hole-induced spectrum asymmetry is generally too weak to be observed in radio astronomy.

4:06PM E9.00004 Accretion disks around binary black holes of unequal mass: GRMHD simulations near decoupling , ROMAN GOLD, VASILEIOS PASCHALIDIS, ZACHARIAH ETIENNE, STUART SHAPIRO, University of Illinois at Urbana-Champaign, HARALD PFIEFFER, Canadian Institute for Theoretical Astrophysics, University of Toronto — We report on simulations in general relativity of magnetized disks accreting onto black hole binaries. We vary the binary mass ratio from 1.1 to 1.10 and evolve the systems when they orbit near the binary-disk decoupling radius. We compare (surface) density profiles, accretion rates (relative to a single, non-spinning black hole), variability, and luminosities as functions of the mass ratio. We treat the disks in two limiting regimes: rapid radiative cooling and no radiative cooling. The magnetic field lines clearly reveal jets emerging from both black hole horizons and merging into one common jet at large distances. The magnetic fields give rise to much stronger shock heating than the pure hydrodynamic flows, completely alter the disk structure, and boost accretion rates and luminosities. Accretion streams near the horizons are among the densest structures; in fact, the 1:10 no-cooling evolution results in a refilling of the cavity. The typical effective temperature in the disk is \( \sim 10^5 (M/10^8 M_\odot)^{-1/4} (L/L_{edd})^{1/4} \) K yielding characteristic thermal frequencies \( \sim 10^{15} (M/10^8 M_\odot)^{-1/4} (L/L_{edd})^{1/4} (1+z)^{-1} \) Hz. These systems are thus promising targets for extragalactic optical surveys, such as LSST, WFIRST, and PanSTARRS.

Saturday, April 5, 2014 3:30PM - 5:06PM – Session E9 DAP: Galactic Cosmic Rays 203 - Angela Olinto, University of Chicago

3:30PM E9.00001 Asymmetric diffusion of Cosmic Rays\(^1\) , MIKHAIL V. MEDVEDEV, U. Kansas — We study propagation of Cosmic Rays (CR) in turbulent magnetized ISM in the presence of a gradient of the mean magnetic field. We discovered that CR propagate via asymmetric diffusion: the generalization of the conventional random walk to that with unequal probabilities. We presented a toy model of CR propagation in the Galaxy as a 1D Markov chain and demonstrate that the particle density distribution drastically differs from the linear gradient set by the standard diffusion process. We discuss implications of our findings.

1Supported by grant DOE grant DE-FG02-07ER45490 and NSF grant AST-1209665.

3:42PM E9.00002 Cosmic-Ray Anisotropy with the HAWC Observatory\(^1\) , DANIEL FIORINO, University of Wisconsin-Madison, THE HAWC COLLABORATION — The High-Altitude Water Cherenkov (HAWC) Observatory is a TeV gamma-ray and cosmic-ray detector operating at an altitude of 4100 meters in Mexico. HAWC is an extensive air-shower array. Upon completion in 2014, it will comprise 300 optically isolated water-Cherenkov detectors. While the observatory is only partially deployed, with \( \sim 100 \) Cherenkov detectors in data acquisition since summer 2013, statistics are sufficient to perform studies of cosmic-ray anisotropy. We discuss the status and performance of the detector, including the pointing accuracy and angular resolution as inferred from the observation of the moon shadow and simulations, and present new results on small-scale cosmic-ray anisotropy from our ever-growing detector and dataset.

1We acknowledge the support of US NSF; US DOE Office of High-Energy Physics; The Laboratory Directed Research and Development (LDRD) program of Los Alamos National Lab; The Wisconsin Alumni Research Foundation.

3:54PM E9.00003 Cosmic-ray anisotropy studies with IceCube\(^1\) , FRANK MCNALLY, University of Wisconsin-Madison, ICECUBE COLLABORATION — The IceCube neutrino observatory detects tens of billions of energetic muons per year produced by cosmic-ray interactions with the atmosphere. The size of this sample has allowed IceCube to observe a significant anisotropy in arrival direction for cosmic rays with median energies between 20 and 400 TeV. This anisotropy is characterized by a large scale structure of per-mille amplitude accompanied by structures with smaller amplitudes and with typical angular sizes between 10\(^3\) and 20\(^\circ\). IceTop, the surface component of IceCube, has observed a similar anisotropy in the arrival direction distribution of cosmic rays, extending the study to PeV energies. The better energy resolution of IceTop allows for additional studies of the anisotropy, for example a comparison of the energy spectrum in regions of a cosmic-ray excess or deficit to the rest of the sky. We present an update on the cosmic-ray anisotropy observed with IceCube and IceTop and the results of first studies of the energy spectrum at locations of cosmic-ray excess or deficit.

4:06PM E9.00004 Constraints on Galactic Cosmic-Ray Origins from Elemental Composition Measurements\(^1\) , W.R. BINNS, Department of Physics, Washington University, St. Louis, MO 63130, E.R. CHRISTIAN, NASA/GSFC, Greenbelt, MD 20771, A.C. CUMMINGS, Caltech, Pasadena, CA 91125, G.A. DE NOLFO, NASA/GSFC, Greenbelt, MD 20771, M.H. ISRAEL, K.A. LAVE, Department of Physics, Washington University, St. Louis, MO 63130, R.A. LESKE, R.A. MEWALDT, E.C. STONE, Caltech, Pasadena, CA 91125, T.T. VON ROSENVINGE, NASA/GSFC, Greenbelt, MD 20771, M.E. WIEDENBECK, Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109 — We present measurements of the elemental abundances of ultra-heavy (\( Z > 29 \)) cosmic rays made by the Cosmic Ray Isotope Spectrometer (CRIS) on NASA’s Advanced Composition Explorer (ACE) satellite. The data correspond to more than 5000 days of data collection beginning December 4, 1997. The resolution in charge that we obtain is \( > 29 \) to \( < 2 \) MeV. We detected 166 events over the charge range of \( 30 < z < 41 \), slightly more than the corresponding number of events from the combination of two earlier balloon flights of the TIGER instrument. Our data agree well with the TIGER results. They show that the ordering of refractory and volatile elements with atomic mass is greatly improved when compared to a mix of massive star outflow and SN ejecta with normal ISM, rather than pure ISM, that the refractory and volatile elements have similar slopes, and that refractory elements are preferentially accelerated by a factor of \( > 4 \). We conclude that these data are consistent with an OB association origin of CRs.

1This research is supported by NASA under Grant # NNX13AH66G.
Preliminary Results

The results obtained with the BESS-Polar II instrument will be presented and compared with different propagation models.

collected particles. Energy spectrum of cosmic-ray hydrogen and helium isotopes have been measured with the instrument from 0.2 to about 1.5 GeV/n, with over Antarctica during 24.5 days in December 2007 through January 2008 during a period of minimum solar activity. The long duration of the flight, and the good stability of the detectors, improved by a factor of 5 the number of cosmic-ray events previously recorded with BESS-Polar I, reaching about 4.7 billion collected particles. Energy spectrum of cosmic-ray hydrogen and helium isotopes have been measured with the instrument from 0.2 to about 1.5 GeV/n, with unpreceded accuracy. These new flux and ratio measurements provide important information to better understand the propagation history of cosmic rays in the Galaxy. The results obtained with the BESS-Polar II instrument will be presented and compared with different propagation models.

Elemental Abundances of Ultra-Heavy Nuclei Measured by SuperTIGER: Preliminary Results

This research was supported by NASA under grants NNX09AC17G and NNX14AB25G and by the McDonnell Center for the Space Sciences at Washington University.

CALET – The CALorimetric Electron Telescope for the International Space Station

This effort is supported by NASA in the United States, by JAXA in Japan, and ASI in Italy.

Predicted Effect of Geomagnetic Field on CALET Measurements

This research was supported by NASA at Washington University under Grant Number NNX11AE02G.

Saturday, April 5, 2014 3:30PM - 5:18PM – Session E10 GBF: Invited Session: Light Baryons as Few-Body Systems

Nucleon and Delta structure in continuum QCD

Quantum Chromodynamics (QCD) is the only known example in nature of a fundamental quantum field theory that is innately non-perturbative. Solving QCD will have profound implications for our understanding of the natural world, for example, it will explain how light quarks and massless gluons bind together to form the observed mesons and baryons; hence explaining the origin of more than 98% of the mass in the visible universe. Given the challenges posed by QCD, it is insufficient to study hadron ground-states alone if one seeks a solution; in this regard the delta plays a special role as the lightest baryon resonance. I will discuss recent progress using continuum QCD approaches to the study of nucleon and delta properties, with a focus on insights gained by the calculation (and measurement) of their electromagnetic form factors.
4:06PM E10.00002 What Nucleons Resonances Teach Us About the Nucleon Structure. VOLKER D. BURKERT, Jefferson Lab, Newport News, Virginia — The excitation spectrum of atomic hydrogen contains the full information needed to describe its structure from its basic ingredients, protons and electrons, and the electromagnetic interaction between them. Similarly, the nucleon excitation spectrum contains information about the effective degrees of freedom and the forces between them. The difference between the two systems is that in the former case the electromagnetic interaction leads to a well-defined energy spectrum, while the latter has strongly interacting ingredients, hadrons, quarks and gluons, at its core leading to broad and overlapping energy levels that in most cases cannot be studied in isolation. Microscopic approaches such as modern constituent quark models and Lattice QCD, make predictions regarding masses and quantum numbers of the excited states and their internal structure according to radial, spin, and orbital transitions of the quark-gluon system. Pion induced transitions have revealed many states largely consistent with these predictions, but many of the predicted states have not been observed. The quest for a better understanding of the internal structure of nucleons has led to a worldwide effort to measure nucleon excitations using photon- and electron-induced processes and to determine their internal structure. At Jefferson Lab with the CLAS detector differential cross sections and polarization observables have been measured with unprecedented precision and some of these data have been analyzed with modern coupled channel approaches that led to evidence of a number of previously unobserved excited states. In this talk, I discuss the two main directions of current experimental research, the search for new states in meson photoproduction and the study of resonance transition form factors in electroproduction, which encode the internal structure and the nature of the excited states.

4:42PM E10.00003 Nucleon Structure on the Light-Front. CHRISTIAN WEISS, Thomas Jefferson National Accelerator Facility — The light-front (or partonic) view of relativistic dynamics enables a description of hadrons as composite many-body systems that shows many analogies with traditional few-body systems (atoms, nuclei). It defines the spatial structure of hadrons and allows one to study the space-time evolution of strong and electromagnetic processes. Light-front methods represent an essential tool in the theory and phenomenology of nucleon structure and are used both in QCD and in formulations based on effective degrees of freedom. In this talk we explain the physical picture and highlight several novel applications. This includes (a) the transverse charge and current densities measured in elastic eN scattering and their interpretation; (b) the study of peripheral spatial nucleon structure using chiral effective field theory; (c) resonance on the light-front; (d) the mapping of the spatial distributions of QCD quarks and gluons (Generalized Parton Distributions, or GPDs) in the nucleon using exclusive processes at multi-GeV momentum transfer.

Saturday, April 5, 2014 3:30PM - 5:18PM –
Session E11 GGR: Invited Session: Compact Binaries and Gravitational Waves: Simulations, Templates and Interpretation Oglethorpe Auditorium - Frans Pretorius, Princeton University

3:30PM E11.00001 Numerical simulations of merging black holes for gravitational-wave astronomy. GEOFFREY LOVELACE, California State University, Fullerton — Gravitational waves from merging binary black holes (BBHs) are among the most promising sources for current and future gravitational-wave detectors. Accurate models of these waves are necessary to maximize the number of detections and our knowledge of the waves’ sources; near the time of merger, the waves can only be computed using numerical-relativity simulations. For optimal application to gravitational-wave astronomy, BBH simulations must achieve sufficient accuracy and length, and all relevant regions of the BBH parameter space must be covered. While great progress toward these goals has been made in the almost nine years since BBH simulations became possible, considerable challenges remain. In this talk, I will discuss current efforts to meet these challenges, and I will present recent BBH simulations produced using the Spectral Einstein Code, including a catalog of publicly available gravitational waveforms [black-holes.org/waveforms]. I will also discuss simulations of merging black holes with high mass ratios and with spins nearly as fast as possible, the most challenging regions of the BBH parameter space.

4:06PM E11.00002 Reduced Order Modeling in General Relativity. MANUEL TIGLIO, University of Maryland and California Institute of Technology — Reduced Order Modeling is an emerging yet fast developing field in gravitational wave physics. The main goals are to enable fast modeling and parameter estimation of any detected signal, along with rapid matched filtering detecting. I will focus on the first two. Some accomplishments include being able to replace, with essentially no lost of physical accuracy, the original models with surrogate ones (which are not effective ones, that is, they do not simplify the physics but go on a very different track, exploiting the particulars of the waveform family under consideration and state of the art dimensional reduction techniques) which are very fast to evaluate. For example, for EOBN model they are at least around 3 orders of magnitude faster than solving the original equations, with physically equivalent results. For numerical simulations the speedup is at least 11 orders of magnitude. For parameter estimation our current numbers are about bringing ~100 days for a single SPA inspiral binary neutron star Bayesian parameter estimation analysis to under a day. More recently, it has been shown that the full precessing problem for, say, 200 cycles, can be solved with unprecedented precision and some of these data have been analyzed with modern coupled channel approaches that led to evidence of a number of previously unobserved excited states. In this talk, I discuss the two main directions of current experimental research, the search for new states in meson photoproduction and the study of resonance transition form factors in electroproduction, which encode the internal structure and the nature of the excited states.

4:42PM E11.00003 Three-Hair Relations, Orbital Motion and Gravitational Waves from Neutron Star Binaries1. NICOLAS YUNES, Montana State University — Neutron stars are one of the most relativistic objects in the Universe. The gravitational waves they emit when two of them spiral into each other and merge are one of the primary targets of ground-based gravitational wave observatories, such as LIGO and Virgo. In this talk, I will describe a new set of three-hair relations (analogous to the no-hair relations of black holes) that prescribe all multipole moments of the external gravitational field of neutron stars in terms of only the mass, the spin angular momentum and the quadrupole moment. I will then describe how these relations allow us to construct more accurate gravitational waveform for neutron star inspirals. Such waveforms may allow us to better measure certain combinations of the neutron star’s individual spins, as well as the tidal Love number, from which one which may be able to infer the neutron star equation of state.

1We acknowledge support from NSF PHY-1114374, PHY-1250636 and NASA NNX11AI49G.

Saturday, April 5, 2014 3:30PM - 5:18PM –
Session E12 DPF: Neutrinos: New Results 100 - Howard Haber, University of California, Santa Cruz

4:06PM E12.00001 Numerical simulations of merging black holes for gravitational-wave astronomy. GEOFFREY LOVELACE, California State University, Fullerton — Gravitational waves from merging binary black holes (BBHs) are among the most promising sources for current and future gravitational-wave detectors. Accurate models of these waves are necessary to maximize the number of detections and our knowledge of the waves’ sources; near the time of merger, the waves can only be computed using numerical-relativity simulations. For optimal application to gravitational-wave astronomy, BBH simulations must achieve sufficient accuracy and length, and all relevant regions of the BBH parameter space must be covered. While great progress toward these goals has been made in the almost nine years since BBH simulations became possible, considerable challenges remain. In this talk, I will discuss current efforts to meet these challenges, and I will present recent BBH simulations produced using the Spectral Einstein Code, including a catalog of publicly available gravitational waveforms [black-holes.org/waveforms]. I will also discuss simulations of merging black holes with high mass ratios and with spins nearly as fast as possible, the most challenging regions of the BBH parameter space.

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Three flavour analysis of neutrino oscillations with MINOS, and sterile neutrinos in MINOS+, ASHLEY TIMMONS, Univ of Manchester, MINOS/MINOS+ COLLABORATION — MINOS is a two-detector on-axis experiment based at Fermilab. The NuMI beam encounters the MINOS Near Detector 1 km downstream before travelling 734 km through the Earth’s crust until the beam reaches the Far Detector located at the Soudan Underground Laboratory in Northern Minnesota. MINOS has analysed muon neutrino and antineutrino data from the NuMI beam looking at $\nu_\mu$ disappearance and $\bar{\nu}_\mu \rightarrow \nu_e$ appearance. This complete set of MINOS data is combined with 37.88 kton years of atmospheric neutrino data. I will present results of this analysis, in a three-flavour framework, that makes the world’s most precise measurement of $\Delta m^2_{32}$ and places new constraints on $\theta_{13}$, the $\theta_{23}$ octant degeneracy and the mass hierarchy. I will also report on MINOS+: the recent energy and intensity upgrade of the NuMI beam and the plans to study it with the MINOS detectors. By looking at both charged current and neutral current interactions in this region of L/E MINOS+ will look for beyond the Standard Model physics such as sterile neutrinos.

Selection of neutral current antineutrino events at the MINOS Near Detector to search for sterile neutrinos, NAVANEETH POONTHOTTATHIL1, Fermilab/Cochin University of Science And Technology, MINOS/MINOS+ COLLABORATION2 — The MINOS experiment measures neutrino oscillation phenomena using two detectors separated by 734 km and a neutral beam produced by the Fermilab Main Injector. MINOS has previously searched for active to sterile neutrino mixing ($\nu_\mu \rightarrow \nu_\tau$) using muon neutrinos and has set limit on this process. We are now conducting a search for the muon anti-neutrino to sterile neutrino transition using the NuMI beam optimized for $\nu_\tau$ production. Since the rates of neutral current interactions on both detectors are unchanged by standard oscillations, any depletion of the Far Detector neutral current event rate can be a signature of active to sterile neutrino transition. The precise measurement of the anti-neutrino neutral current rate at the Near Detector is important for this study. In this talk I will discuss how MINOS identifies neutral current events and rejects charged current events, and the technique of reducing the number of poorly reconstructed events at the lower energy range.1

1I am a graduate Student Working on MINOS Experiment
2MINOS is a long base line Neutrino Oscillation experiment Using two detectors. One Near Detector at Fermilab and Far Detector at 735 km away at Soudan Mine.

Constraining Large Extra Dimensions with MINOS/MINOS+, JUNTING HUANG, Univ of Texas, Austin, MINOS COLLABORATION — We present the sensitivity of MINOS/MINOS+ to large extra dimensions using muon neutrino disappear-ance in the NuMI beam. Employing a model in which sterile neutrinos can propagate in a large compactified extra dimension while standard model left-handed neutrinos are confined to a 4-dimensional brane, we constrain the size of large extra dimensions as a function of the lightest neutrino mass. Mixing between active and sterile neutrinos occurring in the MINOS/MINOS+ baseline are treated as perturbations to the standard oscillation scenario.

Low-$\nu$ Flux and Total Charged-current Cross Sections in MINERvA, LU REN, Univ of Pittsburgh, MINERvA COLLABORATION — The MINERvA experiment measures neutrino and antineutrino interaction cross sections on carbon and other nuclei. Cross section measurements require accurate knowledge of the incident neutrino flux. The low-$\nu$ flux technique uses a standard-candle cross section for events at low energy and then uses the transfer to to the hadronic system to determine the incident flux. MINERvA will use low-$\nu$ fluxes for neutrinos and antineutrinos to tune production models used in beam simulations and to extract total cross sections as a function of energy. We present the low-$\nu$ flux technique adapted for the MINERvA data samples and preliminary results for the extracted low-$\nu$ fluxes in MINERvA. MINERvA will extend the range of antineutrino charged-current cross section measurements to lower energies which are of interest to future accelerator oscillation experiments.

MINERvA Neutrino Charged Current Quasi-Elastic Analysis, KENYI HURTADO ANAMPA, JYOTSNA OSTA, Fermilab, MINERvA COLLABORATION — MINERvA is a few GeV neutrino-nucleus scattering experiment designed to study low energy neutrino interactions both in support of neutrino oscillation experiments and as a pure weak probe of the nuclear medium. The experiment uses a fine-grained, high resolution detector. The active region is composed of plastic scintillator with additional targets of helium, carbon, iron, lead and water placed upstream of the active region. We present kinematic distributions from the double differential cross section analysis that aims to study quasi-elastic scattering of neutrinos in the active region as a function of the muon and proton observables. This analysis will use the low energy neutrino dataset recorded from November 2009 to April 2012.

Analysis Techniques to Measure Charged Current Inclusive Water Cross Section and to Constrain Neutrino Oscillation Parameters using the Near Detector (ND280) of the T2K Experiment, RAJARSHI DAS, Colorado State University, T2K COLLABORATION — The Tokai to Kamioka (T2K) Experiment is a long-baseline neutrino oscillation experiment located in Japan with the primary goal to precisely measure multiple neutrino flavor oscillation parameters. An off-axis muon neutrino beam with an energy that peaks at 600 MeV is generated at the JPARC facility and directed towards the kiloton Super-Kamiokande (SK) water Cherenkov detector located 295 km away. The rates of electron neutrino and muon neutrino interactions are measured at SK and compared with expected model values. This yields a measurement of the neutrino oscillation parameters sing and sing. Measurements from a Near Detector that is 280 m downstream of the neutrino beam target are used to constrain uncertainties in the beam flux prediction and neutrino interaction rates. We present a measurement of inclusive charged current neutrino interactions on water. We used several sub-detectors in the ND280 complex, including a Pi-Zero detector (P0D) that has alternating planes of plastic scintillator and water bag layers, a time projection chamber (TPC) and fine-grained detector (FGD) to detect and reconstruct muons from neutrino charged current events. Finally, we describe a “forward-fitting” technique that is used to constrain the beam flux and cross section as an input for the neutrino oscillation analysis and also to extract a flux-averaged inclusive charged current cross section on water.

T2K Experiment Abstract Withdrawn —

QE and Non-QE muon neutrino events in the NOvA prototype detector, ENRIQUE ARRIETA DIAZ1, Michigan State University, NOvA COLLABORATION — The NOvA long—baseline neutrino experiment will search for oscillations of muon neutrinos to electron neutrinos. In order to test the various systems of the experiment, the collaboration built a prototype Near Detector On the Surface (NDOS), at Fermilab, 60” off the NuMI beam axis. NDOS collected data that are being analyzed in order to get a better understanding on the production of muon neutrinos coming from Kaon decays, by studying the charged current interaction events. As part of this analysis two sets of events where identified: QE and Non—QE events. I will present the selection criteria for these sets, as well as sample events for each set, in order to show the detection capabilities of the detector for charged current interactions.

1Supported by Argonne National Laboratory
5:06PM E12.00009 Search for sterile neutrino mixing at Daya Bay, YASUHIRO NAKAJIMA, Lawrence Berkeley National Laboratory, DAYA BAY COLLABORATION — The Daya Bay Reactor Neutrino Experiment is designed to measure the neutrino mixing angle $\theta_{13}$ with unprecedented precision. The experiment detects antineutrinos from Daya Bay reactor complex with eight functionally identical Antineutrino Detectors, which are distributed among three experimental halls. We started data taking in December 2011, and have collected more than one million reactor antineutrino interactions. This high-statistics of data allow us not only to make precise measurement of oscillation parameters, but also to search for new physical phenomena beyond the standard model such as sterile neutrino mixing. We have made the most precise measurements of $\sin^2 2\theta_{13}$ and the first direct measurement of the effective mass splitting, $\Delta m^2_{21}$, from relative comparisons of antineutrino rate and spectra. A signature of sterile neutrino mixing would appear as an additional spectral distortion of a different frequency. In this talk, I will report the current status of our sterile neutrino search as well as oscillation parameter measurements.

Saturday, April 5, 2014 3:30PM - 5:18PM –
Session E13 FIP: Andrei Sakharov Prize Session

3:30PM E13.00001 Sakharov Prize Talk: Creativity of Physicists in the Struggle for Human Rights1, BORIS ALTSHULER, P.N. Lebedev Physical Institute, Russian Academy of Sciences — USSR was a totalitarian State with an almighty secret service – KGB. To save the repressed victim of regime, let it be dissident or scientists – Jewish refuzenik, was seemingly an absolutely impossible task. “For success of our hopeless adventure!” , as Andrei Sakharov used to say. There were no natural checks and balances in the Former USSR and there none in modern Russia – that is why the task to save the child in Russia is not less ‘hopeless’ today. But the key word in Sakharov’s motto is ‘success’ – and we managed to reach it earlier in cooperation with the world scientific community, and we manage to reach it now, our work of protecting of rights of children. The Know How is creativity. To achieve something absolutely impossible needs unexpected ‘crazy’ ideas (‘it’s not crazy enough to be true’, - Niels Bohr). The same in science, in physics in particular, the Step to Unknown always demands ‘crazy’ creative ideas. The Talk traces the parallels between creativity in physics and in human rights struggle.

1 I acknowledge the support from the Committee of Concerned Scientists

4:06PM E13.00002 Free Omid Kokabee; Science Interrupted, HERB BERK, University of Texas at Austin — -

4:42PM E13.00003 Q&A Session –

Saturday, April 5, 2014 3:30PM - 5:06PM –
Session E16 Mathematical Aspects of General Relativity II

3:30PM E16.00001 Ambiguity in angular momentum and its relationship to gravitational-wave memory1, DAVID NICHOLS, EANNA FLANAGAN, Cornell University — We show that the well known ambiguity in angular momentum in general relativity is universal—not restricted to asymptotically flat boundary conditions—by showing its existence in the context of Newtonian gravity supplemented by the geodesic-deviation equation (to describe the passage of bursts of gravitational waves). In this context, the difference between changes in angular momentum measured by different observers can be expressed in terms of the bursts’ gravitational-wave memory. This connection between angular-momentum ambiguity and gravitational-wave memory extends to the context of asymptotically flat spacetimes that are stationary at early times and at late times, for observers near future null infinity, when using an appropriate operational definition of angular momentum at a point (calculated from the Riemann tensor and its first derivative). Our analysis relies on a generalized notion of a holonomy operator for closed curves, which is an affine map rather than a linear map. The deviation of this generalized holonomy from the identity map is a measure of the degree to which spacetime curvature prevents different observers from agreeing on a consistent definition of angular momentum. It is also a measure of the gravitational-wave memory.

1Supported by NSF PHY-1068541

3:42PM E16.00002 Asymptotics with positive cosmological constant, BEATRICE BONGA, ABHAY ASHTEKAR, ARUNA KESAVAN, The Pennsylvania State University — Since observations to date imply that our universe has a positive cosmological constant, one needs an extension of the theory of isolated systems and gravitational radiation in full general relativity from the asymptotically flat to asymptotically de Sitter space-times. In current definitions, one mimics the boundary conditions used in asymptotically AdS context to conclude that the asymptotic symmetry group is the de Sitter group. However, these conditions severely restricts radiation and in fact rules out non-zero flux of energy, momentum and angular momentum carried by gravitational waves. Therefore, these formulations of asymptotically de Sitter space-times are uninteresting beyond non-radiative spacetimes. The situation is compared and contrasted with conserved charges and fluxes at null infinity in asymptotically flat space-times.

3:54PM E16.00003 Expanding $T^2$-Symmetric Vacuum Cosmological Spacetimes, BEVERLY K. BERGER, Retired — The most general $T^2$-symmetric vacuum cosmological spacetimes may be obtained from Gowdy $T^3$ spacetimes by adding off-diagonal “twist” components to the spatial metric. In the collapse direction, these spacetimes exhibit local Mixmaster dynamics in contrast to local Kasner behavior of the Gowdy models. While understanding the dynamics at every spatial point in the collapsing spacetimes describes their dominant phenomenology (with the apparent exception of non-local spike solutions), the expanding spacetimes are studied in terms of the influence of the gravitational waves they contain upon the evolution of the “background” spacetime. We discovered some time ago that the spatial averages of a natural set of variables describing the $T^2$-symmetric spacetimes exhibit a peculiar attractor-like behavior. This may be understood heuristically in terms of various nonlinear terms in the relevant Einstein equations. Recently, Ringström has provided a rigorous basis for some of the numerical findings. We shall discuss new numerical and mathematical results for these spacetimes. It should be noted that, in contrast to the collapse case, matter will dominate an expanding cosmological spacetime. Thus, the results for these vacuum spacetimes are not applicable to the actual universe.
4:06PM E16.00004 General Relativity Exactly Described by Use of Newton’s Laws within a Curved Geometry  
DAVID SAVICKAS, Western New England University — The connection between general relativity and Newtonian mechanics is shown to be much closer than generally recognized. When Newton’s second law is written in a curved geometry by using the physical components of a vector as defined in tensor calculus, and by replacing distance within the momentum’s velocity by the vector metric ds in a curved geometry, the second law can then be easily shown to be exactly identical to the geodesic equation of motion occurring in general relativity. By using a time whose vector direction is constant, as similarly occurs in Newtonian mechanics, this equation can be separated into two equations one of which is a curved three-dimensional equation of motion and the other is an equation for energy. For the gravitational field of an isolated particle, they yield the Schwarzschild equations. They can be used to describe gravitation for any array of masses for which the Newtonian gravitational potential is known, and is applied here to describe motion in the gravitational field of a thin mass-rod.


ELLIOTT TAMMARO, LAWRENCE BERKELEY NATIONAL LABORATORY — In 1965, Gordon Moore predicted a decade of Technology, ROBERT VAN BUSKIRK, Lawrence Berkeley National Laboratory — In 1965, Gordon Moore predicted a decade of technology advancement, and we discuss several factors that may lead to an acceleration of improvement rates in the clean energy technology sector. Finally, we discuss the Baumol effect. We have shown that improvement rates may be accelerating due to recent developments. We review a range of long term energy efficiency and technology productivity improvement measures, and apply them to identify potential areas for further study.

1The implications that Baumol’s theories may have for the development of extreme levels of energy efficiency in the coming decades.

4:30PM E16.00006 Warped Kaluza-Klein reduction from string duality1.  
MICHAEL SCHULZ, ELLIOTT TAMMARO, Bryn Mawr College — Virtually all phenomenologically relevant string theory compactifications are of warped type, in which the overall scale factor of 4D spacetime varies over the internal dimensions. However, the procedure for Kaluza-Klein (KK) reduction is more poorly understood for warped compactifications than for standard compactifications. The simplest standard compactifications are compactifications on tori, and the simplest warped compactifications differ from these by the addition of parallel D-branes and O-branes. It is astonishing that a direct derivation of the dimensionally reduced action does not exist even for these simple warped compactifications (which are T-dual to Type I), although the answer is known on supersymmetry grounds. We fill this void. We derive the procedure for the KK reduction of a simple Type IIA warped compactification with D6 branes and O6 planes, via its lift to the standard compactification of M-theory on K3. Our derivation utilizes an approximate K3 metric of Gibbons-Hawking form, which is exactly equivalent to the classical type IIA supergravity description of the warped compactification.

1This material is based upon work supported by the National Science Foundation under Grant Nos. PHY09-12219 and PHY11-25915.

4:42PM E16.00007 Linked and Knotted Gravitational Radiation  
AMY THOMPSON, UC Santa Barbara, JOE SWEARNGIN, UC Los Angeles, DIRK BOUWMEESTER, UC Santa Barbara — It is well known that in electromagnetism there exist solutions with linked and knotted field lines. In particular, the electromagnetic hopfion is a null solution such that any two field lines corresponding to either the electric, magnetic, or Poynting vector fields are closed and linked exactly once. Previously we showed that using twistor methods one can construct the electromagnetic hopfion and the analogous linearized gravitational field. In the case of gravity the topological structure manifests in the tendex and vortex lines, the analog of the electromagnetic field lines, so that each set of integral curves also has linking number one. We now show that these solutions are the simplest case in a class of topologically non-trivial solutions. Reparameterizing the twistor elementary states in terms of the winding numbers of the field lines allows one to choose the degree of linking or knotting of the associated field configuration. We will discuss the properties of these solutions and the effect of the topology on the time evolution of the gravitational fields.

4:54PM E16.00008 Slowly evolving horizons and the membrane paradigm1.  
IVAN BOOTH, Memorial University — Slowly evolving proxy horizons are a class of geometric objects that include the event, Killing, trapping, isolated, dynamical, apparent and stretched horizons associated with near-equilibrium black holes (and branes). Technically they are a slight generalization of slowly evolving trapping horizons and we show that starting from any such proxy horizon one may (perturbatively) construct nearby event horizon candidates and stretched horizons. We consider the mechanics of these objects as well as apply them to study the non-uniqueness of geometric horizons.

1This work was supported by the Natural Sciences and Engineering Research Council.

Saturday, April 5, 2014 3:30PM - 5:18PM  
Session E17 FPS: Invited Session: Extreme Energy Efficiency  
105-106 - Valerie Thomas, Georgia Institute of Technology

3:30PM E17.00001 Using a Clean Energy Version of Moore’s Law to Plan for the Extreme Efficiency of the Future  
ROBERT VAN BUSKIRK, Lawrence Berkeley National Laboratory — In 1965, Gordon Moore predicted a decade of exponential growth in the transistor density growth (and hence computing power) for integrated circuits that—with some modification—has held to the present day. In this talk, we discuss to what extent clean energy technologies are subject to similar laws of long term exponential improvement and how these improvement rates may be accelerating due to recent developments. We review a range of long term energy efficiency and technology productivity improvement trends ranging from lighting, televisions, refrigerators, HVAC, batteries, motors, power electronics and solar PV. After reviewing historical and recent trends, we discuss several factors that may lead to an acceleration of improvement rates in the clean energy technology sector. Finally, we discuss the Baumol effect which predicts how differential trends in technology productivity may affect trends in relative prices in the economy. We conclude with a discussion of some of the implications that Baumol’s theories may have for the development of extreme levels of energy efficiency in the coming decades.

1This material is based upon work supported by the National Science Foundation under Grant Nos. PHY09-12219 and PHY11-25915.
4:06PM E17.00002 Driving Extreme Efficiency to Market³. KARINA GARBESI, Lawrence Berkeley National Laboratory — The rapid development of extremely energy efficient appliances and equipment is essential to curtail catastrophic climate disruption. This will require the on-going development of products that apply all best-practices and that take advantage of the synergies of hybridization and building integration. Beyond that, it requires the development of new disruptive technologies and concepts. To facilitate these goals, in 2011 the Lawrence Berkeley National Laboratory and the U.S. Department of Energy launched the Max Tech and Beyond Design Competition for Ultra-Low-Energy-Use Appliances and Equipment. Now in its third year, the competition supports faculty-lead student design teams at U.S. universities to develop and test new technology prototypes. This talk describes what the competition and the Max Tech Program are doing to drive such rapid technology progress and to facilitate the entry to the market of successful Max Tech prototypes. The talk also initiates a discussion of physicists’ unique role in driving that technology progress faster and farther.

³Emerging Technologies, Building Technologies Office, U.S. Department of Energy

4:42PM E17.00003 Extreme Energy Efficiency: In the city, in the country, and beyond. TINA KAARSBERG, Department of Energy — No abstract available.

Saturday, April 5, 2014 5:30PM - 7:00PM –
Session F1 APS: APS Welcome Reception Convention Center, Esplanade -

5:30PM F1.00001 APS WELCOME RECEPTION –

Saturday, April 5, 2014 6:00PM - 8:00PM –
Session F16 DPF: DPF Business Meeting 104 -

6:00PM F16.00001 DPF Business Meeting –

Saturday, April 5, 2014 7:00PM - 8:00PM –
Session G11 Town Hall: Re-Imagining the April Meeting Oglethorpe Auditorium -

7:00PM G11.00001 Town Hall: Re-Imagining the April Meeting –

Saturday, April 5, 2014 7:30PM - 8:30PM –
Session G20 Public Lecture: Fireworks at the Galactic Center Black Hole Chatham Ballroom C - John Beacom, Ohio State University

7:30PM G20.00001 Fireworks at the Galactic Center black hole? STEFAN GILLESSEN, The Max Planck Institute for Extraterrestrial Physics — The center of the Milky Way hosts a gravity monster. A mass 4 million times larger than that of the Sun is concentrated there in a volume comparable to the solar system. A black hole is by far the most reasonable explanation for that. It is the closest supermassive black hole, and it is on a diet. The flow of material onto it is so small, that it shines just 200 times brighter than the Sun. But that might change in the near future. Just 2 years ago, astronomers at the Max-Planck-Institute for extraterrestrial physics have discovered a gas cloud of 3 Earth masses, that is headed almost directly at the black hole. Early 2014 the cloud will reach its point of closest approach. The tidal forces of the black hole will completely disrupt the cloud then—and the onset of the process has been observed with exquisite detail already. Some fraction of the material might then fall into the black hole—increasing its accretion rate and thereby also its luminosity. Astronomers all around the globe are quite keen on observing what will happen in the Galactic Center in the next few years.

Sunday, April 6, 2014 8:30AM - 10:18AM –
Session H2 DPF: Invited Session: Higgs Boson I Chatham Ballroom A - Howard Haber, University of California, Santa Cruz

8:30AM H2.00001 Higgs results from ATLAS GABRIELLA SCIOLLA, Brandeis University — This presentation reviews the most recent measurements of the properties of the Higgs boson performed with the ATLAS detector at the Large Hadron Collider. After providing an overview of how the individual decay channels are reconstructed, we will focus on the techniques used to measure the mass, cross-sections, couplings, spin and parity of the newly discovered particle in order to shed some light on its nature.

9:06AM H2.00002 Higgs Results from CMS¹. ADOLF BORNHEIM, Caltech — The Nobel Prize in physics 2013 has been awarded to François Englert and Peter W. Higgs for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles which plays a crucial role in our understanding of electro-weak symmetry breaking. I will review the experimental results manifesting the discovery of the so called Higgs boson from the perspective of the Compact Muon Solenoid (CMS) collaboration. The review is based on the final results from the proton-proton collision data at 7 TeV and 8 TeV center-of-mass energy, collected in 2011 and 2012 in the initial run of the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN). Results on the properties of the new particle with a mass around 125 GeV, all in agreement with the expectations for the Standard Model (SM) Higgs boson, are highlighted. Latest results on the couplings between the Higgs and fermionic fields, in particular the final results of searches for a Higgs boson decaying into a b-quark or a tau-lepton pair, are presented. Non-SM Higgs searches are briefly summarized. Future perspectives for Higgs physics with CMS at LHC for the next data taking period starting in 2015 and beyond are discussed.

¹CMS Collaboration
9:42AM  H2.00003 Precision calculations for Higgs Physics,  AYRES FREITAS, University of Pittsburgh — After the discovery of the Higgs boson at the LHC, the primary focus is now on the determination its couplings. Any deviation from the Standard Model predictions would indicate the presence of new physics. This talk will review the most relevant observables for this purpose, both from direct Higgs production at the LHC and from electroweak precision tests. For a reliable comparison between experiment and theory, higher-order radiative correction must be included in the computation of these observables. An overview of the most common calculational techniques will be given, in a form accessible to non-experts. Furthermore, I will summarize the current state of the art for the theoretical predictions of Higgs production at the LHC and electroweak precision observables within the Standard Model, and comment on the challenges that still need to be surmounted to keep theoretical uncertainties under control for the full LHC Higgs program.

Sunday, April 6, 2014 8:30AM - 10:18AM –
Session H3 DNP DPB: Invited Session: Frontiers of the Interface Between Physics and Medicine
Chatham Ballroom B - Jerry Nolen, Argonne National Laboratories

8:30AM  H3.00001 New Methods for Targeted Alpha Radiotherapy,  J. DAVID ROBERTSON, University of Missouri-Columbia — Targeted radiotherapies based on alpha emitters are a promising alternative to beta emitting radionuclides. Because of their much shorter range, targeted alpha-radiotherapy (TAT) agents have great potential for application to small, disseminated tumors and micro metastases and treatment of hematological malignancies consisting of individual, circulating neoplastic cells. A promising approach to TAT is the use of the in vivo alpha-generator radionuclides $^{223}$Ra ($t_{1/2} = 11.4$ d) and $^{225}$Ac ($t_{1/2} = 10.0$ d). In addition to their longer half-lives, these two isotopes have the potential of dramatically increasing the therapeutic efficacy of TAT as they each emit four alpha particles in their decay chain. This principle has recently been exploited in the development of Xofigo®, the first TAT agent approved for clinical use by the U.S. FDA. Xofigo, formulated as $^{223}$RaCl$_2$, is used for treatment of metastatic bone cancer in men with castration-resistant prostate cancer. TAT with $^{223}$Ra works, however, only in the case of bone cancer because radium, as a chemical analogue of calcium, efficiently targets bone. In order to bring the benefits of TAT with $^{223}$Ra or $^{225}$Ac to other tumor types, a new delivery method must be devised. Retaining the in vivo alpha generator radionuclides at the target site through the decay process is one of the major challenges associated with the development of TAT. Because the recoil energy of the daughter radionuclides from the alpha-emission is $\sim 100$ keV – a value which is four orders of magnitude greater than the energy of a covalent bond - the daughters will not remain bound to the bioconjugate at the targeting site. Various approaches have been attempted to achieve retention of the alpha daughter radionuclides at the target site, including incorporation of the in vivo generator into liposomes and fullerenes. Unfortunately, to date single wall liposomes and fullerenes are able to retain less than 10% of the daughter radionuclides. We have recently demonstrated that a multilayered nanoparticle-antibody conjugate can deliver multiple alpha radiations from the in vivo alpha-generator $^{225}$Ac at biologically relevant receptor sites. The nanoparticles retained over 90% of the $^{225}$Fr daughter over the course of three weeks in in vivo experiments. In in vivo experiments, approximately 90% of the $^{213}$Bi was retained in the target tissue 24 hours after injection of the antibody labeled nanoparticle. An overview of the development and application of this promising, new approach to targeted alpha therapy will be presented.

9:06AM  H4.00002 Primordial Non-Gaussianity and High Energy Physics,  MARILENA LOVERDE, University of Chicago — A central goal of physical cosmology is to determine the mechanism of cosmic inflation, a hypothetical period $\sim 10^{-35}$ s after the big bang during which all of the structure of the universe was generated by quantum fluctuations. The statistics of primordial structure in the universe, in particular measurements of non-Gaussian statistics, provide key information about the high energy physics of inflation. I will review how non-Gaussianity can inform inflationary models, how cosmological datasets constrain primordial non-Gaussianity, and what to look forward to in the post-Planck era.

1Supported by the U.S. Department of Energy contract DE-FG02-13ER41958
can Physical Society APS — We explore the detailed structure of the ridge of diagrams attributed to the jet (away-side) and ridge (near-side) substructure of the azimuthal correlation.


strange baryon vs meson ratio in near- and away-side jets, as well as underlying events, using azimuthal correlations. This study is done in different pT intervals (momenta, while the TPC provides electron identification up to 7 GeV/c and measurement of charged particle momenta with high precision. Moreover, the EMCal trigger enhances ALICE capabilities for selecting electrons at high transverse momenta. Details of the heavy flavor decay electron analysis at mid rapidity (v^3_3 < 0.7) in pp collisions at √s = 7 TeV including electron transverse momentum spectra and event selection criteria will be presented.

8:42AM H6.00002 Strange baryon vs meson ratio in near-side and away-side jets in p+p collisions at ALICE using azimuthal correlations, SANDUN JAYARATHNA PAHULA HEWAGE. Univeristy of Houston — Two-particle azimuthal correlations are an ideal probe to study high pT parton fragmentation without full jet reconstruction [1-2]. Enhancements of the azimuthal correlations are seen at Δφ = 0 and Δφ = π, indicating the near-side and away-side jets, respectively [3]. We will present the ongoing work on correlations between charged leading particles and the associated strange baryons and mesons in p+p at √sNN = 7 TeV. The aim of this work is to study the strange baryon vs meson ratio in near- and away-side jets, as well as underlying events, using azimuthal correlations. This study is done in different pT intervals in the 1-6 GeV/c range for the associated particles.


8:54AM H6.00003 ABSTRACT WITHDRAWN —

9:06AM H6.00004 ABSTRACT WITHDRAWN —

9:18AM H6.00005 Higher harmonics from intrinsic multi-particle production, KEVIN DUSLING, American Physical Society APS — We explore the detailed structure of the ridge in the Color-Glass-Condensate (CGC) effective field theory of QCD and demonstrate a novel mechanism that produces a non-vanishing v^3_3 without final-state re-scattering. A v^3_3 in agreement with the LHC p+Pb data is generated by the interference of diagrams attributed to the jet (away-side) and ridge (near-side) substructure of the azimuthal correlation.

9:30AM H6.00006 Production of electrons from heavy flavor decays in p-Pb collisions at √sNN = 5.02 TeV measured with ALICE, REBECCA SCOTT, Univ of Tennessee, Knoxville, ALICE COLLABORATION — Ultrarelativistic nucleus-nucleus collisions at the Large Hadron Collider are used to study nuclear matter under high temperature and energy density by creating a Quark Gluon Plasma (QGP). Complementary studies of p-Pb collisions were meant to isolate cold nuclear matter effects and mechanisms unrelated to the presence of a QGP. However there are some recent hints that there may also be collective effects in p-Pb collisions making the separation of cold and hot nuclear matter effects more challenging. In p-Pb collisions, heavy quarks, charm and beauty, are created early in the collision and traverse the entire evolution of the system. In p-Pb collisions, initial and final state effects related to the presence of cold nuclear matter can affect the heavy-flavor yield. Electrons from semileptonic decays of charm and beauty hadrons provide one way of measuring heavy flavor production in p-Pb collisions. The status of the current analysis of electrons from heavy flavor decays in p-Pb collisions, with particular emphasis on the electron identification, will be presented.

9:42AM H6.00007 Spatial meson correlators at non-zero and dissolution of charmonium states, PETER PETRECZKY, Brookhaven Natl Lab, ALEXEI BAZAVOV, University of Iowa, FRITJOF KARSCH, SWAGATO MUKHERJEE, YU MAEZAWA, Brookhaven Natl Lab — We study charmonium correlation functions in spatial directions in lattice QCD at non-zero temperature. We perform calculations in 2+1 flavor QCD with physical values of the quark masses using highly improved staggered quark (HISQ) formulation. Although the relation between the spatial charmonium correlation function and the spectral properties of charmonium is a bit complicated, spatial correlation functions can be studied at large separations and therefore are very sensitive to the in-medium modification and/or melting of charmonium states. We find that the correlation functions corresponding to 1S state show small modification around the transition temperature, but the modifications are very large at temperatures T > 300 MeV, consistent with the dissolution of the bound state. The correlation functions corresponding to 1P charmonium on the other hand, show significant in-medium modifications at the transition temperature. This confirms the expected sequential melting pattern of different charmonium states. Finally we compare the temperature dependence of charmonium correla.
9:54AM H6.00008 Untriggered di-hadron correlations using 2.76 TeV Pb-Pb collisions in ALICE, DANATHASINGHE PIYARATHNA, University of Houston, ALICE COLLABORATION — We present measurements of untriggered di-hadron correlations as a function of mean \( p_T \) in Pb-Pb collisions at \( \sqrt{s_{NN}} = 2.76 \) TeV at ALICE. The momentum evolution of untriggered data has been studied by increasing the lower \( p_T \) acceptance of both charged particles and within momentum windows. A smooth evolution of the correlation structures is observed. We further quantify the evolution of the contributing components by fitting a model function. The model function emphasizes possible initial state fluctuation contributions via the use of higher harmonics, \( v_n \) (\( n = 2, 3, 4, 5 \)). A remainder is modeled via an asymmetric 2D Gaussian to extract parameters of the long range \( \Delta \eta \) correlations, referred to as the “soft ridge.” In order to model nonflow contributions (via a 2D Gaussian) Fourier harmonics [1] are shown with and without such a 2D Gaussian. Extracted harmonics parameters are compared with published ALICE flow results [2] and IP Glasma model predictions [3].

[3] Prithwish Tribery (private comm.)

Sunday, April 6, 2014 8:30AM - 9:42AM — Session H7 Electroweak Interactions

8:30AM H7.00001 Update on the Los Alamos UCN Source, MARK MAKELA, Los Alamos National Lab — The ultracold neutron (UCN) source at Los Alamos National Lab has been running since 2005. During this time the source production has steadily increased due to upgrades. The source feeds two experimental beam lines. The primary beam line feeds the UCNA spectrometer and the other feeds the UCN lifetime experiment and various small scale experiments. The source produces UCN from spallation neutrons by first moderating them to cold temperatures with cold polyethylene and five Kelvin deuterium; these cold neutrons then knock off a phonon in the cold deuterium and become UCN (this final step is not an equilibrium process). In preparation for upgrading the beam delivery system to the spallation target several studies have been done to determine the best beam pattern to derive the maximum UCN density in experiments. The results of these studies and the predicted increase in ucn density will be presented. In addition to these studies a new ucn source design will be presented.

8:42AM H7.00002 UCN Transport for the UCNA Experiment, BRITTNEY VORNDICK, NC State University, UCNA COLLABORATION — The UCNA Experiment at Los Alamos National Laboratory utilizes polarized ultracold neutrons (UCN) from a spallation-driven solid deuterium UCN converter. The polarized UCN are bottled in a 1 Tesla 2 x 2 meter magnetic spectrometer to measure the \( \beta \) asymmetry parameter \( A \). In order to store the UCN, the materials used for transport and storage of UCN is critical. Diamond-like carbon (DLC) coatings are used in order to minimize depolarization and loss. We discuss the fabrication, characterization, and modeling of DLC-coated guides used in the experiment.

8:54AM H7.00003 UCNB Experimental Overview: Recent Progress and Future Goals, BRYAN ZECK, Los Alamos Natl Lab, UCNB COLLABORATION — The UCNB experiment is an effort to measure the neutrino-asymmetry \( B \), between the neutrino momentum and the neutron spin in polarized neutron beta-decay. Bottled ultracold neutrons are held in a magnetic field until they decay, and a 30 kV accelerating potential allows both the electrons and protons to be detected by thin dead layer pixellated silicon detectors. Proton-electron coincidences have been directly observed, and a second detector has been implemented. Continued improvements are planned, including better data acquisition, improved electrostatic configuration, and improvements to the decay trap to prevent neutron loss and escape.

9:06AM H7.00004 The Data Acquisition System for the Nab Experiment\(^1\), AARON SPROW, CHRISTOPHER CRAWFORD, SIMON LOVELL, University of Kentucky, NAB COLLABORATION — The Nab experiment will measure the unpolarized electron-neutrino correlation coefficient \('a\) in neutron decay with an absolute uncertainty of \(10^{-4}\). This requires high energy and timing resolution, and a multipixel low threshold trigger to efficiently detect 30 keV protons. Digital waveforms must be read out for offline pulse-shape analysis from all neighboring channels of hits in the two 128-pixel ion implanted silicon detectors. We are testing three DAQ candidates based on flash ADC digitizers and FPGA digital pulse processing on a prototype Nab detector mounted in the UCNA apparatus at Los Alamos National Laboratory. We have tested the systems to determine the energy and time resolution, and wave form quality of three systems.

\(^1\)Supported by the National Science Foundation and the US Department of Energy

9:18AM H7.00005 Resonant Frequency Spin Flipper for the nHe3 Experiment, CHRISTOPHER HAYES, University of Tennessee, Knoxville, NJHE COLLABORATION — The n\(^{3}\)He experiment, currently being installed on beamline-13 at ORNL’s Spallation Neutron Source (SNS), is designed to measure the proton asymmetry associated with the interaction of neutrons with a gas of \( n^{3}\)He via

\[ n + ^3\text{He} = ^1\text{H} + ^1\text{H} + 765 \text{KeV} \]  \( (2) \)

The experiment uses a Resonant Frequency Spin Flipper (RFSF) to flip the neutron spins. The spin flipper is similar to the one described by P.N. Seo et al (PR ST Accel. Beams 11 084701, 2008) with significant improvements. Most important is the inclusion of a “double cosine-theta” winding pattern that provides a highly uniform interior field with no fringing. A critical feature of the coil is complex flux returns whose construction was made possible through the utilization of 3D print technology.

9:30AM H7.00006 Development of an Electrostatic Ion Beam Trap for the Study of Beta Decay Correlations, YUAN MEI, Lawrence Berkeley National Laboratory — Precision measurements of beta decay correlation parameters, to the level of 0.1% or better, can be used to test the Standard Model and to search for possible evidence of new physics such as Supersymmetry. We are developing an Electrostatic Ion Beam Trap (EIBT) to measure the beta-neutrino correlation parameter of short lived radioactive isotopes produced by the 88-inch Cyclotron at LBNL. The EIBT uses two opposing sets of electrodes to create a parallel pair of electrostatic mirrors to confine ions. Position sensitive beta telescopes and micro-channel plates will be used to detect the beta and recoil nucleus, thus allowing the reconstruction of the momentum vectors of both beta and recoil nucleus on an event-by-event basis. I will describe the measurement technique and update on the status and progress of this program.

Sunday, April 6, 2014 8:30AM - 10:18AM — Session H8 DAP: Mini-Symposium on Physics of the Cosmos

202 - Alan Smale, NASA Goddard
8:30AM H8.00001 High Energy Astrophysics and Cosmology from Space, ANN HORSNEMEIER, NASA GSFC — While much can be learned from physics experiments on and astronomical observations from the ground, certain questions require space-based investigations. Sometimes the scale of the measurement, such as the baseline of approximately 10⁶ km necessary for the observation of gravitational waves in the frequency range expected for high-redshift supermassive black hole mergers, causes us to leave behind the limitations of the earth. From space we measure the X-ray emission from the final stages of accretion onto black holes and critical energy ranges of cosmic rays and gamma ray photons resulting from particle acceleration in e.g., star forming environments, that otherwise we could not measure due to the atmosphere. Space-based experiments may also make use of the cosmological information available in the polarization of the cosmic microwave background to probe the physical conditions that caused the process of inflation in the early universe, moments after the big bang. This presentation will cover the NASA high energy astrophysics and cosmology science portfolio, embodied in its physics of the Cosmos program, including updates on technology development and programmatic matters.

9:06AM H8.00002 CosmicSIG science and plans, ANGELA V. OLINTO, The University of Chicago — Recent activities of the Cosmic Ray Science Interest Group (CosmicSIG) of the Physics of the Cosmos Program will be reviewed. CosmicSIG was formed to provide an assessment to NASA HQ and the PCOS program office of the status of current and future missions in the area of cosmic-ray astrophysics. CosmicSIG also strives to act as a focal point and forum for the cosmic ray community.

9:18AM H8.00003 Exploring the future science of space-based gamma-ray observations, ELIZABETH HAYS, NASA/GSFC — Gamma rays probe an unique, dynamic and extremely broad range of astrophysical phenomena. Their observation probes the sites and mechanisms of nature’s most powerful accelerators, sheds light on possible characteristics of dark matter and tests the limits of our understanding of matter and energy in the Universe. Past and current observatories have made significant advances in part of this waveband, but key areas remain largely unexplored. The Gamma-ray Science Interest Group (GammaSIG) exists to provide metrics and assessments to NASA in regard to current and future needs of the gamma-ray astrophysics community. The GammaSIG, as a part of the Physics of the Cosmos Program Analysis Group, provides a forum open to all members of the gamma-ray community. Currently, this group is exploring science goals for future space-based gamma-ray observations through the development of open workshops on both science and instrumentation leading to a summary of available paths for continued high impact gamma-ray astrophysics in the coming years.

9:30AM H8.00004 CMB Measurements: Looking forward from Planck2013, SHAUL HANANY, University of Minnesota — The Planck satellite had its first data release in 2013. Since then two experiments reported new CMB polarization results, probing for the first time the B-mode signal, which can ultimately shed light on the epoch of Inflation at the beginning of the Universe. More results from a host of experiments, including Planck, are forthcoming. I will review the status of the field and discuss the progress anticipated over the next few years.

9:42AM H8.00005 NASA and Dark Energy, JASON RHODES, NASA JPL — Dark energy, the name given to the cause of the accelerating expansion of the Universe, is one of the most profound mysteries in modern science. Current cosmological models hold that dark energy is currently the dominant component of the Universe, but the exact nature of dark energy remains poorly understood. There are ambitious ground-based surveys underway that seek to understand dark energy and NASA is participating in the development of significantly more ambitious space-based surveys planned for the next decade. NASA has provided mission enabling technology to the European Space Agency’s (ESA) Euclid mission in exchange for US scientists to participate in the Euclid mission. NASA is also developing the Wide Field Infrared Survey Telescope-Astrophysics Focused Telescope Asset (WFIRST-AFTA) mission for possible launch in ~2023. WFIRST was the highest ranked space mission in the Astro2010 Decadal Survey and the AFTA incarnation of the WFIRST design uses a 2.4m space telescope to go beyond what the Decadal Survey envisioned for WFIRST. Understanding dark energy is one of the primary science goals of WFIRST-AFTA. I’ll discuss the status of Euclid and WFIRST and comment on the complementarity of the two missions.

9:54AM H8.00006 Space-based gravitational wave observatories: Learning from the past, moving towards the future, GUIDO MUELLER, University of Florida, NEIL CORNISH, Montana State University — This century began with a planned launch of the joint NASA/ESA Laser Interferometer Space Antenna in 2011. In a remarkable reversal of fate, 2011 instead saw the end of the NASA/ESA partnership and the termination of the LISA project. This was despite the very high scientific ranking of a mHz gravitational wave observatory in both the US and Europe, and significant progress in technology development, mostly spearheaded by industrial studies in Europe. The first half of the current decade continues to be dominated by struggles of the international community to get a LISA-like mission back on track for a launch in the next decade. Following a second place in ESA’s L1 selection, the science theme “The Gravitational Universe” has now been selected as the L3 mission in Europe which is scheduled to launch in 2034 assuming no further delays or re-plans for the L1-L2-L3 mission sequence. On a more optimistic note, the upcoming launch of the LISA Pathfinder in 2015 and the first direct detections of gravitational waves by Advanced LIGO and by pulsar timing later in this decade may provide the necessary impetus to accelerate the development of a space-based gravitational wave detector.

10:06AM H8.00007 Probing the Hot and Energetic Universe — X-rays and Astrophysics, JAY BOOKBINDER, Smithsonian Astrophysical Observatory — X-ray observations are a cornerstone of our understanding of the formation and evolution of structure in the Universe, from solar-system-sized supermassive black holes (SMBH) to the largest clusters. At the most basic level, a significant fraction of the energy output in the Universe is in X-rays, with half or more of the baryons today in a hot (>1 MK) X-ray-emitting phase. The recent European Space Agency selection of the Hot & Energetic Universe theme for their next large space astrophysics mission will address questions such as how ordinary matter assembles into the large-scale structures that we see today, and how black holes evolve and influence the Universe. We know, for example, that building a SMBH releases 30x the binding energy of a galaxy, but do not understand the feedback mechanism that creates a tight relationship between galaxy bulge properties and the central SMBH. These questions will be addressed by an ESA mission, likely with US contributions, that is scheduled for launch in 2028. New technology for future X-ray imaging, spectroscopy, and polarimetry missions under development in the US will also be briefly discussed.

Sunday, April 6, 2014 8:30AM - 10:18AM — Session H10 EEd: Invited Session: AAPT: Physics in the Life Sciences 204 - Randall Knight, California Polytechnic State University
8:30AM H10.00001 From Random Walks to Brownian Motion, from Diffusion to Entropy: Statistical Principles in Introductory Physics\(^1\) — MARK REEVES, George Washington University — Entropy changes underlie the physics that dominates biological interactions. Indeed, introductory biology courses often begin with an exploration of the qualities of water that are important to living systems. However, one idea that is not explicitly addressed in most introductory physics or biology textbooks is the dominant contribution of the entropy in driving important biological processes towards equilibrium. From diffusion to cell-membrane formation, to electrostatic binding in protein folding, to the functioning of nerve cells, entropic effects often act to counterbalance deterministic forces such as electrostatic attraction and in so doing, allow for effective molecular signaling. A small group of biology, biophysics and computer science faculty have worked together for the past five years to develop curricular modules (based on SCALEUP pedagogy) that enable students to create models of stochastic and deterministic processes. Our students are first-year engineering and science students in the calculus-based physics course and they are not expected to know biology beyond the high-school level. In our class, they learn to reduce seemingly complex biological processes and structures to be described by tractable models that include deterministic processes and simple probabilistic inference. The students test these models in simulations and in laboratory experiments that are biologically relevant. The students are challenged to bridge the gap as statistical parameterization of their data (mean and standard deviation) and simple model-building by inference. This allows the students to quantitatively describe realistic cellular processes such as diffusion, ionic transport, and ligand-receptor binding. Moreover, the students confront “random” forces and traditional forces in problems, simulations, and in laboratory exploration throughout the year-long course as they move from traditional kinematics through thermodynamics to electrostatic interactions. This talk will present a number of these exercises, with particular focus on the hands-on experiments done by the students. We will give examples of the tangible material that our students work with throughout the two-semester sequence of their course on introductory physics with a bio focus.

\(^1\)Supported by NSF DUE.

9:06AM H10.00002 Optimizing Introductory Physics for the Life Sciences: Placing Physics in Biological Context — CATHERINE CROUCH, Swarthmore College — Physics is a critical foundation for today’s life sciences and medicine. However, the physics content and ways of thinking identified by life scientists as most important for their fields are often not taught, or underemphasized, in traditional introductory physics courses. Furthermore, such courses rarely give students practice using physics to understand living systems in a substantial way. Consequently, students are unlikely to recognize the value of physics to their chosen fields, or to develop facility in applying physics to biological systems. At Swarthmore, as at several other institutions engaged in reforming this course, we have reorganized the introductory course for life science students around touchstone biological examples, in which fundamental physics contributes significantly to understanding biological phenomena or research techniques, in order to make explicit the value of physics to the life sciences. We have also focused on the physics topics and approaches most relevant to biology while seeking to develop rigorous qualitative reasoning and quantitative problem solving skills, using established pedagogical best practices. Each unit is motivated by and culminates with students analyzing one or more touchstone examples. For example, in the second semester we emphasize electric potential and potential difference modeling of a cell’s membrane and of electrical interactions in biochemistry to help them develop a more sophisticated understanding of electric forces, field, and potential, including in the salt water environment of life. Other second semester touchstones include optics of vision and microscopes, circuit models for neural signaling, and magnetotactic bacteria. When possible, we have adapted existing research-based curricular materials to support these examples. This talk will describe the design and development process for this course, give examples of materials, and present initial assessment data evaluating both content learning and student attitudes.

9:42AM H10.00003 Coordinating an IPLS class with a biology curriculum: NEXUS/Physics\(^1\) — EDWARD REDISH, Univ of Maryland-College Park — A multi-disciplinary team of scientists has been reinventing the Introductory Physics for Life Scientists (IPLS) course at the University of Maryland. We focus on physics that connects elements common to the curriculum for all life scientists — molecular and cellular biology — with building general scientific competencies, such as mathematical modeling, reasoning from core principles, and multi-representation translation. The prerequisites for the class include calculus, chemistry, and biology. In addition to building the basic ideas of the Newtonian framework, electric currents, and optics, our prerequisites allow us to include topics such as atomic interactions and chemical bonding, random motion and diffusion, thermodynamics (including entropy and free energy), and spectroscopy. Our chemical bonding unit helps students link the view of energy developed in traditional macroscopic physics with the idea of chemical bonding as a source of energy presented in their chemistry and biology classes. Education research has played a central role in our design, as has a strong collaboration between our Discipline-Based Education and the Biophysics Research groups. These elements permit us to combine modern pedagogy with cutting-edge insights into the physics of living systems.

\(^1\)Supported in part by a grant from HHMI and the US NSF grant #1122818/

Sunday, April 6, 2014 8:30AM - 10:18AM — Session H11 GGR FGSA: Invited Session: Careers beyond General Relativity Oglethorpe Auditorium — Benjamin Farr, Northwestern University

8:30AM H11.00001 Numerical Relativity as preparation for Industrial Data Science, a personal perspective — KENNETH SMITH, Applied Technical Systems, Inc. — Much of the conversation in commercial enterprises these days revolves around industry buzz words such as Big Data, Data Science, and being Data Driven. Beyond the hype surrounding these terms, there is a real, continuously growing movement for organizations to make better use of the data assets they have to inform decisions, strategy, and policy. This push is not unique to the commercial sector; governmental and academic organizations are also embracing such initiatives. The skills required to staff a Data Science project typically come from a number of disciplines, ranging from computer science, statistics, modeling and simulation, to information technology, but the emerging wisdom in the community is that the rigor and discipline of a scientific background often makes for the best data scientists. In this talk, I will offer a personal perspective on making the transition from a career in computational physics (specifically Numerical Relativity) to a career in industry, where I have focused on helping organizations make more informed decisions through better access and analysis of data at their disposal. I will identify the skills and training that carry over from a background in physics, discuss the gaps in that preparation, hypothesize as to where this industry is headed, and offer a frank look at a life outside of academia.

9:06AM H11.00002 From Cosmology to Consulting — WILLIAM NELSON, Princeton Consultants — I will discuss my transition from Quantum Gravity and Cosmology to the world of consulting and describe the differences and similarities between academia and industry. I will give some dos and don’ts for industry interviews and jobs searches.

9:42AM H11.00003 Developing Technology Products - A Physicist’s Perspective — MICHAEL BURKA, Thermo Fisher Scientific — There are many physicists working in the industrial sector. We rarely have the word physicist in our job title; we are far more commonly called engineers or scientists. But, we are physicists, and we succeed because our training in physics has given us the habits of mind and the technical skills that one needs to solve complex technical challenges. This talk will explore the transition from physics research to technology product development using examples from my own career, first as a postdoctoral fellow and research scientist on the LIGO project, and then developing products in the spectroscopy, telecommunications, and medical device industries. Approaches to identifying and pursuing opportunities in industry will be discussed.
8:42AM H12.00002 The XENON1T Demonstrator: Impact of the recirculation of the gas above the liquid xenon on the purity , HUGO CONTRERAS, Columbia University, XENON COLLABORATION — XENON1T is the third detector in the XENON project for direct detection of Dark Matter. Its construction started at the end of 2013, and will achieve a sensitivity in the spin-independent cross section to 2.e-47 cm² for a 50GeV/c² WIMP. XENON1T is a dual phase liquid xenon TPC detector with a fiducial mass of 1.1 ton and a length of 1m. To address the most important technical challenges involved in the scaling of this kind of detectors a facility was built in the Nevis Laboratories at Columbia University, the XENON1T Demonstrator, a dual-phase TPC with a 1-meter drift length. One of the main research topics in this facility has been the improvement of the purification process in XENON1T. The new approach includes the direct recirculation of the gas xenon layer on top of the active liquid xenon, to improve both the purification time and the maximum purity achievable in XENON1T. In this talk we will summarize the results obtained with this improved recirculation system in the XENON1T Demonstrator.

8:54AM H12.00003 A New Method for Electronic Recoil Calibration in Liquid Noble Dark Matter Detectors , SEAN MACMULLIN, Purdue University, XENON COLLABORATION — Calibration of next-generation liquid noble dark matter detectors present new challenges because radiation from external sources will not probe the entire target, owing to its large volume and high stopping power. For electronic recoil calibration in particular, a proposed solution is to dissolve a source of low-energy β-electrons directly into the liquid. A particularly promising candidate is ²¹¹Pb, a daughter of ²²²Rn. We have acquired a custom-made source of electrodeposited ²²⁸Th that efficiently emanates the desired ²²⁰Rn. Details of recent measurements of mixing ²²⁰Rn and its daughters in a liquid xenon detector and future prospects will be presented.

9:06AM H12.00004 Limits on GeV-scale WIMPs using charge signals in XENON100 , RICHARD WALL, Rice University, XENON100 COLLABORATION — Various theoretical models and recent experimental results have led to growing interest in the search for WIMP-like dark matter in the mass range of a few GeV. One important class of detector used in this study is based on the liquid-gas, dual-phase Xenon time projection chamber (as in XENON100 and LUX). These detectors nominally use both scintillation (S1) and ionization (S2) signals to localize collision events in their sensitive volumes and thus reject background events, but it is known that the efficiency for detecting small S1 signals (such as are expected from a GeV-scale WIMP interaction) is much smaller than the efficiency for detecting an S2 from the same recoil. By removing the requirement of an observed S1 signal, one can thus effectively lower the energy threshold of the detector, and study GeV-scale WIMPs with greater sensitivity. With this in mind, we measure the rate of WIMP candidates in 225 days of XENON100 data in events with small S2 signals (with or without an accompanying S1) and which pass other simple selection cuts optimized for GeV-scale WIMPs. This rate is then used to set a limit on the WIMP-nucleon cross-section for the mass range 1-10 GeV.

9:18AM H12.00005 SuperCDMS SNOLAB Experiment and Active Neutron Veto , YU CHEN, Syracuse University, SUPERCDMS COLLABORATION — The SuperCDMS SNOLAB experiment will attempt direct detection of the most promising candidate for dark matter, Weakly Interacting Massive Particles (WIMPs) using cryogenically cooled germanium and silicon semiconductors that provide sub-keV thresholds and rejection of most radioactivity or cosmic-ray-induced backgrounds. An active neutron veto with high efficiency for tagging neutron-induced backgrounds will not only directly reduce the neutron background rate, but also provide an in-situ measurement of the neutron activity near the dark matter target. This active veto will consist of liquid scintillator doped with an isotope with high neutron-capture cross section. I will present a brief overview of the experiment, and report in detail on the current status of simulation and prototyping of this neutron veto.

9:30AM H12.00006 Optimizing SuperCDMS phonon energy sensitivity by studying quasiparticle transport in Al films , JEFFREY YEN, BENJAMIN SHANK, BLAS CABRERA, ROBERT MOFFATT, PETER REDL, Stanford University, PAUL BRINK, ASTRID TOMADA, MATT CHERRY, SLAC National Accelerator Laboratory, BETTY YOUNG, BETTY TARTORICI, JOHN MARK KREIKEBAUM, Santa Clara University. CDMS COLLABORATION — In order to further improve the phonon energy sensitivity of Cryogenic Dark Matter Search (CDMS) detectors, we studied quasiparticle transport at ~ 40 mK in superconducting Al films similar in geometry to those used for CDMS detectors. Test structures of Al were deposited and photolithographically patterned on Si wafers using the same production-line equipment used to fabricate kg-scale CDMS detectors. Three Al film lengths and two film thicknesses were used in this study. In the test experiments described here, a 55Fe source was used to excite a NaCl reflector, producing 2.6 keV x-rays that hit our test devices after passing through a collimator. The impinging x-rays broke Cooper pairs in the Al films, producing quasiparticles that propagated into W transition edge sensors (TESs) coupled to the ends of the Al films. In this talk, we will give the motivation behind these studies, describe our experimental setup, and compare our data to results obtained using signal processing models constructed from basic physical parameters. We show that a non-linear, non-stationary optimal filter applied to the data allows us to precisely measure quasiparticle diffusion and other aspects of energy transport in our thin-film Al-W test devices. These results are being used to further optimize next-generation CDMS detectors.

9:42AM H12.00007 A Template-Matching Method For Measuring Energy Depositions In TES Films , BENJAMIN SHANK, JEFFREY YEN, BLAS CABRERA, JOHN MARK KREIKEBAUM, ROBERT MOFFATT, PETER REDL, Stanford University, BETTY YOUNG, Santa Clara University, Stanford University, PAUL BRINK, MATTHEW CHERRY, ASTRID TOMADA, SLAC National Accelerator Facility, SUPERCDMS COLLABORATION — Transition edge sensors (TES) have a wide variety of applications in particle astrophysics for detecting incoming particles with high energy resolution. In TES design, the need for sufficient heat capacity to avoid saturation limits the ultimate energy resolution. Building on the TES model developed for SuperCDMS by Yen et. al, for tungsten TESs deposited next to aluminum collection fins, we outline a time-domain non-linear optimal filter method for reconstructing energy depositions in TES films. This allows us to operate devices into their saturation region while taking into account changing noise performance and loss of energy collection. We show how this method has improved our understanding of quasiparticle diffusion and energy collection in our superconducting sensors.
9:54AM H12.00008 Geant4 Simulations of SuperCDMS iZip Detector Charge Carrier Propagation. ROBERT AGENE, Univ of Florida - Gainesville, DANIEL BRANDT, SLAC National Accelerator Laboratory, PETER REDL, Stanford University, MAKOTO ASAI, SLAC National Accelerator Laboratory, DANA FAIEZ, University of California Berkeley, MIKE KELSEY, ENRICO BAGLI, SLAC National Accelerator Laboratory, ADAM ANDERSON, CHANDLER SCHLUFF, Massachusetts Institute of Technology, SUPERCDMS COLLABORATION — The SuperCDMS experiment uses germanium crystal detectors instrumented with ionization and phonon readout circuits to search for dark matter. In order to simulate the response of the detectors to particle interactions the SuperCDMS Detector Monte Carlo (DMC) group has been implementing the processes governing electrons and phonons at low temperatures in Geant4. The charge portion of the DMC simulates oblique propagation of the electrons through the L-valleys, propagation of holes through the Γ-valleys, inter-valley scattering, and emission of Neganov-Luke phonons in a complex applied electric field. The field is calculated by applying a directed walk search on a tetrahedral mesh of known potentials and then interpolating the value. This talk will present an overview of the DMC status and a comparison of the charge portion of the DMC to experimental data of electron-hole pair propagation in germanium.

10:06AM H12.00009 Spatial Imaging of Charge Transport in Germanium at Low Temperature. ROBERT MOFFATT, BLAS CABRERA, Stanford Univ, FEDJA KADRIBASIC, Texas A&M University, PETER REDL, BENJAMIN SHANK, Stanford Univ, BETTY YOUNG, Santa Clara University, DANIEL BRANDT, PAUL BRINK, MATTHEW CHERRY, ASTRID TOMADA, SLAC National Accelerator Laboratory — Because germanium is an indirect-gap semiconductor, the energy minima of the conduction band occur at four locations on the edges of the Brillouin zone. These minima have differing anisotropic mass tensors, causing electrons to travel obliquely to an applied electric field and to separate into four distinct clusters. A better understanding this process may improve the reconstruction of particle interactions in the germanium detectors used by the Cryogenic Dark Matter Search (CDMS). In addition, the possibility exists that the distribution of electrons among the four minima may preserve some information about the initial direction of a dark matter recoil event. To observe this oblique propagation, we excited a point source of charge carriers with a focused laser pulse on one face of a 4mm thick germanium crystal. After the electrons were drifted through a uniform electric field, the pattern of charge density arriving on the opposite face was mapped and used to reconstruct the trajectories of the four clusters. This talk will present the latest results of the charge-transport experiment, including measurements of the electron and hole charge density patterns and the scattering rate between energy minima as a function of both temperature and electric field strength.

Sunday, April 6, 2014 8:30AM - 10:18AM — Session H13 GPMFC DPF: QCD Physics

8:30AM H13.00001 FCNC Top Quark Production Via Anomalous Gluon Coupling1. ELWIN MARTIN, Georgia Institute of Technology, NIKOLAOS KIDONAKIS, Kennesaw State University — We calculate flavor-changing neutral current (FCNC) processes with top-quark production via anomalous gluon couplings at various LHC energies. We present the FCNC process \( p\bar{p} \rightarrow t\bar{g} \). We go beyond leading order and include soft-gluon corrections through next-to-next-to-leading order. Additionally, we report the impact of QCD scale variation on the cross section.

1This material is based upon work supported by the National Science Foundation under Grant No. PHY 1212472.

8:42AM H13.00002 Radii of protons and a way to resolve the proton size puzzle. XIAO-FAN CHEN, Harbin Institute of Technology — How to determine radii of protons is a hot topic in recent particle physics. From the research, one can gain information about proton structure and quark-quark interaction, and test quantum chromodynamics and quantum electrodynamics. In this paper, we study radii of protons in terms of wave functions and the way to resolve the proton size puzzle.

8:54AM H13.00003 Study of double parton interactions in photon + 3 jets events and photon + b/c + 2 jets events at the Tevatron. GEORGY GOLOVANOV, Joint Institute for Nuclear Research. D0 COLLABORATION — We have used a sample of photon + 3 jets as well as photon + b/c + 2 jets events collected by the D0 experiment with an integrated luminosity of 8.7 fb\(^{-1}\) to determine the fraction of events with hard double parton (DP) scattering in a single proton-antiproton collision at \( \sqrt{s} = 1.96 \) TeV. The DP fraction and effective cross section, a process-independent scale parameter related to the parton density inside the nucleon, are measured in the kinematic region \( p_T^{j1} > 26 \) GeV, \( p_T^{j1} > 15 \) GeV, and \( 15 \leq p_T^{j2,3} \leq 35 \) GeV.

9:06AM H13.00004 Signal Reconstruction and Performance of the ATLAS Hadronic calorimeter1. ATLAS ATLAS, ATLAS, ATLAS COLLABORATION — The Tile Calorimeter (TileCal) of the ATLAS experiment is the hadronic calorimeter designed for energy reconstruction of hadrons, jets, tau-particles and missing transverse energy. Latest results on calibration, signal reconstruction and performance of the TileCal detector using pp collision data are presented. The studies of the TileCal response to single isolated charged particles and the noise description with increasing pile-up are presented. In addition, TileCal upgrade plans are discussed.

1on behalf of the ATLAS Collaboration

9:18AM H13.00005 Comparisons of Exact Amplitude–Based Resummation Predictions and LHC Data1. A. MUKHOPADHYAY, Baylor University, Waco, TX, USA, S.K. MAJHI, IACS, Kolkata, IN, B.F.L. WARD, Baylor University, Waco, TX, USA, S.A. YOST, The Citadel, Charleston, SC, USA — We present the current status of the comparisons with the respective data of the predictions of our approach of exact amplitude-based resummation in quantum field theory as applied to precision QCD calculations as needed for LHC physics. The agreement between the theoretical predictions and the data exhibited continues to be encouraging.

1Work supported by CERN TH Unit, DoE grants DE-FG02-09ER41600, DE-PS02-09ER090-01 and grants from The Citadel Foundation.

9:30AM H13.00006 Measurements of \( W + b + X \) and \( W + c + X \) production cross sections at the Tevatron. OLGA GOGOTA, Kiev National University, D0 COLLABORATION — Studies of associated production of a \( W \) boson with heavy quark \((b/c)\) jets provide important tests of perturbative quantum chromodynamics calculations. A good understanding of such processes is also essential because they constitute a major background to the production of the standard model Higgs boson in association with a \( W \) boson. We present measurements of \( W + b + X \) and \( W + c + X \) production using Run 2 Tevatron data collected by the D0 detector. The measurements are performed for the integrated acceptance as well as differentially as a function of leading jet transverse momenta. These results are compared to theory calculations as well as prediction from Monte Carlo generators.
9:42AM H13.00007 Topological insulators and the QCD vacuum: the theta parameter as a Berry phase, HARRY THACKER, Univ of Virginia — There is considerable evidence, based on large $N_c$ chiral dynamics, holographic QCD, and Monte Carlo studies, that the QCD vacuum is permeated by discrete quasivacua separated by domain walls across which the local value of the topological $\theta$ parameter jumps by $\pm 2\pi$. This scenario is realized in a 2-dimensional $U(1)$ gauge theory, the $CP^{N-1}$ sigma model, where a pointlike charge is a domain wall, and $\theta$ describes the background electric flux and the polarization of charged pairs in the vacuum. The transition between discrete $\theta$ vacua occurs via the transport of integer units of charge between the two spatial boundaries of the domain. We show that this screening process, and the role of $\theta$ as an order parameter describing electric polarization, are naturally formulated in terms of Bloch wave eigenstates of the Dirac Hamiltonian in the background gauge field. This formulation is similar to the Berry phase description of electric polarization and quantized charge transport in topological insulators.

9:54AM H13.00008 Measurements of the prompt single $J/\psi$ and double $J/\psi$ production cross section at the Tevatron, ROBERT HIROSKY, University of Virginia, D0 COLLABORATION — We present measurements of the production cross section of prompt $J/\psi$ mesons, as well as the cross section of simultaneous production of two prompt $J/\psi$ mesons, in proton-antiproton collisions at $\sqrt{s} = 1.96$ TeV using 8.1 fb$^{-1}$ of Tevatron data collected by the D0 experiment. The latter cross section is separated into contributions due to single parton and double parton scatterings. The $J/\psi$ mesons are fully reconstructed in the muonic final state. Using these measurements, the effective cross section, a parameter characterizing an effective spatial area of parton-parton interaction and tightly related to the parton spatial density inside the nucleon, is also measured.

10:06AM H13.00009 Measurement of the muon charge asymmetry in inclusive pp to WX production at sqrt(s) = 7 TeV, HASAN OGUL, University of Iowa, CMS, CMS COLLABORATION — Measurements of the muon charge asymmetry in inclusive pp to WX production at sqrt(s) = 7 TeV are presented. The data sample corresponds to an integrated luminosity of 4.7 inverse femtobarns recorded with the CMS detector at the LHC. With a sample of more than twenty million W to mu nu events, the statistical precision is greatly improved in comparison to previous measurements. These new results provide additional constraints on the parton distribution functions of the proton in the range of the Bjorken scaling variable x from 10E-3 to 10E-1. These measurements are used together with the cross sections for inclusive single inelastic ep scattering at HERA in a next-to-leading-order QCD analysis. The determination of the valence quark distributions is improved.

Sunday, April 6, 2014 8:30AM - 10:18AM – Session H14 GHP: Spin Structure

8:30AM H14.00001 Sivers Function in the Quasi-Classical Approximation1, MATTHEW SIEVERT, YURI KOVCHEGOV, Ohio State Univ - Columbus — We study the origin of the Sivers function in the quasi-classical limit (McLerran-Venugopalan model), applicable when the density of color charges is large. The classical limit can be achieved by a heavy nucleus, which already possesses a large number of color charges in its rest frame, or by boosting any hadron to sufficiently high energy that gluon bremsstrahlung drives up the charge density. The large charge density in the classical limit allows us to resum multiple rescatterings and permits a mean-field description, such as a hadron made up of a large number of independent low-$x$ partons. This allows us to decompose the TMD’s of the hadron in terms of the TMD’s of its partons, the Wigner distributions of the partons within the hadron, and additional functions that account for the interaction of the partons. This work can be readily extended to study other TMD’s and to include quantum evolution.

1This research is sponsored in part by the U.S. Department of Energy under Grant No. DE-SC0004286

8:42AM H14.00002 Transverse Single-Spin Asymmetries for Jet-like Events at Forward Rapidities in $p + p$ Collisions at $\sqrt{s} = 500$ GeV with the STAR Experiment1, MRIGANKA MOULI MONDAL, Texas A&M University, STAR COLLABORATION — Large transverse single-spin asymmetries ($A_N$) have been observed for forward inclusive hadron production in $p + p$ collisions at various energies. In the collinear perturbative scattering picture, twist-3 multi-parton correlations can give rise to such an asymmetry. A transversely polarized quark can also give rise to a spin-dependent distribution of its hadron fragments via the Collins mechanism. The observed $A_N$ may involve contributions from both processes. These can be disentangled by studying asymmetries for jets, direct photons and jet-fragments. The STAR Forward Meson Spectrometer (FMS), a Pb-glass electromagnetic calorimeter covering the pseudo-rapidity range 2.6-4.2 and full azimuth, can detect photons, neutral pions and eta mesons. We are measuring $A_N$ for jet-like events reconstructed from photons in the FMS in $p + p$ collisions at $\sqrt{s} = 500$ GeV that were recorded during the 2011 RHIC run. We study $A_N$ as a function of the number of observed photons, thereby exploring asymmetries for a range of event classes. The current status of the analysis will be discussed.

1Mriganka Mouli Mondal, Texas A&M University (for the STAR Collaboration)

8:54AM H14.00003 Measurement of transverse spin dependent fragmentation of $\pi^0/\eta$ mesons in $e^+e^-$ Annihilation at Belle1, HAIRONG LI, Indiana University, BELLE COLLABORATION — Large transverse single spin asymmetries $A_N$ have been observed in polarized proton-proton collisions over a wide range of energies. The mechanism behind this effect is still not understood. One possible contribution is the so-called Collins effect, which describes the polarization dependent fragmentation of transversely polarized quarks. In addition on shedding light on the mechanism behind $A_N$ in polarized $p + p$ collisions a precise knowledge of the spin dependent fragmentation function is also needed for the extraction of the so-called transversity parton distribution function (PDF), one of the three leading twist PDFs that is needed to describe the proton in a collinear picture. Recently, the Collins effect has been measured for charged pions in $e^+e^-$ annihilation at the Belle and BaBar experiments. This talk will focus on the measurement of the Collins effect for the neutral $\pi^0$ and $\eta$ mesons in $e^+e^-$ annihilation near the $Y(4S)$ resonance at the Belle experiment. This channel is of interest to study the flavor dependence of the Collins effect and to investigate the mechanism behind the observed difference of $A_N$ for $\eta$ and $\pi^0$ mesons.

1Indiana University (for Belle collaboration)
9:06AM H14.00004 Extracting $W$ Single Spin Asymmetry in Longitudinally Polarized $pp$ Collisions at PHENIX forward arms\(^1\), ABRAHAM MELES\(^2\), New Mexico State University — The parity-violating asymmetry $A_2$ in the production of $W$ bosons in $p+p$ collisions at $\sqrt{s} = 510$ GeV is sensitive to the polarization of light quarks and anti-quarks in the proton. However, identifying the lepton from the decay of the $W$ is challenging due to a great background of hadronic processes. In the forward and backward hemispheres of PHENIX at RHIC, the muon spectrometers have been recently upgraded in order to provide additional trigger and tracking information to suppress those backgrounds. One of those upgrades is the Forward Vertex (FVTX) detector, a silicon-strip tracker. In 2013, PHENIX collected approximately 240 pb\(^{-1}\) of polarized $p+p$ collisions at $\sqrt{s} = 510$ GeV with a beam polarization of 52\%. The ability of the FVTX to improve the $W$ signal will be reviewed, and progress on analysis of real data in the RHIC 2013 run will be discussed.

\(^1\)Supported by the US DOE, Office of Science
\(^2\)(Physics Department, New Mexico State University, Las Cruces NM 88003)

9:18AM H14.00005 Neutron structure via forward tagging of the $eD \rightarrow e'NX$ reaction at the Electron-Ion Collider , KIJUN PARK, Old Dominion University, JEFFERSON LAB COLLABORATION — I report about the status of a Jefferson Lab 2014 LDRD project exploring the physics potential of deep-inelastic scattering on polarized light ions with forward spectator nucleon tagging with the proposed Electron-Ion Collider (EIC). Such measurements offer unique capabilities for precision studies of neutron spin structure, nuclear modifications of partonic structure, and multiple scattering effects at high energies. We simulate the tagged processes on the $D$ as a function of the $Q^2$, $x_{Bj}$, and the spectator momenta. We quantify the effects of the intrinsic motion of beam particles, as well as the EIC detector acceptance and resolution, on the projected observables. We present results of a model-independent extraction of the free neutron structure function $F_{2n}$ through on-shell extrapolation in the spectator momentum [MSargesian]. Comparison of the bound proton structure function $F_{2p}$ with the free proton result provides a crucial test of the method and allows for an unambiguous identification of nuclear binding effects. Future work will extend these studies to polarized deuterons (spin structure functions $g_1^T$ and $g_2^T$) and hard exclusive processes (GPDs), and model the final-state detection through a full GEANT4-based simulation.

9:30AM H14.00006 Deeply virtual Compton scattering on longitudinally polarized protons at CLAS , ANGELA BISELLI, Fairfield Univ, CLAS COLLABORATION — The Generalized Parton Distributions (GPDs) have emerged as a universal tool to describe hadrons in terms of their elementary constituents, the quarks and the gluons. Deeply Virtual Compton Scattering (DVCS) ($ep \rightarrow e'p\gamma$) is one of the simplest processes that can be described in terms of GPDs. The DVCS-Bethe-Heitler (BH) interference gives rise to spin asymmetries, which can be connected to combinations of Compton Form Factors (CFFs), which are integrals of GPDs. The longitudinal target single-spin asymmetry (SSA) is directly proportional to the imaginary part of the DVCS amplitude, and gives access to a combination of the CFFs $Im(H)$ and $Im(N)$, whereas the double-spin asymmetry (DSA) is proportional to a combination of the CFFs $Re(H)$ and $Re(N)$. These asymmetries were measured in a dedicated experiment at Jefferson Lab using the CEBAF 6-GeV polarized-electron beam, a longitudinally polarized solid-state $^{14}$N target, and the CEBAF Large Acceptance Spectrometer, together with the Inner Calorimeter. DVCS/BH events were selected over the following kinematic ranges: $1 < Q^2 < 4.5$ GeV\(^2\), $0.1 < x_B < 0.58$, $0.08 < -t < 1.8$ GeV\(^2\) and, the target-SSA and DSA were

9:42AM H14.00007 Quark Angular Momentum Distribution in the Transverse Plane , LEKHA ADHIKARI\(^1\), MATTHIAS BURKARDT\(^2\), New Mexico State University — Several possibilities to relate the $t$-dependence of generalized parton distributions (GPDs) to the distribution of angular momentum in the transverse plane are discussed. None of them turns out to correctly describe the orbital angular momentum distribution that one would identify for a longitudinally polarized target.

\(^1\)Graduate Student
\(^2\)Professor, Ph. D. Advisor

9:54AM H14.00008 The D-term of Exploding Q-Balls , MICHAEL CANTARA, PETER SCHWEITZER, Univ of Connecticut - Storrs — Form factors of the energy momentum tensor contain essential information on the considered particle such as mass, spin, and a property called D-term. Although it is experimentally unknown, the D-term is a particle property as fundamental as mass, spin, electric charge or magnetic moment. Only very recently it became clear how the D-term of the nucleon can in principle be studied in hard exclusive reactions like deeply virtual Compton scattering or hard meson production. But present data do not yet allow an unambiguous determination of the D-term of nucleons or nuclei. Meanwhile the only source of information are theoretical studies. Interestingly, in all calculations (in models, effective theories) the D-terms of various particles (pions, nucleons, nuclei, photons) were always found to be negative. The deeper reason for this was recently elucidated in a study of Q-balls in scalar field theories with U(1) symmetry: stable Q-balls must have a negative D-term. However, also meta-stable and even unstable Q-balls have negative D-terms. The emerging question is whether one can ever encounter a positive D-term in a physical situation. We show that this can indeed happen in the Q-ball system in the limit when unstable Q-balls dissociate into a Q-cloud, i.e. free and unbound Q-quantas.
8:30AM H15.00001 Mis-modelling in Gravitational Wave Astronomy: The Trouble with Templates, LAURA SAMPSON, NEIL CORNISH, NICOLAS YUNES, Montana State University — Waveform templates are a powerful tool for extracting and characterizing gravitational wave signals. There are, however, attendant dangers in using these highly restrictive signal priors. If strong field gravity is not accurately described by General Relativity (GR), then using GR templates may result in fundamental bias in the recovered parameters, or worse - a complete failure to detect signals. Here we study such dangers, concentrating on three distinct possibilities. First, we show that there exist modified theories compatible with all existing tests that would fail to be detected by the LIGO/Virgo network using searches based on GR templates, but which would be detected using a one parameter post-Einsteinian extension. Second, we study modified theories that produce departures from GR that do not naively fit into the simplest parameterized post-Einsteinian (ppE) scheme. We show that even the simplest ppE templates are still capable of picking up these strange signals and diagnosing a departure from GR. Third, we study how using inspiral-only ppE waveforms for signals that include merger and ringdown can lead to problems in misidentifying a GR departure. We present an easy technique that allows us to self-consistently identify the inspiral portion of the signal.

8:42AM H15.00002 A sparse representation of gravitational waves from precessing compact binaries, JONATHAN BLACKMAN, BELA SZILAGYI, CHAD GALLEY, Cal Inst of Tech (Caltech), MANUEL TIGLIO, Cal Inst of Tech (Caltech), University of Maryland — With the advancement of gravitational wave detectors coming online in the near future, there is a need for accurate models of gravitational waveforms emitted by binary neutron stars and/or black holes. Post-Newtonian approximations work well for the early inspiral and there are models covering the late inspiral as well as merger and ringdown for the non-precessing case. While numerical relativity simulations have no difficulty with precession and can now provide accurate waveforms for a broad range of parameters, covering the 7 dimensional precessing parameter space with ~ 10^7 simulations is not feasible. There is still hope, as reduced order modelling techniques have been highly successful in reducing the impact of the curse of dimensionality for lower dimensional cases. We construct a reduced basis of Post-Newtonian waveforms for the full parameter space with mass ratios up to 10 and spins up to 0.9, and find that for the last 100 orbits only ~ 50 waveforms are needed. The huge compression relies heavily on a reparametrization which seeks to reduce the non-linearity of the waveforms. We also show that the addition of merger and ringdown only mildly increases the size of the basis.

8:54AM H15.00003 Bayesian Inference for Transient Gravitational Waves and Instrument Glitches: Theory, NEIL CORNISH, Montana State University, TYSON LITTENBERG, Northwestern University — A central challenge in Gravitational Wave Astronomy is identifying weak signals in the presence of non-stationary and non-Gaussian noise. This requires good models for both the signals and the noise. When accurate signal models are available, such as for binary Neutron star systems, it is possible to make robust detection statements even when the noise is poorly understood. In contrast, searches for “un-modeled” burst signals are strongly impacted by the methods used to characterize the noise. I will describe a Bayesian approach to the problem that employs a multi-component, variable dimension, parameterized noise model that explicitly accounts for non-stationarity and non-Gaussianity in data from interferometric gravitational wave detectors.

9:06AM H15.00004 Bayesian Inference for Gravitational Wave Transients and Instrument Glitches: Applications, TYSON LITTENBERG, CIERA/Northwestern University, NEIL CORNISH, Montana State University, VICKY KALOGERA, CIERA/Northwestern University — Optimally identifying and characterizing gravitational wave signals requires accurate models for both the signal and the noise. We have developed a pair of tools, BayesLine and BayesWave, that work together to reliably extract signals from either compact binary mergers or un-modeled bursts of gravitational waves from the non-stationary and non-Gaussian noise of the LIGO instruments. BayesLine dynamically estimates the power spectrum of the Gaussian component of the noise, including the many line features, while BayesWave models noise transients (glitches) and, in the absence of template waveforms, gravitational wave bursts. The effectiveness of this novel approach is demonstrated on data from LIGO’s sixth science run.

9:18AM H15.00005 Detecting and characterizing black hole binary mergers without waveform templates, MARGARET MILLHOUSE, NEIL CORNISH, Montana State University, TYSON LITTENBERG, Northwestern University — LIGO/Virgo searches for transient gravitational waves are conventionally divided into two classes - "un-modeled" burst searches and template based searches. But these are just two extremes in a continuum of possibilities that depend on the strength of our prior knowledge of the signals. The BayesWave algorithm is a flexible approach to gravitational wave data analysis that is able to span the full continuum of models. I will describe how a model of the time-frequency evolution of a binary system can be used as a parameterized signal prior that allows us to detect binary black hole mergers and extract physical properties such as the masses and spins without the need for waveform templates.

9:30AM H15.00006 Identification of BBH Merger Phenomenology Through Principal Component Analysis, DEIRDRE SHOEMAKER, JAMES CLARK, LAURA CADONATI, University of Massachusetts, Amherst, IK SIONG HENG, University of Glasgow, NICHOLAS MANGINI, University of Massachusetts, Amherst, LARNE PEKOWSKY, Georgia Institute of Technology — Recent years have seen dramatic progress in numerical simulations of the coalescence of binary black hole systems. However, the simulation of highly asymmetric, spinning systems and the construction of accurate waveforms for them is still problematic. We propose a data-driven estimation in such a high dimensional space, even using recently developed stochastic Bayesian analyses, is extremely computationally expensive. In addition to the parameter estimation solution using phenomenological templates and physical parameters, it would be informative to have a prompt, robust and automatic indication of whether the signal exhibits evidence for various signal traits such as precessional modulation or the presence of higher-order mode content. One possible approach here is to form catalogues of numerical relativity waveforms with distinct physical effects such as this and determine the relative probability that a given GW signal lies in each catalogue. We introduce, and report on the development of, an algorithm designed to perform this task for “burst-like” (i.e., merger-ringdown dominated) waveforms via principal analysis of waveform catalogues and the use of nested sampling to perform Bayesian model selection.

9:42AM H15.00007 Burst Searches for Compact Binary Coalescences, SERGEY KLIMENKO, University of Florida, LIGO COLLABORATION — Compact Binary coalescences (CBC) are the most promising sources of gravitational waves (GW) for the first detection with advanced GW detectors. Being the most efficient GW emitters among anticipated GW sources, they are also well understood theoretically in the framework of General Relativity. In this talk I will discuss different flavors of CBC sources and two types of search methods employed in the GW data analysis: template and excess power. While template methods are the most optimal for CBC sources, I will concentrate on the excess power methods, which are typical for searches of generic GW transients (bursts). How to use burst searches for CBC sources? Why would we do this? What can we learn about CBC sources from a burst search? - these and other questions will be discussed in the talk.

9:54AM H15.00008 Search for Gravitational Waves from Eccentric Binary Black Holes, VAIBHAV TIWARI, SERGEI KLIMENKO, Univ of Florida - Gainesville, LIGO BURST GROUP TEAM — Searches for compact binaries assume them to have circular orbits by the time the emitted gravitational radiation enter the frequency range of ground-based detectors. However such systems could also be produced through other channels, like dynamical interaction in galactic nuclei, when a significant fraction of formed binaries may maintain high eccentricities throughout their lifetime. These binaries have unique gravitational wave signatures and are not captured efficiently by searches designed for circular systems. We discuss this promising source of gravitational wave radiation and outline detection strategies with the initial and advanced ground-based detectors.
Sunday, April 6, 2014 8:30AM - 10:18AM –
Session H17 DCOMP DAP: Invited Session: The Impact of Advanced Digital Resources on Research in Physics 105-106 - Barry Schneider, National Institute of Standards and Technology

8:30AM H17.00001 Unearthing the excited hadron resonances in lattice QCD using NSF XSEDE resources
1. COLIN MORNINGSTAR, Carnegie Mellon University — Recent advances in computational techniques in lattice QCD, combined with the formidable capabilities of NSF XSEDE computing and data management resources, has enabled unprecedented access for theoretical studies to QCD excited states. First results of stationary-state levels in several symmetry sectors using very large sets of both single-meson and two-meson operators are presented. Our results are obtained in large volumes using quark masses producing a pion mass of 240 MeV, nearing the physical limit. Level identification using probe operators is discussed.

1Work supported by the NSF under award PHY-1306805 using XSEDE resources under award TG-MCA075017.

9:06AM H17.00002 Petascale Simulations of Core-Collapse Supernovae1, CHRISTIAN D. OTT, TAPIR, Caltech — Core-collapse supernovae from massive stars are among the most energetic events in the universe. They liberate a mass-energy equivalent of ~15% of a solar mass in the collapse of their progenitor star’s core. The majority (~99%) of this energy is carried away by neutrinos, while ~1% is transferred to the kinetic energy of the explosive outflow. A smaller, yet still tremendous amount of energy is emitted in electromagnetic and gravitational waves. Core collapse and the subsequent supernova evolution towards explosion involve a broad range of physics: Boltzmann transport of neutrinos, weak interactions, nuclear reactions, the nuclear equation of state, magnetohydrodynamics, and gravity. The problem is also multi-scale and for modeling the supernova engine, one must generally resolve physical scales from ~10000 km down to below ~100 m. Due to its multi-physics multi-scale nature, the core-collapse supernova problem poses a formidable computational challenge that requires petascale resources of the caliber of the NSF BlueWaters system. I review the computational approaches employed by the core-collapse supernova modeling community and present an overview of recent results from the first set of full 3D simulations.

1Supported by NSF under grant nos. PHY-1151197, AST-1212170, and OCI-0905046


Sunday, April 6, 2014 9:30AM - 10:30AM –
Session H18 FPS: FPS Business Meeting Jasper Boardroom -

9:30AM H18.00001 FPS Business Meeting —

Sunday, April 6, 2014 10:30AM - 12:00PM –
Session H20 Undergraduate Awards Brunch Hyatt Regency Savannah Scarbrough 3-4 -

10:30AM H20.00001 Undergraduate Awards Brunch —At this event, all undergraduate session presenters at the Meeting will be recognized with a special certificate, and top undergraduate oral and poster presenters will receive special physics prizes. A light meal will be served. Mentors are welcome and encouraged to attend.

Sunday, April 6, 2014 10:45AM - 12:33PM –
Session J2 DAP DPF: Invited Session: Dark Matter - Beyond WIMPs Chatham Ballroom A - Carsten Rott, Sungkyunkwan University

10:45AM J2.00001 Dark Matter Theory Beyond WIMPs in Light of Astroparticle and Collider Constraints, TRACY SLATYER, MIT — No abstract available.

11:21AM J2.00002 keV-mass dark matter candidates and constraints, SHUNSAKU HORIZUCHI, UC Irvine — The cold dark matter cosmological model has been extremely successful in explaining cosmic structure on large scales, but has ongoing challenges from observations that probe small-scale structures. Warm dark matter (WDM) provides a compelling alternative that help resolve such issues whilst maintaining the successes on large scales. After overviewing motivations for going beyond WIMP-based dark matter, I will review candidates of keV-mass WDM particles and their production mechanisms in the early Universe. I will then discuss their cosmological implications and explore the variety of constraints coming from structure as well as X-ray observations.

11:57AM J2.00003 Exploring the Dark Sector, ROUVEN ESSIG, Stony Brook University — Dark sectors, consisting of new, light, weakly-coupled particles that do not interact with the known strong, weak, or electromagnetic forces, are a particularly compelling possibility for new physics. Nature may contain numerous dark sectors, each with their own beautiful structure, distinct particles, and forces. This talk summarizes the physics motivation for dark sectors and the exciting opportunities for experimental exploration. It discusses axions, axion-like particles, dark photons, and other dark-sector particles, including sub-GeV dark matter. In many cases, the exploration of dark sectors can proceed with existing facilities and comparatively modest experiments. A rich, diverse, and low-cost experimental program has the potential for one or more game-changing discoveries.

Sunday, April 6, 2014 10:45AM - 12:33PM –
Session J3 GHP GFB: Invited Session: Chromo Dynamics Chatham Ballroom B - Matthias Burkardt, New Mexico State University
very well with experimental data up to $Z$ well for reliability in the perpendicular direction towards very neutron-rich nuclei. We compare calculated masses, and fission-fragment mass distributions in the heavy r-process region. Probabilities, ground-state spins and other quantities to experimental data. Also of interest to nucleosynthesis studies are our calculated fission barrier heights of $Z$ nuclei. These are retained by other nuclei to balance photoejection rates (quasiequilibrium). The abundance distribution adjusts slowly as remaining abundance lines (2) light curves of supernovae (3) chemical energy of free carbon dissociated from CO molecules (4) huge abundances of radiogenic daughters. I illustrate regions of shape coexistence. A troublesome staggering in the neutron separation energies in FRDM(1992) has almost disappeared. The of ground-state zero-point energies, A brief summary is in Phys. Rev. Lett. FRDM(2012) has an accuracy of 0.5595 MeV with respect to the AME2003 evaluation. There are several reasons for this improvement. A few are: 1) we included. New calculations of the pion distribution amplitude and elastic form factor combine to clarify a long standing puzzle about the transition domain $Q$ in continuum QCD-modeling of light quark hadrons. Some discussion of the high $Q^2$ behavior of elastic and transition electromagnetic form factors will be included. The behavior of elastic and transition electromagnetic form factors will be included. The transition domain where a perturbative elastic scattering mechanism takes over. Other meson distribution amplitudes and parton distribution functions may be discussed. Supported in part by the National Science Foundation Grant PHY-1206187.

Sunday, April 6, 2014 10:45AM - 11:45AM –
Session J4 DAP: Invited Session: Probing Inflation with the Cosmic Microwave Background
Chatham Ballroom C - Lloyd Knox, University of California, Davis

10:45AM J4.00001 Detection of Degree-Scale CMB B-Mode Polarization with BICEP2, JAMIE BOCK, California Institute of Technology — We report results from the BICEP2 experiment, a Cosmic Microwave Background (CMB) polarimeter specifically designed to search for the signal of inflationary gravitational waves in the B-mode power spectrum. We find an excess of B-mode power over the lensed lambda-CDM model which is inconsistent with the null hypothesis at a significance of $> 5$ sigma. Through jackknife tests and simulations based on detailed calibration measurements we show that systematic contamination is much smaller than the observed excess. We also estimate potential foreground signals and find that available models predict these to be considerably smaller than the observed signal. Additionally, cross-correlating BICEP2 against 100 GHz maps from the BICEP1 experiment, the excess signal is confirmed with 3-sigma significance and its spectral index is found to be consistent with that of the CMB, disfavoring synchrotron or dust at 2.3 sigma and 2.2 sigma, respectively. The observed B-mode power spectrum is wellfit by a lensed lambda CDM + tensor theoretical model with tensor/scalar ratio $r = 0.20 \pm 0.07 \pm 0.05$, with $r = 0$ disfavored at 7.0 sigma. We also discuss recent developments and future prospects.

10:45AM J6.00001 The sensitivity of r-process nucleosynthesis to individual nuclear properties, REBECCA SURMAN, Union College — Calculations of rapid neutron capture, or r-process, nucleosynthesis require nuclear data for thousands of nuclei far from stability. We currently have experimental information for only a handful of these nuclei, though many more neutron-rich species are within the reach of current and next generation experimental facilities. Sensitivity studies are one way to get at which of these thousands of nuclear properties are the most crucial to measure for the r-process. Our r-process sensitivity studies examine the roles of individual nuclear masses, beta decay rates, neutron capture rates, and beta-delayed neutron emission probabilities in r-process simulations in a variety of potential astrophysical environments. Here we will point out the pieces of nuclear data with the greatest impact on the final r-process abundance pattern and describe the mechanisms by which this influence occurs.

This work was supported in part by the Department of Energy under contract DE-FG02-05ER41398 and the National Science Foundation through the Joint Institute for Nuclear Astrophysics grant number PHY0822648.

11:21AM J6.00002 An astrophysical engine that stores gravitational work as nuclear Coulomb energy, DONALD CLAYTON, Clemson University — I describe supernovae gravity machines that store large internal nuclear Coulomb energy, $0.80Z^2A^{-1/3}$MeV per nucleus. Excess of it is returned later by electron capture and positron emission. Decay energy manifests as (1) observable gamma-ray lines (2) light curves of supernovae (3) chemical energy of free carbon dissociated from CO molecules (4) huge abundances of radiogenic daughters. I illustrate by rapid silicon burning, a natural epoch in SN II. Gravitational work produces the high temperatures that photoeject nucleons and alpha particles from heavy nuclei. These are retained by other nuclei to balance photoionization rates (quasiequilibrium). The abundance distribution adjusts slowly as remaining abundance of $Z-N^2$Si decomposes, so p, n, $\alpha$ recaptures hug the $Z=N$ line. This occurs in milliseconds, too rapidly for weak decay to alter bulk $Z/N$ ratio. The figure displays those quasiequilibrium abundances color-coded to their decays. $Z=N-2K$ nuclei having $k<11$ are stable, whereas $k>10$ are radioactive owing to excess Coulomb energy. Weak decays radiate that excess energy weeks later to fuel the four macroscopic energetic phenomena cited. How startling to think of the Coulomb nuclear force as storing cosmic energy and its weak decay releasing macroscopic activation to SNII.

11:33AM J6.00003 Benchmarks of results obtained in the new finite-range droplet model, PETER MOLLER, Los Alamos National Laboratory — The FRDM(1992) mass table has an accuracy of 0.669 MeV with respect to a 1989 mass evaluation. The FRDM(2012) has an accuracy of 0.5595 MeV with respect to the AME2003 evaluation. There are several reasons for this improvement. A few are: 1) we calculate the potential energy in a 4D deformation space with densely spaced grid points, 2) we include axial asymmetry, and 3) we have improved the calculation of ground-state zero-point energies, A brief summary is in Phys. Rev. Lett. 108 (2012) 052501. Locally, substantial improvements are achieved, mainly in regions of shape coexistence. A troublesome staggering in the neutron separation energies in FRDM(1992) has almost disappeared. The $Q_n$ values compare very well with experimental data up to $Z = 118$, which are very far (about 40 units in $A$) from the data to which the model was adjusted. This may bode well for reliability in the perpendicular direction towards very neutron-rich nuclei. We compare calculated masses, $\beta$-decay half-lives, $\beta$-delayed neutron-emission probabilities, ground-state spins and other quantities to experimental data. Also of interest to nucleosynthesis studies are our calculated fission-barrier heights and fission-fragment mass distributions in the heavy r-process region.
11:45 AM J6.00004 Effective Reaction Rates (ERR) for the Helium Burning Reactions¹. M. M. AUSTIN, MSU/NSCL, CHRISTOPHER WEST, University of Minnesota, ALEXANDER HEGE, University of Minnesota, Monash University, JINA COLLABORATION — Simulations of helium burning in presupernova stars are subject to uncertainties in the rates of both the triple alpha and $^{12}\alpha(c,\gamma)$ reactions and to approximations in the simulation itself, particularly in the treatment of convection. We have attempted to treat this problem in a consistent manner by introducing “Effective Reaction Rates” (ERR) for the two reactions, their parameters fixed by requiring that they reproduce the production of the intermediate mass and s-only isotopes. The process is based upon a data base of 2112 simulations (West et al., ApJ 769, 2 (2013)) in which the two rates are varied by $\pm 2\sigma$ for a set of 12 stars with masses from 12 – 30 $M_\odot$. We find that the abundances are well reproduced for ERR lying along a line $r_{\alpha,\gamma} = r_{\alpha,\gamma} + 0.35$. It is a test of the ERR procedure that the ERRs reproduce a variety of observables. For points along the ERR line, the central C fraction at the end of helium burning, the remnant mass after the SN explosion, and the yields of the neutrino isotopes have constant values.

¹US NSF: PHY08-22648 (JINA), PHY11-02511; US DOE: DE-AC52-06NA25396; ARC: FT120100

11:57AM J6.00005 Sensitive r-process nuclei production at Notre Dame, MAXIME BRODEUR, University of Notre Dame — Abundance calculations of the astrophysical rapid-neutron capture process, which is responsible for the synthesis of about half of the elements heavier than iron requires precise and accurate knowledge of ground state properties of neutron-rich nuclei. These sensitive quantities are often uncertain or unmeasured and must be calculated using phenomenological nuclear models. This lack of data is due to a combination of the minute production of these exotic nuclei and a lack of available experimental time. Indeed, all the relevant experimental efforts currently take place a reduced number of large user facilities where strong experimental time competition put a constraint on the number of measurements that can be performed yearly. To mitigate the situation, we propose the implementation of a dedicated radioactive ion beam facility at the University of Notre Dame. Neutron-rich nuclei will be produced in an element-independent manner by the proton-induced fission of actinide targets following the IG-ISOL method. This new facility will not only provide needed radioactive ion beams for research, but will also help reinforce the development of the future scientific workforce.

12:09PM J6.00006 $\beta$-decay studies of very neutron-rich Pd and Ag isotopes, KARL SMITH, Univ. of Notre Dame, Joint Institute of Nuclear Astrophysics, National Superconducting Cyclotron Laboratory, Helmholtzzentrum fur Schwerionenforschung, S323 / S410 COLLABORATION — The rapid-neutron capture process (r-process) is attributed as the source of nearly half the elements heavier than iron. To gain insight into the r-process nucleosynthesis, uncertainties such as the nuclear physics involved must be minimized. An experiment was performed to measure properties of neutron-rich nuclei just below the $N = 82$ shell closure believed to be responsible for production of the $A = 130$ peak in the solar r-process abundance pattern. $\beta$-decay half-lives and neutron branching ratios, $P_n$ values, were measured for Pd and Ag isotopes at the GSI Fragment Separator (FRS). The FRS provided in-flight separation and identification of fission fragments produced by a 900 MeV/u $^{238}$U beam. Ions of interest were implanted in the Silicon Implantation detector and Beta Absorber (SIMBA) array. The large pixelation of the array allowed for position-time correlation between implants and the corresponding $\beta$-decays. The parent nucleus may decay to an excited state in the daughter, above the neutron separation energy emitting a neutron. Those neutrons were moderated and detected in Beta deLayEd Neutron (BELEN) detector surrounding SIMBA. Resulting analysis of half-lives and neutron emission branching ratios including a time-dependent backround will be presented.

12:21PM J6.00007 Validation of (d,p$\gamma$) as a Surrogate for (n,$\gamma$) A. RATKIEWICZ, J.A. CIZEWSKI, A. ADEKOLA, S. BURCHE, M.E. HOWARD, B. MANNING, S.L. RICE, C. SHAND, Rutgers University, J.T. BURKE, R.J. CASPERSON, N.D. SCIELZO, LLNL, R.A.E. AUSTIN, St. Mary’s University, N. FOTIADIS, LANL, R.O. HUGHES, T.J. ROSS, Richmond University, M. MCCLESKEY, TAMU, S.D. PAIN, ORNL, W.A. PETERS, ORAU — The abundance pattern of nuclei produced in the stellar r-process may be impacted by the rates at which participating exotic nuclei capture neutrons at late times in the process. These neutron capture rates are difficult or impossible to measure directly; therefore a surrogate method to constrain them must be identified. The low-energy (d,p) transfer reaction is a promising candidate for a surrogate, as it shares many characteristics (such as low angular momentum branching ratios) with the neutron capture reaction. We report on a campaign to validate (d,p$\gamma$) as a surrogate for (n,$\gamma$) using $^{95}$Mo as a target and focusing on excitations in $^{96}$Mo near the neutron separation energy. We will present preliminary results from completed measurements and plans to extend the campaign to an inverse kinematics measurement of $^{95}$Mo(d,p$\gamma$) with techniques being developed for radioactive ion beams. This work was supported in part by the U.S. DOE and the NSF.

2014 April 6, 2014; 10:45AM - 12:33PM
Session J7 Neutrino Physics

10:45AM J7.00001 The MicroBooNE Experiment, RYAN GROSSO, University of Cincinnati, MICROBOONNE COLLABORATION — The MicroBooNE Experiment is a 170-ton Liquid Argon Time Projection Chamber (LArTPC) that will commence taking data in the Booster Neutrino Beam at Fermilab in 2014. The TPC active volume forms a rectangular solid of dimensions 2.3 m × 2.6 m × 10.4 m (87-ton) to record ionization signals from particles produced in neutrino interactions. Scintillation light detected by a Photomultiplier Tube array will be used to provide precise event timing information. This talk outlines the physics goals of the experiment along with the fabrication, assembly, and commissioning of the MicroBooNE LArTPC. Finally, the present status of the experiment will be summarized.

10:57AM J7.00002 EXO-200 Detector Performance and Results, SERERES JOHNSTON, University of Massachusetts - Amherst. EXO-200 COLLABORATION — Experimental searches for neutrinoless double-beta ($^0\beta\beta$) decay are motivated by the access this process gives to the absolute neutrino mass scale. This process is also sensitive to bounds on the Majorana mass parameter, $m_\nu$, which could be as small as $10^{-5}$ eV. The EXO-200 experiment will detect $^0\beta\beta$ decays by detecting two or more energetic electrons in an array of 2000 superconducting silicon detectors. The detection efficiency is $85\%$. The background level is $2.10^{-5}$ (stat) $\times 10^{-3}$ event per year. The results of this experiment will be presented.

11:09AM J7.00003 Simulation-based Validation of Pulse Shape Discrimination for the Majorana Demonstrator¹. BENJAMIN SHANKS, University of North Carolina at Chapel Hill, MAJORANA COLLABORATION — The MAJORANA DEMONSTRATOR, currently under construction at Sanford Underground Research Facility, will search for neutrinoless double beta decay ($^0\beta\beta$) in $^{76}$Ge. Given the extremely long half-life of this decay, the experiment aims to reduce background to $< 3$ counts/tonne-year in the 4-keV-wide region of interest. Because of the unique characteristics of the p-type point contact (PPC) detectors used in the DEMONSTRATOR, pulse shape analysis (PSA) can be used to discriminate $0\beta\beta$ signal events from background gamma rays. A simulation framework has been written to validate the PSA algorithms. Described here are results of validation studies, comparing PSA results on simulated and experimental data.

¹This work is supported by grants from the DOE Office of Nuclear Physics and the NSF Particle Astrophysics program.
11:21AM J7.00004 The Majorana low background low noise front-end electronics, NICOLAS ABRAGLL, Lawrence Berkeley National Laboratory, MAJORANA COLLABORATION — The Majorana Demonstrator will search for the neutrinoless double beta decay ($\beta\beta(0ν)$) of $^{76}$Ge with a mixed array of enriched and natural germanium detectors. In view of the next generation of tonne-scale germanium-based $\beta\beta(0ν)$-decay searches that will probe the neutrino mass scale in the inverted-hierarchy region, a major goal of the experiment is to demonstrate a path forward to achieving a background rate at or below 1 cnt/(ROI-t-y) in the 4 keV region of interest (ROI) around the 2039-keV Q-value of the $^{76}$Ge $\beta\beta(0ν)$-decay. Such a requirement on the background level in conjunction with the best possible energy resolution to increase the signal-to-noise ratio in the ROI significantly constrain the readout electronics. We present here the low background low noise front-end electronics developed for the low-capacitance P-type point-contact (PFC) germanium detectors of the Majorana Demonstrator. This resistive-feedback front-end, specifically designed to have low mass, is fabricated on a radioactivity-assayed fused silica substrate where the feedback resistor consists of a sputtered thin film of high purity amorphous germanium and the feedback capacitor is based on the stray capacitance between circuit Au traces.

11:33AM J7.00005 Improving the estimation of reactor antineutrino spectra, MAREK KOS, DAVID ASNER, KIMBERLY BURNS, BRYCE GREENFIELD, MALACHI SCHRAM, JOHN ORRELL, LYNN WOOD, BRENT VANDEVENDE, DAVID WOOTAN, Pacific Northwest National Lab — The flux of antineutrinos emanating from reactors has been used for a range of experiments studying neutrino properties. Results from these experiments are in tension with models that have mixing only among the three active neutrino flavors of the Standard Model. Knowledge of reactor antineutrino flux is based on inversion of total reactor beta spectra measured at the Institut Laue Langevin in the 1980s. Recent reanalysis of that data has resulted in a significant 3% upward shift in the antineutrino flux with implications for the possible existence of sterile neutrinos. We explore the possibility that the present situation could be improved with a new measurement of the underlying reactor beta spectrum. Possibilities are considered to improve knowledge of the beta source by using actinide foils activated in a neutron beam tailored to the energy spectrum found in a reactor core, and magnetic beta spectroscopy tracking to suppress backgrounds and control systematics.

11:45AM J7.00006 Spectral Function Implementation in Neutrino Event Generator and Its Impact on Neutrino Oscillation Parameters, CHUN-MIN JEN, Virginia Polytechnic Institute and State University, MICROBOONE COLLABORATION — The spectral function exceeds the Fermi Gas model in stating the lepton-nucleon interaction. In the first part of my talk, I will introduce the physics concepts of the spectral function and related validation work using electron data collected over a broad range of kinematics conditions. The measured cross-sections, through conducting quasi-elastic electron scattering experiments, are determined by a set of well-controlled beam energies and scattering angles, and thus more reliable. We found the spectral function can better predict the cross-section than the Fermi Gas model. As a result, the associated systematic uncertainty with the computed cross-section is greatly suppressed. In the second part of my talk, I will briefly describe what is the impact of using different nuclear models on the determination of neutrino oscillation parameters. An analysis is performed using GLoBES and shows that a 10% shift in the uncertainty with the computed cross-section is greatly suppressed. In the second part of my talk, I will briefly describe what is the impact of using different nuclear models on the determination of neutrino oscillation parameters.

11:57AM J7.00007 Analysis of the nuclear dependence of the $\nu_\mu$ charged current inclusive cross section with MINERvA, RONALD RANSOME, Rutgers University, MINERVA COLLABORATION — Neutrino experiments use heavy nuclei (Fe, Pb, C) to achieve necessary statistics. However, the use of heavy nuclei exposes these experiments to the nuclear dependence of neutrino-nucleus cross sections, which are poorly known and difficult to model. The MINERvA (Main Injector Experiment for $\nu-A$), a few-GeV neutrino nucleus scattering experiment at Fermilab, seeks to remedy the situation by directly studying the A-dependence of exclusive and inclusive channels. The MINERvA detector contains an 8 ton fully active fine-grained scintillator tracking core and targets of carbon, iron, lead, water and liquid helium which sit upstream of the tracking core. We present results from our analysis using the nuclear targets: ratios of the $\nu_\mu$ charged-current inclusive cross section in carbon, iron, lead and plastic scintillator (CH).

Sunday, April 6, 2014 10:45AM - 12:33PM –
Session J8 DAP: Ultra-high Energy Cosmic Rays

10:45AM J8.00001 High Energy Neutrino Emission Induced by Ultrahigh Energy Nuclei in Cluster Accretion Shocks, KE FANG, ANGELA OLINTO, Univ of Chicago — Accretion shocks in clusters of galaxies can potentially accelerate protons to above $10^{19}$ eV and nuclei to ultrahigh energies. High energy neutrinos are produced when these cosmic rays interact with baryons of the massive cluster, or with CMB photons during their extragalactic propagation. In light of the recent IceCube discovery of TeV-PeV neutrinos, we calculate the neutrino emissions from accretion shocks, using a complete numerical propagation method and calibrated based on precision LCDM simulation. We pin down the uncertainty and degeneracy in source parameters by taking into account the cosmological evolution of cluster mass, density profiles, velocity dispersions, and along with the gravitational gas accretion rates. We find that the neutrino spectrum is distinct from $E^{-\gamma}$ after considering the cluster mass function which impact both maximum energy and luminosity of the accelerated cosmic rays. We compare the cumulative neutrino flux to sensitivities of the existing and future high energy neutrino observatories. We also discuss the implication of our results on the scenario of cluster accretion shocks being the sources of ultrahigh energy cosmic rays.
10:57 AM J8.00002 Multiwavelength calibration of the Pierre Auger Observatory fluorescence detectors and its effect on reconstructed parameters\(^1\). BEN GOOKIN, JEFF BRACK, ALEXEI DOROFEEV, JOHN HARTON, YEVGENIY PETROV, Colorado State University — The fluorescence detector of the Pierre Auger Observatory is sensitive to primary particle composition of cosmic rays through the measurement of the depth of shower maximum, \(X_{\text{max}}\). \(X_{\text{max}}\) as a function of energy, or the elongation rate, depends on the primary particle composition, and any uncertainty in the \(X_{\text{max}}\) measurement could lead to a bias in the interpretation of the elongation rate. One uncertainty may arise from how the detector efficiency is calibrated as a function of wavelength. The calibration of the Pierre Auger Observatory fluorescence detector is performed using a uniform 2.5m diameter light source that allows for an end-to-end measurement of all detector components. The multiwavelength calibration utilizes the 2.5m diameter light source where the output of a xenon flasher is fed into a monochromator and the monochromator selects single wavelengths across the nitrogen fluorescence spectrum to measure the efficiency of the detector. A recent change in fluorescence detector efficiency altered the energy scale of the Pierre Auger Observatory by 4\%. Presented here is the effect on \(X_{\text{max}}\) due to the above change in efficiency and preliminary results from a more detailed multiwavelength calibration and its effects on energy reconstruction and \(X_{\text{max}}\).

\(^1\)Supported by DOE

11:09 AM J8.00003 Study of double-bump air showers contaminated by clouds and Cherenkov light. AMIR SHADKAM, Louisiana State University — Complex air shower development (“double-bumps”) can be used to study hadronic physics at high energy but can also arise from other effects. Fits using two Gaussian functions of the age-parameter have been applied to the Pierre Auger Observatory data and have identified a large set of events with irregular shower profile shapes. Clouds can scatter the air shower fluorescence and Cherenkov light and affect the amount of detected light. Cloud maps extracted from GOES satellites data are used to identify the events contaminated with clouds. Also some examples of contamination with direct Cherenkov light are presented here.

11:21 AM J8.00004 Fluorescence Detection of Cosmic Ray Air Showers Between 10\(^{16.5}\) eV and 10\(^{19}\) eV with the Telescope Array Low Energy Extension (TALE). ZACHARY ZUNDEL, JEREMY SMITH, STAN THOMAS, TAREQ ABUZAYYAD, DMITRI IVANOV, JOHN MATTHEWS, CHARLIE JUI, University of Utah, TELESCOPE ARRAY COLLABORATION — The Telescope Array Experiment has been observing cosmic ray air showers at energies above 10\(^{18}\) eV since 2008. TA operates three Fluorescence Detector (FD) sites, with telescopes that observe 3-31 deg in elevation. The FD sites are located at the periphery of a surface array of 507 scintillation counters covering 700 km\(^2\), with 1.2km spacing. The TA Collaboration has completed building a low-energy extension at its Middle drum FD site. Ten new telescopes currently observe between 33 and 51 degrees in elevation. A graded ground array of between 400 and 600m will be placed in front of the TALE FD. With these upgrades, the physics threshold of TA will be lowered to 10\(^{15.5}\) eV. The TA Low Energy Extension (TALE) will explore the energy regime corresponding to that of the LHC in center-of-mass frame. This is also the range where the transition from galactic to extra-galactic cosmic ray flux is suspected to occur. We will give a brief overview of the physics, and report on the progress of TALE toward measuring the cosmic ray spectrum between 10\(^{16.5}\) eV and 10\(^{19}\) eV.

11:33 AM J8.00005 Telescope Array measurement of UHECR composition from stereoscopic fluorescence detection. THOMAS STROMAN, DOUGLAS BERGMAN, TAREQ ABU ZAYYAD, Univ of Utah, TELESCOPE ARRAY COLLABORATION — The chemical composition of ultra-high-energy cosmic rays (UHECRs) is an important constraint on models of UHECR production and propagation, and must be determined experimentally. A UHECR-induced extensive air shower’s longitudinal development is dictated by the energy per nucleon of the primary particle. The observed distribution of atmospheric slant depths (\(X_{\text{max}}\)) is therefore sensitive to the composition, facilitating measurement of the relative abundances of “light” (proton-like) and “heavy” (iron-like) primary UHECR particles. The Telescope Array (TA) experiment, the northern hemisphere’s largest UHECR detector, includes three fluorescence detector (FD) stations that record the longitudinal development of the extensive air showers produced by UHECR arrivals. “Stereo” observation of individual showers by multiple FDs tightly constrains the trajectory reconstruction, allowing a precise measurement of \(X_{\text{max}}\) as well as energy. We will present the stereo TA data from six years of operation and progress toward a measurement of chemical composition.

11:45 AM J8.00006 Anisotropy in Cosmic Ray Arrival Directions Observed by the Telescope Array. BENJAMIN STOKES, University of Utah, TELESCOPE ARRAY COLLABORATION — The Telescope Array cosmic ray observatory has now accumulated more than five years of data. For ultra-high energy cosmic rays, this has resulted in an event set several times larger than what was previously available for the Northern Hemisphere. Ongoing arrival direction anisotropy searches include correlation to astrophysical catalogs, harmonic analysis, and point sources. Current results will be presented.

11:57 AM J8.00007 First Results from the Telescope Array RAdar (TARA) Detector\(^1\). ISAAC MYERS, University of Utah, TARA (TELESCOPE ARRAY RADAR) COLLABORATION, TELESCOPE ARRAY COLLABORATION — The TARA cosmic ray detector has been in operation for about a year and a half. This bi-static radar detector was designed with the goal of detecting cosmic rays in coincidence with Telescope Array (TA). A new high power (25 kW, 5 MW effective radiated power) transmitter and antenna array and 250 MHz FPGA-based DAQ have been operational since August 2013. The eight-Yagi antenna array broadcasts a 54.1 MHz tone across the TA surface detector array toward our receiver station 50 km away at the Long Ridge fluorescence detector. Receiving antennas feed an intelligent DAQ that self-adjusts to the fluctuating radio background and which employs a bank of matched filters that search in real-time for chirp radar echoes. Millions of triggers have been collected in this mode. A second mode is a forced trigger scheme that uses the trigger status of the fluorescence telescope. Of those triggers collected in FD-triggered mode, about 800 correspond with well-reconstructed TA events. I will describe recent advancements in calibrating key components in the transmitter and receiver RF chains and the analysis of FD-triggered data.

\(^1\)Work supported by W.M. Keck Foundation and NSF.

12:09 PM J8.00008 ABSTRACT WITHDRAWN
12:21PM J8.00009 The Global Light System for JEM-EUSO1, LAWRENCE WIENCZEK, Colorado School of Mines, JIM ADAMS, University of Alabama in Huntsville, MARK CHRISTL, NASA Marshall Space Flight Center, JOHANNES ESER, FRED SARAZINO, Colorado School of Mines, JEM-EUSO COLLABORATION — The sources of the highest energy particles known to exist in the universe remain an open question. The falling energy spectrum and low flux of these extreme energy messengers pose a measurement challenge for current and next generation detectors. Particle test beams at 100 EeV do not exist. Calibrated light sources (UV pulsed lasers and Xe Flashes) directed into the sky provide a proven alternative. The optical signatures that these sources generate in air fluorescence detectors have similarities to the optical signatures of the very rare 100 EeV air showers. The Global Light System (GLS) is a network of 12 calibrated Xe flashers and 6 UV lasers that will be deployed around the globe to benchmark the JEM-EUSO space based instrument. An additional GLS unit will be flown occasionally by aircraft. Prototype GLS systems in preparation will be flown by helicopter under the EUSO-Balloon instrument scheduled for flight later this year and also used to test the EUSO-TA prototype. As part of the development of the GLS, we are also planning to support the TUS orbital ultra high energy cosmic ray detector that has been prepared for launch on board the Lomonosov satellite.

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Sunday, April 6, 2014 10:45AM - 12:33PM – Session J10 FIP DBB: Invited Session: Large Scale International Facilities I: Photon Sources

10:45AM J10.00001 LCLS – The Upgrade Path, UWE BERGMANN, SLAC National Accelerator Laboratory — With ultrashort and ultrabright X-ray pulses (> 10^12 photons in pulses of < 100 femtosecond length) X-ray Free electron lasers provide revolutionary new capabilities to study a wide range of phenomena including novel states of matter, quantum materials, ultrafast chemistry and structural biology. Starting operations in 2009 the Linac Coherent Light Source (LCLS) at SLAC has been the first of such machines delivering 280 eV ~ 11 keV X-ray pulses to users at a rate of 120 Hz. The success of the LCLS has positively impacted numerous efforts around the world and there are now five hard X-ray FELs in operation or under construction in addition to two FELs that operate in the VUV and soft X-ray region. The planned LCLS upgrade, LCLS-II, has recently been modified in order to address the recommendation of a report of the Basic Energy Science Advisory Committee from last summer. We will present examples of some of the most exciting LCLS science highlights, discuss operation updates and present the parameters of the new LCLS-II upgrade.

11:21AM J10.00002 European XFEL: Status and Overview of Research Instrumentation, S.L. MOLOTDSOV, European XFEL, Hamburg, Germany — The European XFEL is a new international research installation that is currently under construction in the Hamburg area in Germany. The facility will generate new knowledge in almost all the technical and scientific disciplines that are shaping our daily life—including nanotechnology, medicine, pharmacodynamics, chemistry, materials science, space engineering and electronics. The ultra-high brilliance femtosecond x-ray flashes of coherent radiation will be produced in a 3.4-kilometre-long facility. Most of it will be housed in tunnels deep below ground. Three sites will provide access to the tunnels and the experiment stations. In its start-up configuration, the European XFEL will comprise 3 self-amplified spontaneous emission (SASE) light sources—undulators operating in energy ranges 3 - 25 keV (SASE 1 and SASE 2) and 0.2 - 3 keV (SASE 3), respectively. The world-unique feature of this XFEL is the possibility to provide up to 27,000 ultra-short flashes (10 - 100 fs) that makes the facility particular suitable for time-resolved spectrosopies including photoemission, (resonance) inelastic X-ray scattering and imaging studies in the range of moderate and hard X-ray photons. Six experimental stations optimized for particular purposes will be installed. Each experiment requires light with special properties, such that the stations are permanently assigned to the different light sources (beamlines) of the European XFEL. In June 2013, underground civil engineering work (tunnels, shafts, halls) has been finished at all three construction sites. In this presentation status and further parameters of the European XFEL facility as well as planned research instrumentation are reviewed.

11:57AM J10.00003 SPring-8 and SACLA Plans for the Future, TETSUYA ISHIKAWA, RIKEN SPring-8 Center — SPring-8, a 3rd-generation synchrotron radiation facility in Japan currently operates at 2.4 nm.rad electron beam emittance, is planning to upgrade to operate below 100 pm.rad by changing the present Chaemin-Green lattice to 5 bend achromat lattice, with keeping positions of all the straight sections as they are. The upgrade, aiming to improve the development of nm focal spot size, helps revealing local properties of heterogeneous materials in a non-destructive manner, while the most of the present applications observe the averaged properties of the samples which are assumed to be homogeneous. The upgrade will hopefully be completed within 10 years. SACLA (SPring-8 Angstrom Compact LASer), an X-ray free electron laser adjacent to SPring-8, is the world’s second SASE X-ray source following to LCLS (Linac Coherent Light Source) at the SLAC National Accelerator Laboratory. New undulator technology permits us to downsize the facility length to be 700 m which is 1/3 of LCLS and 2/9 of Euro XFEL. We have constructed a tight focusing system for the XFEL beam to obtain 50 nm focal spot diameter. The power density of the focused XFEL reached 10^8 W/cm^2. We are currently designing 7 nm focusing system to get the high power density of 10^9 W/cm^2. We are seeking for the ways to further downsize the facility length. Our temporary goal at the moment is to build 100 m long hard X-ray FEL facility in middle 2030s. R&Ds for the mini-pole undulators and higher energy gradient linear accelerator are starting soon.

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10:45AM J11.00001 Excellence in Physics Education Award: Modeling Theory for Physics Instruction, DAVID HESTENES, Arizona State Univ — All humans create mental models to plan and guide their interactions with the physical world. Science has greatly refined and extended this ability by creating and validating formal scientific models of physical things and processes. Research in physics education has found that mental models created from everyday experience are largely incompatible with scientific models. This suggests that the fundamental problem in learning and understanding science is coordinating mental models with scientific models. Modeling Theory has drawn on resources of cognitive science to work out extensive implications of this suggestion and guide development of an approach to science pedagogy and curriculum design called Modeling Instruction. Modeling Instruction has been widely applied to high school physics and, more recently, to chemistry and biology, with noteworthy results.

11:21AM J11.00002 Excellence in Physics Education Award: Graduate Programs for Professional Development of Physics Teachers, JANE JACKSON, retired — The landscape for high school physics is changing rapidly, especially with the need to merge physics into a coherent STEM curriculum that smoothly integrates it with chemistry and biology. Accordingly, there is an urgent need for graduate professional development programs to help in-service teachers cope with these changes. One such program was created in 2001 by the physics department at Arizona State University after a decade of NSF funding for the Modeling Instruction Program. We discuss what has been learned from that experience with recommendations for creating similar programs at other universities.

10:45AM J12.00001 Data acquisition system for the n^3He experiment , LATIFUL KABIR, Univ of Kentucky, THE N3HE COLLABORATION — The n^3He experiment at the Spallation Neutron Source will measure the parity violating spin asymmetry of the recoil proton in the reaction n + n^3He → p + T +765 KeV. This is sensitive to ΔI=0 and 1 components of the Hadronic Weak Interaction (HWI), and is expected to be extremely small (of the order 10^{-7}). Protons from the reaction are recorded in current mode in order to achieve a statistical sensitivity of 10^{-8} in a reasonable amount of time. In addition instrumental asymmetries must be suppressed by an additional order of magnitude. The asymmetry is measured as a function of time-of-flight of the neutron to study the energy dependence of any systematic effects. We will present details and preliminary tests of the 144 channel data acquisition system designed to meet these requirements.

10:57AM J12.00002 Solid xenon radiation detectors¹ , MICHELLE J. DOLINSKI, Drexel University — Cryogenic liquid xenon detectors have become a popular technology in the search for rare events, such as dark matter interactions and neutrinoless double beta decay. The power of the liquid xenon detector technology is in the combination of the ionization and scintillation signals, resulting in particle discrimination and improved energy resolution over the ionization-only signal. The improved energy resolution results from a unique anti-correlation phenomenon that has not been described from first principles. Solid xenon bolometers, under development at Drexel University, are expected to have excellent counting statistics in the phonon channel, with energy resolution of 0.1% or better. This additional energy channel may offer the final piece of the puzzle in understanding liquid xenon detector energy response.

¹Supported by a grant from the Charles E. Kaufman Foundation.

11:09AM J12.00003 Capacitive coupling based wire chamber diagnostic system , GABRIEL COLLIN, Massachusetts Inst of Tech-MIT, MICROBOONE COLLABORATION — This talk describes a method for inducing charge on a wire plane by pulsing a capacitively coupled antenna. This is designed to aid other systems in diagnosing wire integrity. Results from studying a prototype with the MicroBooNE TPC will be presented.

11:21AM J12.00004 Hermetic Packaging and Measurements of the Gain, Time Resolution, and Spatial Resolution of a 20x20 cm^2 MCP-based Picosecond Photo-Detector , ANDREY ELAGIN, University of Chicago, LAPPD COLLABORATION — The Large-Area Picosecond Photo-Detector Collaboration (LAPPD) is currently developing a large-area, modular photo-detector system composed of thin, planar, glass-body modules, each with two 20×20 cm^2 ALD-functionalized MCPs in a chevron geometry. We have successfully demonstrated a technique to make an indium vacuum seal between the photo-cathode window and the module body. With a complete detector system approximating the detector design, we have measured a gain of up to 2×10^5, single-photon time-of-flight resolution of ~60 ps, differential time resolution of ~5 ps, and spatial resolution better than 1 mm in two dimensions using an anode configuration covering 90 cm by 20 cm.

11:33AM J12.00005 A measure on proportional scintillation properties in liquid xenon , JUNJI NAGANOMA, Rice Univ — I present a property measurement on proportional scintillation in liquid xenon (LXe). LXe time projection chamber (TPC) has superior features for the direct detections of weekly interacting massive particle (WIMP) due to its high density, usability of scintillation and ionization signals for particle identification, capability of position reconstruction, relatively higher WIMP cross section, and sensitivity to spin-independent and spin-dependent interactions. Currently XENON and LUX collaborations utilize liquid-gas double-phase Xe detectors, denser liquid phase is for WIMP interaction, and gas phase is for ionization signal detection. There are some technical difficulties for future larger size double-phase Xe detector, such as precise liquid level control and high cathode voltage to keep 1kV/cm electric field. Single phase TPC using proportional scintillation in LXe can overcome these difficulties since liquid level control is not necessary and cathode voltage can be reduced while keeping the same electric field by arranging electrodes properly. To test the feasibility of the concept we measured the properties of proportional scintillation in LXe using thin wire and gas electron multiplier at Columbia University Nevis labs.

11:45AM J12.00006 Kimballton Underground Research Facility , STEVEN DEREK ROUNTREE, Virginia Tech — The Kimballton Underground Research Facility (KURF) is an operating deep underground research facility with six active projects, and greater than 50 trained researchers. KURF is 30 minutes from the Virginia Tech (VT) campus in an operating limestone mine with drive-in access (eg: roll-back truck, motor coach), over 50 miles of drifts (all 40’×20’; the current lab is 35’×22’×100’), and 1700’ of overburden (1450m.w.e.). The laboratory was built in 2007 and offers fiber optic internet, LN2, 480/220/110 V power, ample water, filtered air, 55 F constant temp, low Rn levels, low rock background activity, and a 1 coach), over 50 miles of drifts (all 40’×20’, 40 kg water mass equipped with commercial 4 in^2 microchannel plate (MCP) photodetectors along the vertical extent. For each MCP, a mirror is mounted on the opposite side of the detector allowing for the detection of both direct and reflected photons. By measuring the relative drift times and positions of the Cherenkov light, the particle track is projected onto the photodetector plane. Each MCP photomultiplier is a monolithic system, with 30 channels of full waveform sampling on a transmission line anode. Using the MCP system’s fine time (~50 ps) and spatial (~1 mm) resolution tagging of single Cherenkov photons, precision track reconstruction using both the prompt and reflected light is possible.

11:57AM J12.00007 Demonstration of a water Cherenkov optical time-projection chamber , ERIC OBERLA, HENRY FRISCH, ANDREY ELAGIN, MATTHEW WETSTEIN, Univ of Chicago — We describe a small prototype water-based optical time projection chamber (OTPC), in which relativistic charged particle tracks are reconstructed using the emitted Cherenkov radiation. The detector is a cylindrical ~40 kg water mass equipped with commercial 4 in^2 microchannel plate (MCP) photodetectors along the vertical extent. For each MCP, a mirror is mounted on the opposite side of the detector allowing for the detection of both direct and reflected photons. By measuring the relative drift times and positions of the Cherenkov light, the particle track is projected onto the photodetector plane. Each MCP photomultiplier is a monolithic system, with 30 channels of full waveform sampling on a transmission line anode. Using the MCP system’s fine time (~50 ps) and spatial (~1 mm) resolution tagging of single Cherenkov photons, precision track reconstruction using both the prompt and reflected light is possible.
12:09PM J12.00008 Design, Production and Testing of Cost-Effective, Large-Area, MCP-based Planar Photodetectors, JUNQI XIE, KAREN BYRUM, MARCEL DE MARTEAU, JOHN NOONAN, SAGAR SETRU, MATHEW VIRGO, ROBERT WAGNER, DEAN WALTERS, XING WANG, LEI XIA, HUYUE ZHAO, Argonne Natl Lab, LAPPD COLLABORATION — Microchannel plate (MCP)-based photodetectors with large-area, thin planar geometry and glass-body assembly, are considered as next generation photodetector to replace photomultiplier tubes. They have shown significant potential for applications in high energy collider physics and astrophysics. Due to the extreme sensitivity of the photocathode to water and oxygen, the production of this kind of photodetectors requires photocathodes to be transferred under high vacuum. A new photodetector production facility at Argonne National Laboratory was designed and constructed. The facility aims to produce small form-factor, MCP-based photodetectors completely made out of glass. 6 x 6 cm$^2$ photodetectors using metal and alkali antimonide as photocathode are currently under production. An overview of the production sequence and first performance results will be presented. Scaling up the production to larger form-factor devices will be discussed. The challenge of sealing a large area photodetector has recently been overcome. Windows with 20x20cm$^2$ active photocathode area were successfully sealed and progress towards a large-area photodetector production progress will be reported.

12:21PM J12.00009 Applying Machine Learning to GlueX Data Analysis, THOMAS BOETTCHER, Indiana University-Bloomington, GLUEX COLLABORATION — GlueX is a high energy physics experiment with the goal of collecting data necessary for understanding confinement in quantum chromodynamics. Beginning in 2015, GlueX will collect huge amounts of data describing billions of particle collisions. In preparation for data collection, efforts are underway to develop a methodology for analyzing these large data sets. One of the primary challenges in GlueX data analysis is isolating events of interest from a proportionally large background. GlueX has recently begun approaching this selection problem using machine learning algorithms, specifically boosted decision trees. Preliminary studies indicate that these algorithms have the potential to offer vast improvements in both signal selection efficiency and purity over more traditional techniques.

Sunday, April 6, 2014 10:45AM - 12:21PM –
Session J13 GPMFC DPF: Top and Electroweak Physics 101 - Howard Haber, University of California, Santa Cruz

10:45AM J13.00001 Preliminary measurement of the top quark pair production in the $\tau$ + jets final state with 20 fb$^{-1}$ of pp collision data recorded at $\sqrt{s} = 8$ TeV with the ATLAS experiment1, AHMED HASIB, Univ of Oklahoma, CATRIN BERNIUS, Louisiana Tech University, PHILLIP GUTIERREZ, Univ of Oklahoma, ATLAS EXPERIMENT COLLABORATION — A preliminary measurement of the top quark pair production cross section in the final state containing a tau lepton that has decayed semi-hadronically and associated jets is presented. The signal events are required to have at least four jets with at least one that is a b-tagged jet. The analysis uses data with an integrated luminosity of 20 fb$^{-1}$ recorded by the ATLAS experiment in proton-proton collisions at the Large Hadron Collider at a center-of-mass energy of 8 TeV.

1We acknowledge the support from the Department of Energy, USA

10:57AM J13.00002 ABSTRACT WITHDRAWN –

11:09AM J13.00003 Measurement of inclusive top pair plus photon production cross-section, MIKHAIL MAKOUSKI, Kansas State University, CMS COLLABORATION — A measurement is presented of the production cross-section of top-quark pairs associated with a photon in proton-proton collisions at a centre-of-mass energy of 8 TeV. The data were recorded at the CMS experiment at the LHC in the year 2012. The measurement is performed in the decay channel with one electron and jets in the final state. Data-driven methods are used to estimate the photon identification efficiency and purity. The measured cross-section is compared with the standard model expectation.

11:21AM J13.00004 CP violation in top-quark pair production and decay , AHMED RASHED, Univ of Mississippi — The LHC becomes a top-quark factory with high precision measurements. This provides a unique chance for searching for new sources of CP violation in the top sector. We search for CP violation in the top-quark production. We introduce the contribution of new physics in the top-pair production with CP violating odd and even couplings. We will discuss this study at the LHC.

11:33AM J13.00005 ABSTRACT WITHDRAWN –

11:45AM J13.00006 $W$ boson mass measurement with D0 data, JENNY HOLZBAUER, University of Mississippi, D0 COLLABORATION — We present current progress of the measurement of the $W^\pm$ boson mass using the full D0 data set. The data were collected from proton and anti-proton collisions produced by the Tevatron at 1.96 TeV center of mass energy. The analysis uses only events with an electron identified in the final state. This sensitive mass measurement is performed using a template method and accurate Monte Carlo modeling is critical. A sample of $Z$ boson events is used for calibration and the analysis is blinded. Analysis methodology and status will be discussed.

11:57AM J13.00007 Measurement of the $W^+W^-$ Production Cross Section in Proton-Proton Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Detector, HAOLU FENG1, Univ of Michigan - Ann Arbor, ATLAS COLLABORATION — We report a measurement of the $W^+W^-$ production cross section in pp collisions at $\sqrt{s} = 8$ TeV. The $W^+W^-$ leptonic decay channels are analyzed using data corresponding to 20.3 fb$^{-1}$ of integrated luminosity collected by the ATLAS detector in 2012 at the CERN Large Hadron Collider. The cross-section results will be presented along with limits on Anomalous Triple-Gauge-Boson Couplings.

1On behalf of the WW Analysis group of ATLAS

12:09PM J13.00008 Probe of WW production in vector boson fusion topology, AJAY KUMAR, University of Delhi, CMS COLLABORATION — Measurement of WW production rate in vector boson fusion topology is presented using the semileptonic final state from diboson decay. This analysis is a benchmark for future studies of WW scattering at high energies. The analysis is performed using a data sample corresponding to an integrated luminosity of 20 fb at 8 TeV proton-proton collision energies recorded by the CMS experiment at the Large Hadron Collider.
10:45AM J15.00001 Local Geometrical Boundary Data for Einstein’s Equations$^1$. JEFFREY WINICOUR, University of Pittsburgh — An outstanding issue in the treatment of boundaries in general relativity is the lack of a local geometric interpretation of the necessary boundary data. For the Cauchy problem, the initial data is supplied by the 3-metric and extrinsic curvature of the initial Cauchy hypersurface, subject to constraints. This Cauchy data determine a solution to Einstein’s equations which is unique up to a diffeomorphism. In joint work with H.-O. Kreiss, we show how three pieces of unconstrained boundary data, which are associated locally with the geometry of the boundary, likewise determine a solution of the initial-boundary value problem which is unique up to a diffeomorphism. One piece of this data, constructed from the extrinsic curvature of the boundary, determines the dynamical evolution of the boundary. The other two pieces constitute a conformal class of rank-2 metrics, which represent the two gravitational degrees of freedom.

$^1$Research supported by NSF grant PHY-1201276 to the University of Pittsburgh.

10:57AM J15.00002 Spectral Cauchy Characteristic Extraction: A New Algorithm for Gravitational Wave Propagation. CASEY HANDMER, BELA SZILAGYI, California Institute of Technology — We present a spectral algorithm for solving the full nonlinear vacuum Einstein field equations in the Bondi framework. Developed within the Spectral Einstein Code (SpEC), we demonstrate spectral Cauchy Characteristic Extraction (CCE), a thorough method for obtaining valid gravitational waveforms from existing and future astrophysical simulations. We demonstrate the new algorithm’s stability, convergence, and agreement with existing CCE methods. We explain how an innovative spectral approach enables greatly improved computational efficiency.

11:09AM J15.00003 Adding light to the gravitational waves on the null cone. MARIA BABIUC, Marshall University — Recent interesting astrophysical observations point towards a multi-messenger, multi-wavelength approach to understanding strong gravitational sources, like compact stars or black hole collisions, supernovae explosions, or even the big bang. Gravitational radiation is properly defined only at future null infinity, but usually is estimated at a finite radius, and then extrapolated. Our group developed a characteristic waveform extraction tool, implemented in an open source code, which computes the gravitational waves infinitely far from their source, in terms of compactified null cones, by numerically solving Einstein equation in Bondi space-time coordinates. The goal is extend the capabilities of the code, by solving Einstein-Maxwell’s equations together with the Maxwell’s equations, to obtain the energy radiated asymptotically at infinity, both in gravitational and electromagnetic waves. The purpose is to analytically derive and numerically calculate both the gravitational waves and the electromagnetic counterparts at infinity, in this characteristic framework. The method is to treat the source of gravitational and electromagnetic radiation as a black box, and therefore the code will be very flexible, with potentially large applicability.

11:21AM J15.00004 Improved Gauge Conditions and Evolution Techniques for Puncture Black Hole Simulations. ZACHARIAH ETIENNE, NASA Goddard Space Flight Center, University of Maryland, and West Virginia University, JOHN BAKER, NASA Goddard Space Flight Center, VASILEIOUS PASCHALIDIS, STUART SHAPIRO, University of Illinois at Urbana-Champaign, BERNARD KELLY, NASA Goddard Space Flight Center — Robust spacetime gauge conditions are critically important to the stability and accuracy of numerical relativity (NR) simulations involving puncture black holes. Most of the NR community continues to use the highly-robust—though nearly decade-old—"moving-puncture gauge conditions" for such simulations. We present improved gauge conditions and evolution techniques that reduce constraint violations by more than an order of magnitude on adaptive-mesh refinement (AMR) grids. It has been found that high-frequency waves propagating away from puncture black holes (e.g., in binary systems) cross progressively lower levels of refinement until they become under-resolved and reflect off an AMR boundary, leading to noisy gravitational waveforms. Such noise does not converge away cleanly with increasing resolution, effectively setting a hard upper limit on waveform accuracy using puncture techniques at computationally feasible resolutions. We demonstrate that our improved puncture gauge conditions reduce this noise by nearly an order of magnitude, and point to possible directions for future improvements.

11:33AM J15.00005 Improved initial data for binary black hole simulations. WILLIAM THROWE, Cornell University, SXS COLLABORATION — Asymptotically matched approximate analytic metrics can provide realistic initial data for binary black hole simulations. We have simulated these data using the Spectral Einstein Code (SpEC) and observe that they show decreased junk radiation and physical parameter drift as compared to commonly used initial data. We have generalized previous asymptotically matched data sets to allow for arbitrary initial hole velocities, and have demonstrated that this method can be used to adjust the eccentricity of the simulated binaries, including describing binary systems with quasicircular orbits.

11:45AM J15.00006 Detecting Near-Extremal Binary Black Holes. DANIEL HEMBERGER, California Institute of Technology, SXS COLLABORATION — There is an ongoing effort in the gravitational wave astronomy community to construct a template bank for Advanced LIGO that includes gravitational waveforms from binary black hole systems with high mass ratios and spins. Using numerical relativity simulations performed with the Spectral Einstein Code, we assess the prospects for detection and parameter estimation of binaries with spins above the expected template bank cutoff spin. This analysis is restricted to equal-mass, non-precessing binaries.

11:57AM J15.00007 Simulations of high-spin black-hole binaries. MARK SCHEEL, Caltech, GEOFFREY LOVELACE, California State University, Fullerton, SXS COLLABORATION — Black holes can in principle have spins up to the Kerr limit $a = 1$, and some (highly uncertain) estimates from X-ray binaries yield $a > 0.98$. Because binaries with highly-spinning black holes may be detectable by LIGO, it is important to be able to simulate and understand these systems. We present binary black hole simulations with large spins, including a generic, precessing simulation with a spin of $a > 0.99$ on one of the black holes. We discuss some of the difficulties with simulating high-spin black holes and how to overcome them.

12:09PM J15.00008 Numerical Relativity reaching into the land of Post-Newtonian Theory. BELA SZILAGYI, Caltech, SXS COLLABORATION — Extensive code improvement of the Spectral Einstein Code has made it now possible for us to perform simulations that start at frequencies where Post Newtonian Theory is accurate. As a first such run we have performed a 175 orbit, mass-ratio 7, non-spinning BBH run at several resolutions. Runs of this type open the gate towards a new level of testing of the various BBH waveform approximants. The important question of “how long should runs be?” receives a new meaning. The talk will focus on current status as well as future plans for these ultra-long simulations.
between different vacua, of which the ones from anti-deSitter to de-Sitter is forbidden in the classical theory. In this talk, we consider toy landscape potentials:

Sunday, April 6, 2014 10:45AM - 12:09PM  
Session J16 Quantum Aspects of Gravitation I  
104 - Steven Carlip, University of California, Davis

10:45AM J16.00001 Hawking radiation in loop quantum gravity . JORGE PULLIN, Louisiana State Univ - Baton Rouge, RODOLFO GAMBINI, Universidad de la Republica Oriental del Uruguay — We use the recently found exact solution representing a spherically symmetric quantum space-time to perform a quantum field theory in quantum space time analysis of a scalar field. The main influence of the presence of the quantum geometry is to yield a theory that effectively lives on a lattice due to the discreteness of space-time in loop quantum gravity. This in particular has consequences for the structure of the quantum vacuum. Essentially all singular behaviors are removed by the discreteness. The resulting formula for the Hawking radiation suffers only small corrections, at least for macroscopic black holes and their natural frequencies and coincides with a formula that had been heuristically derived in the past.

10:57AM J16.00002 Non-singular AdS-dS transitions in a landscape scenario, BRAJESH GUPT, PARAMPREET SINGH, Louisiana State Univ - Baton Rouge — In the multiverse scenario allowing eternal inflation, it is an important problem to understand transitions between different vacua, of which the ones from anti-deSitter to de-Sitter is forbidden in the classical theory. In this talk, we consider toy landscape potentials: a double well and a triple well potential allowing anti-deSitter and de-Sitter vacua, in the effective dynamics of loop quantum cosmology for the k = -1 FRW model. We show that due to the non-perturbative quantum gravity effects as understood in loop quantum cosmology, non-singular anti-deSitter to de-Sitter transitions are possible. In the future evolution, an anti-deSitter bubble universe does not encounter a big crunch singularity but undergoes a big bounce occurring at a scale determined by the underlying quantum geometry. These non-singular transitions provide a mechanism through which a probe or a “watcher,” used to define a local measure, can safely evolve through the bounce and geodesics can be smoothly extended from anti-deSitter to de-Sitter vacua.

11:09AM J16.00003 Effective dynamics of Kantowski-Sachs spacetime in loop quantum cosmology . ANTON JOE, PARAMPREET SINGH, Louisiana State University — We study singularity resolution in Kantowski-Sachs spacetime in the effective loop quantum cosmology setting for various matter models such as dust, radiation, cosmic strings, cosmological constant and scalar fields. We find the inverse triad correction and bounds on energy density, shear scalar and expansion scalar. The evolution of universe after bounce is studied and found that a Nariai-like spacetime is obtained for different choices of matter. We analyze the stability of these quantum Nariai-like spacetimes with respect to homogeneous perturbations and find that unlike classical Nariai spacetimes, these are stable.

11:21AM J16.00004 Two-point function for a BEC analogue black hole when a mass term is present. RICHARD A. DUDLEY, PAUL R. ANDERSON, Wake Forest University, ROBERTO BALBINOT, Universita di Bologna and INFN sezione di Bologna, ALESSANDRO FABBRI, Centro Studi e Ricerche Enrico Fermi (Rome), Universita di Bologna, and Universidad de Valencia-CSIC, RENAUD PARENTANI, Universite Paris-Sud — The two-point function for phonons is computed using quantum field theory in curved space techniques for a Bose-Einstein condensate that serves as an analogue black hole. This is done in the case that the BEC is moving at a constant speed in a particular direction and excitations of the mode functions occur in the transverse direction as well as the direction of motion. The calculation reduces to an effective 1+1 dimensional calculation and the transverse excitations add a mass term to the mode equation for the phonons. The low frequency modes in the region well outside of the sonic horizon. The effects of this on the two point correlation function are investigated.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

13:33AM J16.00005 Inequivalence Between Active Gravitational Mass and Energy for a Composite Quantum Body R. BAGMET, A. LEBED, Department of Physics, University of Arizona — We derive active gravitational mass operator for the simplest composite quantum body – a hydrogen atom [1]. We show that, despite the fact that it does not commute with energy operator, taken in the absence of gravitational field, the equivalence between the expectation values of active gravitational mass and energy survives for stationary quantum states. Inequivalence between active gravitational mass and energy reveals itself as time-dependent oscillations of the expectation values of active gravitational mass for non-stationary quantum states.


11:45AM J16.00006 Quantum-Mechanical Correction to the Speed of Light in a Gravitational Potential, JAMES FRANSON, University of Maryland Baltimore County — We consider a model in which the gravitational potential energy of massive particles is included in the Hamiltonian of the Dirac equation. This results in a predicted correction to the speed of light that is proportional to the fine structure constant [1]. The correction to the speed of light obtained in this way depends on the gravitational potential and not the gravitational field, which is not gauge invariant and presumably nonphysical. Nevertheless, the predicted results are in reasonable agreement with experimental observations from Supernova 1987a, where the first neutrinos arrived 7.7 hours before the first photons.


11:57AM J16.00007 ABSTRACT WITHDRAWN
The Born-Oppenheimer approximation provides a coherent QCD framework for describing the \( \text{XYZ} \) states. The additional hints that will be provided by current and upcoming experiments guarantee the eventual solution of the \( \text{XYZ} \) puzzle.

MICHAEL MAY, Stanford University — Nuclear weapons pose a combination of political and ethical dilemmas the solution to which has not been found. On one hand, in the view of both US government leaders and US allies, nuclear deterrence continues to play an essential part in the US role as the ultimate source of military strength for the alliances among the major democratic countries. It also continues to be in demand by countries that believe themselves to be isolated and threatened. On the other hand, nuclear weapons, besides being effective deterrents, can cause unprecedented loss of life and risk the demise of civilizations. No ban or technical precaution could prevent the rebuilding of nuclear weapons in a crisis. No diplomatic arrangement to date has erased the threat of invasion and war in the world. Only the abandonment of war and the threat of war as instruments of policy can make nuclear weapons obsolete. The slow, halting, risky road to that end remains the only hope for a world in which lasting solutions to the nuclear dilemmas are possible.

RAMAMURTI RAJARAMAN, Emeritus Professor of Physics, Jawaharlal Nehru University, New Delhi and Co-Chair, International Panel on Fissile Materials — The world has built up a huge glut of Fissile Materials, posing a potentially devastating threat. While specialists in the field have been aware of this danger for a long time, it was only after President Obama organized the Nuclear Security Summit in 2010 that the attention of the world’s political leadership was drawn to it. We will present here an introductory overview of Fissile materials— their definition, significance and their production facilities and stocks in different parts of the world. We will also mention some of the efforts being made to verifiably cap and reduce their stocks as well as the technical and political complications involved in the process.

Michael Tuts, Georgia Institute of Technology — Over the last decade many new states, often dubbed \( \text{XYZ} \) states, have been discovered in the excited charmonium spectrum. The models for the \( \text{XYZ} \) states has become broader with the discovery of \( \text{X} \), \( \text{Y} \), or \( \text{Z} \) mesons that have been discovered during the last decade. The models for the \( \text{XYZ} \) states has become broader with the discovery of \( \text{X} \), \( \text{Y} \), and \( \text{Z} \) mesons that have been discovered in the excited charmonium spectrum. It has long been noted that several of these states have masses, widths, or decay modes that seem to be inconsistent with a simple quark-antiquark (\( \bar{c} \bar{c} \)) interpretation. In the past year, the spectrum of \( \text{XYZ} \) states has become broader with the discovery of multiple structures in the charmonium system that have electric charge, and therefore cannot be \( \bar{c} \bar{c} \) mesons. In this talk, I will review the recent developments in excited charmonium spectroscopy using data collected with the BESIII, Belle, and CLEO-c detectors. The results will be discussed in the context of both the known charmonium and bottomonium spectra, and prospects for future study will be presented.

Eric Braaten, Ohio State University — The \( \text{XYZ} \) mesons are unexpeced \( \bar{c} \bar{c} \) and \( \bar{b} \bar{b} \) mesons that have been discovered during the last decade. The models for the \( \text{XYZ} \) mesons that have been proposed, none of which have revealed a compelling pattern, include conventional quarkonium, quarkonium hybrids, and quarkonium tetraquarks (whose four constituents can be clustered in various ways). The Born-Oppenheimer approximation provides a coherent QCD framework for describing the \( \text{XYZ} \) mesons that can be informed by lattice QCD. The additional hints that will be provided by current and upcoming experiments guarantee the eventual solution of the \( \text{XYZ} \) puzzle.

ERIC BRAATEN, Ohio State University — The \( \text{XYZ} \) mesons are unexpected \( \bar{c} \bar{c} \) and \( \bar{b} \bar{b} \) mesons that have been discovered during the last decade. The models for the \( \text{XYZ} \) mesons that have been proposed, none of which have revealed a compelling pattern, include conventional quarkonium, quarkonium hybrids, and quarkonium tetraquarks (whose four constituents can be clustered in various ways). The Born-Oppenheimer approximation provides a coherent QCD framework for describing the \( \text{XYZ} \) mesons that can be informed by lattice QCD. The additional hints that will be provided by current and upcoming experiments guarantee the eventual solution of the \( \text{XYZ} \) puzzle.

\[1\] This research was supported in part by the Department of Energy under grant DE-FG02-05ER15715.
1:30PM K3.00001 Systematic Uncertainty in the Analysis of the Reactor Neutrino Anomaly.

ANNA HAYES, Los Alamos National Laboratory. — We examine uncertainties in the analysis of the reactor neutrino anomaly, wherein it is suggested that only about 94% of the emitted antineutrino flux was detected in short baseline experiments. We find that the form of the corrections that lead to the anomaly are very uncertain for the 30% of the flux that arises from forbidden decays. This uncertainty was estimated in four ways, is larger than the size of the anomaly, and is unlikely to be reduced without accurate direct measurements of the antineutrino flux. Given the present lack of detailed knowledge of the structure of the forbidden transitions, it is not possible to convert the measured aggregate fission beta spectra to antineutrino spectra to the accuracy needed to infer an anomaly. Neutrino physics conclusions based on the original anomaly need to be revisited, as do oscillation analyses that assumed that the antineutrino flux is known to better than approximately 5%.

2:06PM K3.00002 MiniBooNE Results and the future of Sterile Neutrino Searches, HEATHER RAY,
University of Florida — There exists a need to address and resolve the growing evidence for short-baseline neutrino oscillations and the possible existence of sterile neutrinos. Such non-standard particles were first invoked to explain the LSND anti-νμ to anti-νe appearance signal. A follow up experiment, MiniBooNE, has observed a 3.8σ excess of events in the 200-1250 MeV oscillation energy range that is consistent with the LSND signal. In addition, lower than expected neutrino induced event rates using calibrated radioactive sources and nuclear reactors can also be explained by the existence of sterile neutrinos. This talk will introduce the motivation for ∼1 eV/c^2 mass sterile neutrinos, discuss latest search results, and short-term and long-term plans to hunt for this mysterious particle.

2:42PM K3.00003 Cosmological and Astrophysical Implications of Sterile neutrinos1. KEVORK ABAZJIAN, Univ of California - Irvine — Cosmology has entered an even more precision-driven epoch, with many of the basic parameters of cosmology being known to the few-percent level. However, some unresolved tensions remain between large scale structure measures of cosmology and primary cosmic microwave background measures. This may indicate new physics in the neutrino sector, since neutrinos are the second most abundant particle in the Universe, and the least quantified. New neutrino physics may include extra (sterile) species of neutrinos, massive neutrinos, or both. I will review the status of these measures as well as the prospects for the resolution of the tension(s). Neutrinos also play a dominant energetics role in Type II supernova explosions, and the presence of new neutrino physics also has implications for supernova physics, which I will also review.

1Supported in part by the NSF CAREER Program.

Sunday, April 6, 2014 1:30PM - 3:18PM – Session K4 DAP GGR: Invited Session: Jets and Astophysical Tests of General Relativity

1:30PM K4.00001 Observationally constraining the jet power extracted from spinning black holes. SERA MARKOFF, API, University of Amsterdam — Black holes of all sizes, from stellar to supermassive, launch relativistic jets of magnetized plasma that can radiate across the entire electromagnetic spectrum. These flows originate from near-event horizon scales, where ordered magnetic fields threading the plasma likely play a defining role in their collimation and source of power. Depending on where the power is extracted from in the system, e.g., the inner accretion flow or the ergosphere of the black hole, there can be a markedly different dependence of observed power on black hole spin. Further complicating our ability to derive from observations is the fact that the exact relationship between jet emission properties and spin will be very model dependent, and the fact that jets themselves evolve depending on the state of the accretion flow. I will present an overview of the current state of the art in understanding black hole jet observations and their relation to spin, as well as discuss some special cases like our Galactic center’s supermassive black hole Sgr A*, and the evolving jets observed in X-ray binary systems.

2:06PM K4.00002 GRMHD simulations of black hole accretion and jets1. ALEXANDER TCHEKHOVSKOY, Lawrence Berkeley National Laboratory — As black holes accrete surrounding gas, they often produce relativistic, collimated outflows, or jets. Jets are expected to form in the vicinity of a black hole, making them powerful probes of strong-field gravity. However, how the properties of a jet connect to those of the accretion flow and the black hole (e.g. black hole spin) remains an area of active research. I will discuss recent progress in first-principles general relativistic magnetohydrodynamic (GRMHD) models of black hole accretion-jet systems, specifically the emerging picture of how jets form and the factors that determine jet properties.

1The speaker is supported by NASA through Einstein Postdoctoral Fellowship.

2:42PM K4.00003 Tests of GR Using Neutron Star - White Dwarf Binaries. SCOTT RANSOM, National Radio Astronomy Observatory — Binary radio pulsars, and in particular the double neutron star (NS) systems, provide famous tests of general relativity due to their relatively compact orbits and the precision with which we can measure them via pulsar timing. Neutron star - white dwarf (WD) systems, though, allow qualitatively different tests of GR due to the several orders-of-magnitude difference in the self-gravities of their compact objects. Compact NS-WD systems, like PSR J1141-6545 and the recently discovered J0348+0432, with a high-mass NS, can test the radiative properties of gravity, such as the possibility of dipolar gravitational wave emission. NS-WD systems in wide circular orbits have been used to test the strong equivalence principle (SEP) by looking for a “polarization” of their orbits via the Nordtvedt effect. Recently, a millisecond pulsar in a triple system, J0337+1715, was discovered which promises much stronger tests of the SEP in the near future. Finally, ongoing pulsar surveys by all the World’s major single-dish radio telescopes will continue to provide exotic (and surprising!) systems for us to monitor.
and substantially reduce nuclear physics uncertainty in astrophysics simulations. We recently performed a TOF-B method provides a way to measure the masses of nuclei far from the valley of beta-stability with sufficient precision to map general features in nuclear structure. Preliminary data and details of the analysis procedure will be presented.

1:30PM K6.00001 Understanding the sensitivity of core-collapse supernovae to weak interaction rates1, 2:18PM K6.00005 Neutron Transport and Systematic Studies with the UCN\(\tau\) Experiment at LANL, 1:54PM K6.00003 Towards an In-Beam Measurement of the Neutron Lifetime to 1 Second, 2:06PM K6.00004 A Novel Approach to Study of Neutron Producing Reactions for Nuclear Astrophysics, 1:30PM K6.00006 Time-of-flight Mass Measurement of Neutron-rich Nuclei1

1This work was supported by the US NSF [PHY-1102511, PHY-0822648 (JINA)]

1Work supported in part by the U.S. Department of Energy and National Science Foundation.

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2:42PM K6.00007 First experiments performed with the JENSA gas jet target system. P.J. THOMPSON, UTK, K.A. CHIPPS, ORNL/UTK, U. GREIFE, CSM, D.W. BARDAYAN, ND, J.C. BLACKMON, L.E. LINHARDT, S.T. PITTMAN, LSU, A. KONTOS, MSU/NSCL/JINA, M. MATOS, IAEA, S.D. PAIN, M.S. SMITH, ORNL, H. SCHATZ, MSU/NSCL, K.T. SCHMITT, ORTEC, JENSA COLLABORATION — With the Jet Experiments in Nuclear Structure and Astrophysics (JENSA) gas jet target, we have the unique opportunity to study reactions with pure gas targets. One reaction of interest is 208Ne(p,t)18Ne. 18Ne can decay via electron capture to the potential astrophysical observable 18F, and states in 18Ne affect the rate of some other astrophysically important reactions, such as 12C(p,n)11B. We present some of the first transfer reaction results using the JENSA gas jet target system performed at Oak Ridge National Laboratory, with a focus on the 208Ne(p,t)18Ne transfer reaction performed with a 37MeV proton beam.

2:54PM K6.00008 Determining the resonance strength of the 56Ni rp-process through (d,n) with VANDLE and MoNA-LISA. W. PETERS, ORNL & University of Tennessee, R. GRZYWACZ, M. MADURGA, S.V. PAULAUSKAS, S. TAYLOR, J. ALLEN, UTK, J.A. CIZEWSKI, B. MANNING, M.E. HOWARD, Rutgers, J. SMITH, M. JONES, T. BAUMANN, M. THOENENNESSEN, MSU/NSCL, D.W. BARDAYAN, Notre Dame & ORNL, S.D. PAIN, ORNL, R.C.C. CLEMENT, US Air Force, J. BROWN, Wabash, B. LUTHER, Concordia, S. ILYUSHKIN, P.D. O’MALLEY, Col. Sch. of Mines, R. IKEYAMA, Wisconsin LaCrosse, R.L. KOZUB, Z.J. BERGSTROM, TTU, P.A. DEYOUNG, Hope, W. ROGERS, Westmont, VANDLE COLLABORATION, MONA COLLABORATION — The rapid proton capture (rp) process of explosive nucleosynthesis is believed to be the driver of X-ray bursts and creates nuclei up to around mass 110. Whereas much of this process burns in an equilibrium determined by half-lives and masses, the waiting point at 56Ni is unique. At this point the process reaches its peak luminosity and the synthesis of almost all heavier nuclei pass through the 56Ni(p,γ)57Cu reaction. Since the gamma-decay width dominates the relevant resonance in 57Cu, a measurement of its proton partial width can be used to extract the proton-capture resonance strength. An experiment to do this was performed at the NSCL using the Versatile Array of Neutron Detectors at Low Energy (VANDLE) along with the MoNA-LISA neutron detector arrays; and was the commissioning experiment for VANDLE with a transfer reaction. The events in the digitizing electronics of VANDLE were event-matched to the MoNA-LISA-Sweeper data acquisition system.

3:06PM K6.00009 Particle-gamma measurements for nuclear astrophysics. S.D. PAIN, Oak Ridge National Laboratory, A. RATKIEWICZ, Rutgers University, D.W. BARDAYAN, University of Notre Dame, T. BAUGHER, Rutgers University, J.C. BLACKMON, Louisiana State University, S. BURCHER, Rutgers University, K.A. CHIPPS, Oak Ridge National Laboratory, University of Tennessee, J.A. CIZEWSKI, S. HARDY, Rutgers University, K.L. JONES, University of Tennessee, R.L. KOZUB, Tennessee Technological University, I. MARSH, Oak Ridge National Laboratory, B. MANNING, Rutgers University, W.A. PETERS, Oak Ridge National Laboratory, University of Tennessee, D. SEWERYNIAK, Argonne National Laboratory, C. SHAND, Rutgers University, M.S. SMITH, Oak Ridge National Laboratory, S. ZHU, Argonne National Laboratory — Transfer reactions in inverse kinematics are one of the few probes available to study in detail the single-particle structure of neutron-rich nuclei involved in rp-process nucleosynthesis. Measurement of de-excitation gamma rays in coincidence with the charged reaction products can aid significantly in resolving the states populated. In addition, the measurement of gamma rays can provide constraints on numerous other properties, such as spin-parities, branching ratios and lifetimes of levels, and is critical to the surrogate technique for determining statistical neutron-capture cross sections. The Gammasphere ORRUBA Dual Detectors for Experimental Structure Studies (GODDESS) is a system designed for such measurements with beams from the ATLAS facility at Argonne National Laboratory. Details of the system and the first planned measurements will be presented.

This work is supported in part by the U.S. Department of Energy and the National Science Foundation.

Sunday, April 6, 2014 1:30PM - 2:42PM – Session K7 Applications of Nuclear Physics 201 - Andy Saunders, Los Alamos National Laboratory

1:30PM K7.00001 Actinide Studies with Ultracold Neutrons. LEAH BROUSSARD, Los Alamos National Laboratory — Understanding the effects of sputtering due to nuclear fission is crucial to the nuclear industry and has wide-reaching applications, including nuclear energy, space science, and national defense. A new program at the Los Alamos Neutron Science Center uses ultracold neutrons (UCN) to induce fission in actinides such as uranium and plutonium. UCN are an ideal tool for finely controlling induced fission as a function of depth in an actinide sample. The mechanism for fission-induced surface damage is not well understood, especially regarding the effect of a surface oxide layer. We will discuss our experimental strategy for studies of UCN-induced fission and the ejected material, and present preliminary data from enriched and depleted uranium.

We gratefully acknowledge the support of the G. T. Seaborg Institute for Transactinium Science and the U.S. Department of Energy through the LANL/LDRD Program for this work.

1:42PM K7.00002 Distinguishing Fissile From Non-Fissile Materials Using Linearly Polarized Gamma Rays. J.M. MUELLER, M.W. AHMED, H.J. KARWOWSKI, L.S. MYERS, H.R. WELLER, W.R. ZIMMERMAN, Triangle Universities Nuclear Laboratory, J. RANDRUP, Lawrence Berkeley National Laboratory, R. VOGT, Lawrence Livermore National Laboratory — Photofission of 232Th, 235,235,238U, 237,237,238,239Pu was induced by nearly 100% linearly polarized, high intensity (~10²⁰ γs per second), and nearly-monoenergetic γ-ray beams of energies between 5.3 and 7.6 MeV at the High Intensity γ-ray Source (HiγS). An array of 12-18 liquid scintillating detectors was used to measure prompt fission neutron yields. The ratio of prompt fission neutron yields parallel to the plane of beam polarization to the yields perpendicular to this plane was measured as a function of beam and neutron energy. A ratio near unity was found for 233,235U, 237,239Pu and 239Pu while a significant ratio (~1.5-3) was found for 232Th, 238U, and 240Pu. This large difference could be used to distinguish fissile isotopes (such as 233,235U and 239Pu) from non-fissile isotopes (such as 232Th, 238U, and 240Pu). The measured ratios agree with the results of a fission calculation (FREYA) which used with previously measured photofission fragment angular distributions as input.

Partially supported by DHS (2010-DN-077-ARI046-02), DOE (DE-AC52-07NA27344 and DE-AC02-05CH11231), and the DOE Office of Science Graduate Fellowship Program (DOE SCGF).
The purpose of this talk is to present preliminary calculations for energy spectra inside a spherical shell shielding and behind a slab in typical space radiation sensitive electronics from the harmful effects of space radiation. Such knowledge allows one to confidently map the radiation environment inside the vehicle.

Marshall Space Flight Center, Huntsville, AL 35812 — Accurate knowledge of energy spectra inside spacecraft is important for protecting astronauts as well as to models. Model verification further enables using Los Alamos National Laboratory SNF assembly models, developed under the Next Generation Safeguards Initiative, to determine emission and signal expectations. Measurement results and future application requirements for UHRGe will be discussed.

2:06PM K7.00004 Geant4 predictions of energy spectra in typical space radiation environment
M.S. SABRA, NASA Postdoctoral Program Fellow, Marshall Space Flight Center, Huntsville, AL 35805, A.F. BARGHOUTY, Astrophysics Office, NASA-Marshall Space Flight Center, Huntsville, AL 35812 — Accurate knowledge of energy spectra inside spacecraft is important for protecting astronauts as well as to sensitive electronics from the harmful effects of space radiation. Such knowledge allows one to confidently map the radiation environment inside the vehicle.

The purpose of this talk is to present preliminary calculations for energy spectra inside a spherical shell shielding and behind a slab in typical space radiation environment using the 3D Monte-Carlo transport code Geant4. We have simulated proton and iron isotopic sources and beams impinging on Aluminum and Gallium arsenide (GaAs) targets at energies of 0.2, 0.6, 1, and 10 GeV/u. If time permits, other radiation sources and beams (α, C, O, and Na) targets (C, Si, Ge, water) will be presented. The results are compared to ground-based measurements where available.

2:18PM K7.00005 Dynamic Allocation of Sugars in Barley
C. R. HOWELL, Duke University and TUNL, C.D. REID, Duke University Department of Biology, A.G. WEISENBERGER, S.J. LEE, J.E. MCKISSON, Thomas Jefferson National Accelerator Facility — Allocation of carbon and nitrogen is a key factor for plant productivity. Measurements are carried out by tracing 11C-tagged sugars using positron emission tomography and coincidence counting. We study the mechanisms of carbohydrate allocation and transport from carbohydrate sources (leaves) to sinks (stem, shoot, roots) under various environmental conditions such as soil nutrient levels and atmospheric CO2 concentration. The data are analyzed using a transfer function analysis technique to model transport and allocation in barley plants. The experimental technique will be described and preliminary results presented.

3 This work was supported in part by USDOE Grant No. DE-FG02-97ER41033 and DE-SC0005057

2:30PM K7.00006 Development of A Modular Plant Imaging PET System and Its Use In Evaluating Corn Plant Root Systems
A. L. CUMBERBATCH, A.S. CROWELL, B.A. FALLIN, C.R. HOWELL, Duke University and TUNL, C.D. REID, Duke University Department of Biology, A.G. WEISENBERGER, S.J. LEE, J.E. MCKISSON, Thomas Jefferson National Accelerator Facility — Allocation of carbon and nitrogen is a key factor for plant productivity. Measurements are carried out by tracing 11C-tagged sugars using positron emission tomography and coincidence counting. We study the mechanisms of carbohydrate allocation and transport from carbohydrate sources (leaves) to sinks (stem, shoot, roots) under various environmental conditions such as soil nutrient levels and atmospheric CO2 concentration. The data are analyzed using a transfer function analysis technique to model transport and allocation in barley plants. The experimental technique will be described and preliminary results presented.

3 This work was supported in part by USDOE Grant No. DE-FG02-97ER41033 and DE-SC0005057

Sunday, April 6, 2014 1:30PM - 3:18PM – Session K8 DAP: Astroparticle Observatories and Techniques

1:30PM K8.00001 Extreme Energy Particles with JEM-EUSO
A. V. OLINTO, The University of Chicago, JEM-EUSO COLLABORATION — The origin of the highest energy cosmic rays is still a great mystery. Recent observations have confirmed the extragalactic origin of cosmic rays above tens of EeV, whose sources should be among the most powerful extragalactic objects. The spectrum shows the effect of propagation from cosmological distances or possibly the maximum energy reach of cosmic accelerators. The lack of significant anisotropies and a possible change of composition are surprising. Not a single source of these extremely energetic events has been identified. To identify the sources a significant increase in statistics is necessary. The pioneering Extreme Universe Space Observatory (EUSO) on the Japanese Experiment Module (JEM) of the International Space Station, JEM-EUSO, will detect a large number of extreme energy cosmic rays finally leading to an identification of these mysterious extreme accelerators.

1:42PM K8.00002 EUSO-BALLOON: a Pathfinder for the Extreme Universe Space Observatory Mission
J. ADAMS, University of Alabama in Huntsville, P. VON BALLMOOS, Institut de Recherche en Astrophysique et Plantologie (IRAP), Toulouse, France, A. CANTARANGELO, INAF Institute at Astronomy, and Astrophysics, Kepler Center, University of Tubingen, Germany, M. CHRISTL, NASA Marshall Space Flight Center, Huntsville, AL, USA, J. WINCKE, Colorado School of Mines, Golden, Colorado, USA, JEM-EUSO COLLABORATION — EUSO-BALLOON is a Pathfinder for the JEM-EUSO (Extreme Universe Space Observatory on the Japanese Experiment Module) mission which is being developed by an international collaboration of scientists from 15 countries. JEM-EUSO is designed to observe Ultra-High Energy Cosmic Ray-induced air showers by measuring the fluorescent and Cherenkov light they emit in the near ultraviolet. Video clips of the showers will be recorded and used to reconstruct the energies and arrival directions of the cosmic rays. EUSO-BALLOON will demonstrate the key JEM-EUSO technologies and techniques including an infrared camera to characterize the atmosphere. It will be flown on stratospheric balloons by the French Space Agency, CNES. The first flight will be in the summer of 2014. The instrument will point to the nadir from an altitude of about 40 km recording both showers and background transient luminous events. EUSO-BALLOON will monitor a 12 by 12 degree field of view. It is currently being integrated and tested at IRAP in Toulouse.

1 This work was supported in part by NASA Grant NNX13AH53G.
2 http://jemeuso.riken.jp
1:54PM K8.00003 Greenland Neutrino Observatory (GNO): A New Detector for Ultra-high Energy Neutrinos. ABIGAIL VIEREGG, University of Chicago, GREENLAND NEUTRINO OBSERVATORY (GNO) COLLABORATION — Neutrinos travel virtually unimpeded through the universe, making them unique messenger particles for cosmic sources and carrying information about very distant sources that would otherwise be unavailable. The observation of ultra-high energy (UHE) neutrinos (E > 10^18 eV) would also allow a measurement of weak interaction couplings at center of mass energies well beyond that of the LHC and reveal the origin of the highest energy cosmic rays. We are planning to deploy a new array of radio detectors for UHE neutrinos near the surface of the ice at Summit Station in Greenland, a year-round NSF station that sits atop 3 km of ice at the height of the Greenland plateau. The full array will have the sensitivity required to discover neutrinos produced through the so-called GZK process (the interaction of the highest energy cosmic rays with cosmic microwave background photons) even in the most pessimistic of models and will detect ~10 events per year at the high-energy portion (E > 10^19 eV) of the observed IceCube astrophysical neutrino spectrum with sub-degree pointing resolution. We are planning to deploy our first module in the summer of 2014.

2:06PM K8.00004 Cerenkov Events Seen by The TALE Air Fluorescence Detector. T. ABUZAYYAD, Z. ZUNDEL, J.D. SMITH, S.B. THOMAS, D. IVANOV, J.N. MATHEWS, C.C.H. JUI, G. THOMSON, University of Utah, TELESCOPE ARRAY COLLABORATION — The Cerenkov Array Low-Energy Extension (TALE) is designed to study cosmic rays at energies above 30 PeV. The TALE FD is comprised of 10 telescopes covering the elevation range 31-58° and 14 telescopes with elevation coverage of 3-31°. A subset of the shower events recorded by TALE are ones for which the Cerenkov light produced by the shower particles dominates the total observed light signal. We have investigated the feasibility of using these events for cosmic rays measurements. With this data, the low energy reach of the TALE detector can be extended down to ~5 PeV. The use of the Cerenkov events collected by an FD represents a new approach to the measurement of cosmic rays at energies above the knee and below 100 PeV. By leveraging a detector built for the purpose of observing cosmic rays at higher energies, this technique adds to the capability of the detector and provides a cost effective way to view an energy region that has thus far been inaccessible to Air Fluorescence detectors. We will report on a first measurement by TALE of the cosmic rays energy spectrum in the energy range of 5 - 100 PeV. Since we are using a newly deployed detector, and we are looking at a new type of event, this result is very preliminary.

2:18PM K8.00005 Telescope Array Radar (TARA) Remote Station Design and Development. SAMRIDA KUNWAR, Univ of Kansas, TELESCOPE ARRAY RADAR (TARA) COLLABORATION — The TARA project is a novel attempt utilizing a bistatic radar technique to detect ultra-high energy cosmic rays. The main components of the radio-frequency radiation arising from the build up of a charge asymmetry in the Hadron shower. We present the design and development of the remote radar receiver system using a technique where the Doppler-shifted reflected signal off of the ionization trail from the cosmic ray is de-chirped. The approach is based on an analog frequency mixing technique whereby the input signal is mixed with a delayed copy of itself i.e. \( s(t) \otimes n(t - \tau) \), resulting in a beat frequency, \( f \), which is proportional to the delay time multiplied by the cosmic ray-induced RF chirp rate. With appropriate filtering, the problem of chirp detection is ultimately reduced to that of detecting the down-converted monochromatic. In contrast to conventional signal processing via digital matched filtering, this is a mostly analog data acquisition system and has lower power consumption at a cost which is also comparatively inexpensive. The remote station is also subject to less radio interference, and adds stereoscopic measurement capabilities which allows unique determination of cosmic ray geometry and core location.

2:30PM K8.00006 Radio Emission from an Electron Shower in a Dielectric in the Presence of a Magnetic Field. STEPHANIE WISSEL, KONSTANTIN BELOV, University of California, Los Angeles, T-510 EXPERIMENT COLLABORATION — Several new experiments employ the radio technique to detect ultra-high-energy cosmic rays. The dominant component of the radio-frequency radiation arises from synchrotron emission due to the magnetic field of the cosmic ray's air shower particles with the Earth's magnetic field. Secondary, but non-negligible, radiation arises from the build up of a charge asymmetry in the shower. We present measurements from the SLAC T-510 experiment in which we bombard a polyethylene target (\( n = 1.5 \)) in a magnetic field (up to a few kiloGauss) with a few GeV electron beam. Antennas in bands ranging between 30-300 MHz and 300-1200 MHz map out the radio emission in bands relevant for ground arrays and balloon-borne experiments such as ANITA. The data presented here serve to calibrate models of radio emission, ZHAires and CoREAS, by providing a suite of controlled, accelerator-based measurements.

2:42PM K8.00007 Optical and Ionization Basic Cosmic Ray Detector. JULIAN FELIX, DIEGO A. ANDRADE, AURORA C. ARAUJO, LUIS ARCEO, CARLOS A. CERVANTES, JORGE A. MOLINA, LUZ R. PALACIOS, Universidad de Guanajuato — There are drift tubes, operating in the Geiger mode, to detect ionization radiation. The fabricated particle detectors are based on photomultiplier tubes. Here is the idea: the basic character of the ionization radiation, in combination with the operational capability of a hybrid detector that combines both a drift tube and a Cerenkov detector, used mainly so far to detect cosmic rays. The basic cell is a structural Aluminum 101.6 cm-long, 2.54 cm X 2.54 cm-cross section, 0.1 cm-thick tube, interiorly polished and filed with air, and Methane-Ar at different concentrations. There is a coaxial 1 mil Tungsten wire Au-coated at ~7000 volts electronically instrumented to read out in both ends; and there is in each end of the Aluminum tube a S10362-11-100U Hamamatsu avalanche photodiode electronically instrumented to be read out simultaneously with the Tungsten wire signal. This report is about the technical operation and construction details, the characterization results and potential applications of this hybrid device as a cosmic ray detector element.

3:06PM K8.00009 Analysis of Silicon Photomultiplier Detector Waveforms from Cosmic Rays using Digital Signal Processing Techniques. JUAN CASTRO, FAVIAN ZAVALA, REXAVALMAR NIDUAZA, ZACHARY WEDEL, SEWAN FAN, Hartnell College, STEFAN RITT, Paul Scherrer Institute, LAURA FATUZZO, Hartnell College — Silicon photomultiplier detectors exhibit high gain, low operating voltage, are insensitive to magnetic fields, and can detect light at the single photon level, making them very attractive for applications in fields such as particle physics, astrophysics, and medical physics. However, they exhibit effects that may prevent their optimal operation, including thermally induced high dark count rate, after pulse effects, and cross talk produced from photons in nearby pixels. In this presentation, we describe our waveform collection technique using two scintillating pads and a Hamamatsu multipixel photon counter (MPPC) to gather cosmic ray produced signal pulses, and our methods of analysis for the detector waveforms. In particular, we discuss our methods of digitization, software implementation of low pass and Gaussian type filters, and the application of a domino ring sampler (DRS4) digitizing board to obtain signal waveforms to determine the operating characteristics for these detectors.

3:18PM K8.00010 Greenland Neutrino Observatory (GNO): A New Detector for Ultra-high Energy Neutrinos. ABIGAIL VIEREGG, University of Chicago, GREENLAND NEUTRINO OBSERVATORY (GNO) COLLABORATION — Neutrinos travel virtually unimpeded through the universe, making them unique messenger particles for cosmic sources and carrying information about very distant sources that would otherwise be unavailable. The observation of ultra-high energy (UHE) neutrinos (E > 10^18 eV) would also allow a measurement of weak interaction couplings at center of mass energies well beyond that of the LHC and reveal the origin of the highest energy cosmic rays. We are planning to deploy a new array of radio detectors for UHE neutrinos near the surface of the ice at Summit Station in Greenland, a year-round NSF station that sits atop 3 km of ice at the height of the Greenland plateau. The full array will have the sensitivity required to discover neutrinos produced through the so-called GZK process (the interaction of the highest energy cosmic rays with cosmic microwave background photons) even in the most pessimistic of models and will detect ~10 events per year at the high-energy portion (E > 10^19 eV) of the observed IceCube astrophysical neutrino spectrum with sub-degree pointing resolution. We are planning to deploy our first module in the summer of 2014.

3:30PM K8.00008 Comparative Analysis of Cherenkov Light Detectors in an Oil Drum. REXAVALMAR NIDUAZA, ZACHARY WEDEL, JUAN CASTRO, FAVIAN ZAVALA, SEWAN FAN, LAURA FATUZZO, Hartnell College — The multi-pixel photomultiplier counter (MPPC) has been used in a number of research development in astro-particle physics and particle physics. In an effort to further implement the MPPC detector, we constructed a modular experimental setup using a 16-inch tall acrylic cylinder filled with distilled water as the light producing medium to determine its feasibility as a possible detector for weak Cherenkov light. We have since progressed towards utilizing an oil drum (approximately 30 gallons) as our light-tight container replacing our prototype. In this talk, we would discuss the results regarding our investigation utilizing 1-inch and 3-inch photo-multiplier tubes (PMTs) with and without a Hamamatsu low-noise (HN) high voltage power supply (HVPS) and their use in an oil drum setup using PMTs in coincidence with the MPPC coupled with wavelength-shifting fibers that are submerged in distilled water inside the oil drum vessel.

3:42PM K8.00003 Greenland Neutrino Observatory (GNO): A New Detector for Ultra-high Energy Neutrinos. ABIGAIL VIEREGG, University of Chicago, GREENLAND NEUTRINO OBSERVATORY (GNO) COLLABORATION — Neutrinos travel virtually unimpeded through the universe, making them unique messenger particles for cosmic sources and carrying information about very distant sources that would otherwise be unavailable. The observation of ultra-high energy (UHE) neutrinos (E > 10^18 eV) would also allow a measurement of weak interaction couplings at center of mass energies well beyond that of the LHC and reveal the origin of the highest energy cosmic rays. We are planning to deploy a new array of radio detectors for UHE neutrinos near the surface of the ice at Summit Station in Greenland, a year-round NSF station that sits atop 3 km of ice at the height of the Greenland plateau. The full array will have the sensitivity required to discover neutrinos produced through the so-called GZK process (the interaction of the highest energy cosmic rays with cosmic microwave background photons) even in the most pessimistic of models and will detect ~10 events per year at the high-energy portion (E > 10^19 eV) of the observed IceCube astrophysical neutrino spectrum with sub-degree pointing resolution. We are planning to deploy our first module in the summer of 2014.
1:30PM K9.00001 Growth of structure in a Universe with complex scalar-field dark matter . TANJA RINDLER-DALLER, University of Michigan, BOHUA LI, PAUL SHAPIRO, University of Texas at Austin — The nature and distribution of dark matter (DM) in the Universe determine the properties of the structures we observe. In recent years, the exploration of different DM candidates has seen a tremendous rise, partly due to the fact that the canonical DM paradigm of a weakly-interacting massive particle (WIMP), has not yet been confirmed experimentally. Moreover, numerical simulations of structure formation of collisionless WIMP DM are often in contradiction with observations of galaxies on small scales. We will assume that ultra-light, self-interacting bosons are responsible for all of the DM. Owing to their ability to form a Bose-Einstein condensate in the very early Universe, DM can be described as a classical complex scalar field (SFDM). In a previous work, we have established that the background evolution of SFDM with a cosmological constant (LSFDM) is in accordance with the concordance LCDM model if the model parameters are properly constrained by observations of the CMB and BBN. However, not only does LSFDM lead to non-standard expansion histories prior to BBN, it can also help to resolve the problems found in the LCDM model on small scales. In this talk, we will present new results on the linear and nonlinear growth of structure in this LSFDM model, and their implications.

1:42PM K9.00002 Constraints on Dark Matter Annihilation by Radio Observations of Milky Way1 , ANDREY EGOROV, ELENA PIERPAOLI, University of Southern California, JENNIFER SIEGAL-GASKINS, California Institute of Technology — WIMP annihilation in the Milky Way (MW) halo is expected to produce various energetic stable particles. These particles can manifest themselves through various emission processes. Such an emission spans almost the whole spectrum from radio to gamma bands. In a recent few years several groups reported the significant gamma ray excess at GeV energies in the MW center region, which can’t be explained by conventional astronomical sources. To explain this excess, one needs either an additional population of millisecond pulsars or the annihilating dark matter (DM). In the DM scenario, one may estimate the necessary WIMP properties. And several groups report close WIMP parameters needed. Naturally, we expect a radio counterpart of this gamma excess to be present, which originates as a synchrotron radiation of leptons produced by WIMP annihilation. And a comprehensive study of such a counterpart has not been conducted yet. Our work is in progress and focuses on the low frequency emission. We are planning to present the general constraints on WIMP properties based on whole sky radio observations of MW (including various radio surveys and Planck data), and also planning to support or weaken the DM interpretation of the gamma excess through studies of its expected counterpart.

1 This work is supported by the Fermi Guest Investigator program.

1:54PM K9.00003 Resolving Small-Scale Dark Matter Structures Using Multi-Source Indirect Detection , KENNY CHUN YU NG, RANJAN LAHA, SHELDON CAMPBELL, The Ohio State University, Columbus, SHUNSAKU HORIUCHI, University of California, Irvine, BASUDEB DASGUPTA, International Center for Theoretical Physics, Trieste, KOHTA MURASE, Institute for Advanced Study, Princeton, JOHN BEACOM, The Ohio State University, Columbus — The extragalactic dark matter (DM) annihilation signal depends on the product of the clumping factor, $\langle \delta^2 \rangle$, and the velocity-weighted annihilation cross section, $\sigma v$. It is important to determine the clumping factor as it depends on the minimum DM halo mass, $M_{\text{min}}$, or equivalently the kinetic decoupling temperature of DM. In this work, we demonstrate how to break the “clumping factor–$\sigma v$” degeneracy by comparing the Isotropically Gamma Ray Background with tentative DM signals from the Galactic Center. We obtain interesting limits on $M_{\text{min}}$ and $\sigma v$. Potential improvements in near future are discussed, which will have significant implications for the tentative DM signals.

2:06PM K9.00004 Dark-matter admixed white dwarfs1 , SHING CHI LEUNG, MING CHUNG CHU, LAP MING LIN, KA WING WONG, Department of Physics and Institute of Theoretical Physics, The Chinese University of Hong Kong, Hong Kong, China — We study the equilibrium structures of white dwarfs (WD) with dark matter cores formed by non-self-annihilating dark matter (DM) particles with masses ranging from 1 GeV to 100 GeV, assuming in form of an ideal degenerate Fermi gas inside the stars. For DM particles of mass 10 GeV and 100 GeV, we find that stable stellar models exist only if the mass of the DM core inside the star is less than $O(10^{-4}) M_{\odot}$ and $O(10^{-4}) M_{\odot}$, respectively. The global properties of these stars, and the corresponding Chandrasekhar mass (CM) limits, are essentially the same as those of traditional WD models without DM. Nevertheless, in the 10 GeV case, the gravitational attraction of the DM core is strong enough to squeeze the normal matter in the core region to densities above neutron drip. For the 1 GeV case, the DM core inside the star can be as massive as $O(0.1) M_{\odot}$ and affects the global structure of the star significantly. The radius of a stellar model with DM can be about two times smaller than that of a traditional WD. Furthermore, the CM limit can be decreased by as much as 40%. Our results may have implications on the extent to which type Ia supernovae can be regarded as standard candles.

1 This work is partially supported by a grant from the Research Grant Council of the Hong Kong Special Administrative Region, China (Project No. 400910).

2:18PM K9.00005 The Luminous Convolution Model-The light side of dark matter1 , SOPHIA CISNEROS, Massachusetts Institute of Technology, NOAH OBLATH, JOE FORMAGGIO, MIT, GEORGE COEDECKE, New Mexico State University, DAVID CHESTER, UCLA, RICHARD OTT, UCDavis, AARON ASHLEY, Massachusetts Institute of Technology, ADRIANNA RODRIGUEZ, MIT — We present a heuristic model for predicting the rotation curves of spiral galaxies. The Luminous Convolution Model (LCM) utilizes Lorentz-type transformations of very small changes in the photon’s frequencies from curved space-time to construct a dynamic mass model of galaxies. These frequency changes are derived using the exact solution to the exterior Kerr wave equation, as opposed to a linearized treatment. The LCM Lorentz-type transformations map between the emitter and the receiver rotating galactic frames, and then to the associated flat frames in each galaxy where the photons are emitted and received. This treatment necessarily rests upon estimates of the luminous matter in both the emitter and the receiver galaxies. The LCM is tested on a sample of 22 randomly chosen galaxies, represented in 33 different data sets. LCM fits are compared to the Navarro, Frenk & White (NFW) Dark Matter Model and to the Modified Newtonian Dynamics (MOND) model when possible. The high degree of sensitivity of the LCM to the initial assumption of a luminous mass to light ratios (M/L), of the given galaxy, is demonstrated. We demonstrate that the LCM is successful across a wide range of spiral galaxies for predicting the observed rotation curves.

1 Through the generous support of the MIT Dr. Martin Luther King Jr. Fellowship program.

2:30PM K9.00006 Luminogenesis RG Flow , KEVIN LUDWICK, Univ of Virginia — Using the constraints from the Planck satellite on inflation models and renormalization-group flow, we present constraints on the mass of dark-matter particles in a unification model with the gauge group $SU(3) \times SU(6) \times U(1)$, which breaks to the standard model with an extra gauge group for dark matter when the inflation rolls into the true vacuum. In this model, inflaton decay gives rise to dark matter, which in turn decays to luminous matter in the right proportion that agrees with cosmological data. Some attractive features of this model include self-interacting dark matter, which may resolve the problems of dwarf-galaxy structures and dark-matter cusps at the centers of galaxies, and the absence of proton decay, which has evaded experimental detection to this day.
2:42PM K9.00007 Flattened Velocity Dispersion in Globular Clusters; A Perspective From Modified Gravity Schemes, MARIA JIMENEZ, XAVIER HERNANDEZ, CHRISTINE ALLEN, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico — Recent observations have confirmed the flattening of the radial velocity dispersion profiles for stars in various nearby globular clusters. Under Newtonian gravity this is explained by invoking tidal heating from the overall Milky Way potential on the outer more loosely bound stars. From the point of view of modified gravity theories, such an outer flattening is expected on crossing the critical acceleration threshold $a_0$, beyond which, a transition to MONDian dynamics expected. From an empirical point of view, we determine Newtonian tidal radii using masses accurately calculated through stellar population modeling, and hence independent of any dynamical assumptions for a sample of globular clusters. Crucially, we find that the asymptotic values of the velocity dispersion profiles scale with the fourth root of the total masses in accordance with the galactic Tully-Fisher relation. Also, in all cases, Newtonian tidal radii at perigalactic are larger that the radii at which the flattening in the velocity dispersion profiles occurs, which correlate with the radii where the $a_0$ threshold is crossed, as expected under modified gravity scenarios.

2:54PM K9.00008 Hunting for topological dark matter with atomic clocks, ANDREI DEREVIanko, University of Nevada, Reno, MAXIM POSPELOV, University of Victoria and Perimeter Institute — The cosmological applications of atomic clocks so far have been limited to searches of the uniform in time drift of fundamental constants. In this paper, we point out that a transient in time change of fundamental constants can be induced by dark matter objects that have large spatial extent, and are built from light non-Standard Model fields. The stability of this type of dark matter can be dictated by the topological reasons. We point out that correlated networks of atomic clocks, some of them already in existence, can be used as a powerful tool to search for the topological defect dark matter, thus providing another important fundamental physics application to the ever-improving accuracy of atomic clocks. During the encounter with a topological defect, as it sweeps through the network, initially synchronized clocks will become desynchronized. Time discrepancies between spatially-separated clocks are expected to exhibit a distinct signature, encoding defect’s space structure and its interaction strength with the Standard Model fields.

3:06PM K9.00009 Study of vortices in Axion BEC dark matter, NILANJAN BANIK, PIERRE SIKIVIE, University of Florida — We present an analytic study of the vortices in the axion BEC dark matter and their effects on the galactic angular momentum distribution of baryons and dark matter in disk galaxies.

Sunday, April 6, 2014 1:30PM - 3:18PM
Session K10 FIP DPB: Invited Session: Large Scale International Facilities II: Particle Accelerators
204 - Christine Darve, European Spallation Source

1:30PM K10.00001 European Spallation Source and Neutron Science, JAMES YECK, European Spallation Source — International collaborations in large-scale scientific projects can link Sciences and Society. Following this goal, the European Spallation Source (ESS) is a multi-disciplinary research centre under design and construction in Lund, Sweden. This new facility is funded by a collaboration of 17 European countries. Scandinavia is providing 50 percent of the construction cost whilst the other member states are providing financial support mainly via in-kind contribution from institutes, laboratories or industries of the given countries. Scientists and engineers from 35 different countries are members of the workforce in Lund who participate in its design and construction. The ESS will enable new opportunities for researchers in fields of life sciences, energy, environmental technology, cultural heritage and fundamental physics by producing very high flux neutrons to study condensed matter physics, chemistry, biology, nuclear physics and materials science. The ESS will be up to 30 times brighter than today’s leading facilities and neutron sources. A tungsten target and a 5 MW long pulse proton accelerator, composed mainly of superconducting Radio-Frequency components, are used to achieve these goals.

2:06PM K10.00002 CERN Roadmap: Exploitation of the Full Potential of the LHC and post-LHC Accelerator Studies, FREDERICK BORDRY, Director of Accelerators and Technology CERN — After a Long Shutdown (LS1), LHC physics will resume in early 2015 while the other injectors and experimental areas of CERN will resume their operation in the second half of 2014. After a short report on the LS1 status, the presentation will describe the operation strategy after the LS1 and the main activities during the LS2. Then, it will give the plans for the full exploitation of the LHC in line with the priority of Update of the European Strategy for Particle Physics: HL (High Luminosity) LHC project. HL-LHC installation is planned for Long Shutdown 3 (LS3), now scheduled for the period 2023-2025 with the goal to reach 3000 fb$^{-1}$ by 2035. Finally post-LHC accelerator studies will be introduced and particularly the Future Circular Collider (FCC) programme centred on a new-generation circular colliders with a circumference of 80 to 100 kilometres.

2:42PM K10.00003 The Facility for Rare Isotope Beams Project, THOMAS GLASMACHER, Thomas Glasc- macher, Facility for Rare Isotope Beams, 640 South Shaw Lane, Michigan State University — The Facility for Rare Isotope Beams (FRIB) will be a U.S. Department of Energy Office of Science (DOE-SC) national user facility supporting the mission of the DOE-SC Office of Nuclear Physics. Centered on a 400kW superconducting linear accelerator providing heavy-ion beams with energies of 200MeV/nucleon for all ions, FRIB will enable scientists to make discoveries with fast, stopped, and reaccelerated rare isotopes. The FRIB project was baselined at a total project cost of $730M with scheduled completion in June 2022. The project is being managed to early completion in 2020 and civil construction has begun on the campus of Michigan State University. This talk will give an overview of the FRIB project, its current status and prospects for discovery.

The design and establishment of FRIB is supported by the U.S. Department of Energy Office of Science under cooperative agreement DE-SC0000661, the State of Michigan and Michigan State University.

Sunday, April 6, 2014 1:30PM - 3:00PM
Session K11 APS: Town Hall on APS Corporate Reform, Open Access Publishing, and the Future of Open Data
Oglethorpe Auditorium -

1:30PM K11.00001 APS Corporate Reform, MALCOLM BEASLEY, APS President and Stanford University —
2:15PM K11.00002 Town Hall Meeting: Open Access and Open Data: What They Mean for APS Journals — JOSEPH SERENE, APS Treasurer/Publisher, MICHAEL LUBELL, APS Director of Public Affairs — For a number of years Congress and the White House have been exploring mechanisms to make scientific literature more available to the public. A mandate for achieving that goal appeared in the 2010 America COMPETES Act, and since then Executive Branch Agencies have been actively developing plans to provide such access. We will review the status of the federal plans and discuss the implications for authors and publishers. We will also report on the status of plans for requiring authors to make available publicly data upon which their published results are based.

Sunday, April 6, 2014 1:30PM - 3:18PM – Session K12 DPF: Neutrinos from Reactors and the Cosmos 100 - Sally Seidel, University of New Mexico

1:30PM K12.00001 PROSPECT: A Precision Reactor Oscillation and Spectrum Experiment, BRYCE LITTLEJOHN, University of Cincinnati, PROSPECT COLLABORATION — Antineutrino detectors operated close to a compact reactor core can provide excellent sensitivity to short-baseline oscillation effects by precisely measuring any relative distortion of the $\sin^2 2\theta_13$ spectrum as a function of both energy and baseline. Such a measurement can be performed in the United States at several highly-enriched uranium fueled research reactors using near-surface segmented scintillator detectors. This talk will describe the preliminary conceptual design and oscillation physics potential of the PROSPECT experiment, a U.S.-based, multi-phase, 2-detector experiment with reactor-detector baselines of 4-20 meters capable of excluding a majority of the suggested sterile neutrino oscillation parameter space at high confidence level. Additional goals, such as precise measurement of the $\sin^2 2\theta_13$ spectrum from a highly-enriched uranium core, as well as development of detection techniques and technology for reactor monitoring applications, will be discussed.

1:42PM K12.00002 Background Characterization for PROSPECT: a US Short-baseline Neutrino Oscillation Experiment, THOMAS LANGFORD, Yale University, PROSPECT COLLABORATION — Segmented antineutrino detectors placed near compact research reactors provide an excellent opportunity to probe short-baseline neutrino oscillations and precisely measure the reactor antineutrino spectrum. The PROSPECT collaboration has developed a conceptual design for an experiment covering the favored reactor anomaly parameter space using two detectors located within 4-20 m of an existing reactor. Research reactors offer the benefits of compact cores, distinct reactor-off periods, and single-isotope fuel. However, they are typically located at ground level, providing little to no overburden to shield detectors. This talk will present the background requirements of the PROSPECT experiment and discuss feasibility studies that have been performed for three potential locations: NIST, INL, and ORNL. Two fast neutron detectors, a muon telescope, and HPGe and NaI gamma detectors have been deployed at the sites to measure reactor-related and cosmogenic backgrounds. The results of background measurements at each site during reactor operation and shutdown will be shown. Additionally, the planned techniques to reduce the impact of each background on the physics reach of the full experiment will also be discussed.

1:54PM K12.00003 Scintillator Development for the PROSPECT Experiment, MINFANG YEH, Brookhaven National Laboratory, PROSPECT COLLABORATION — Doped scintillator is the target material of choice for antineutrino detection as it utilizes the time-delayed coincidence signature of the positron annihilation and neutron capture resulting from the Inverse Beta Decay (IBD) interaction. Additionally, the multiple gamma rays or heavy ions emitted after neutron capture on either Gd or $^{6}$Li respectively provide a distinct signal for the identification of antineutrino events and therefore significantly enhance accidental background reduction. The choice of scintillator and dopant depends on the detector requirements and scintillator performance criteria. Both Gd and $^{6}$Li doped scintillators have been used in other reactor antineutrino experiments such as DoubleChooz, Daya Bay, RENO, and Bugge3 and are currently under investigation by the PROSPECT collaboration. Their properties in terms of light yield, optical transparency, chemical stability and background rejection efficiency using Pulse Shape Discrimination (PSD) will be reported.

2:06PM K12.00004 The Watchman Detector Design, STEVEN DAZELEY, Lawrence Livermore Natl Lab, WATCHMAN COLLABORATION — The Watchman collaboration is proposing a kiloton scale antineutrino detector of reactor-based antineutrinos for non-proliferation purposes. As an added bonus the detector will also have the capability to search for evidence of sterile neutrino oscillation, super-nova antineutrinos and, in a second phase, measure the neutrino mass hierarchy. Despite that fact that KamiLAND demonstrated the feasibility of kiloton scale, long distance antineutrino detection with liquid scintillator, similar detectors at the megaton scale remain problematic for environmental, cost and light attenuation reasons. Water, with gadolinium added for neutron sensitivity, may be the detection medium of choice if its efficiency can be shown to be competitive with scintillator. The goal of the Watchman project, therefore, is to demonstrate medium distance reactor antineutrino detection, and thus demonstrate the feasibility of moving to water-based megaton scale antineutrino detectors in the future. This talk will describe the scope of the experiment, the physics and engineering challenges involved, the proposed design and the predicted performance of the experimental non-proliferation and high-energy physics program.

2:18PM K12.00005 WATCHMAN: Reactor Monitoring and Neutrino Physics with a Gadolinium Doped Water Detector, ADAM BERNSTEIN, LLNL, WATCHMAN TEAM — WATCHMAN (WATER Cherenkov Monitoring of AntiNeutrinos) is a new US based experiment that will exploit the low energy antineutrino signal from reactors, supernova and decay-at-rest antineutrino beams to pursue a broad physics program. WATCHMAN aims to be the first detector in the world to detect low energy antineutrinos in water, by adding a gadolinium dopant that increases the efficiency for the final-state neutron arising from the antineutrino interactions on protons in the water. WATCHMAN will also serve as the world’s first demonstration detector of remote reactor monitoring for nonproliferation applications, using a scalable water-based technology. In this talk, I will provide an overview of the physics potential of WATCHMAN, and explain the overlap of its nonproliferation and fundamental science goals.

1Research sponsored by the U.S. Department of Energy, Office of Nuclear Physics and Office of High Energy Physics, under contract with Brookhaven National Laboratory-Brookhaven Science Associates

1Lawrence Livermore National Laboratory is operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration under Contract DE-AC52-07NA27344. Release number LLNL-ABS-648381

2Prepared by LLNL under Contract DE-AC52-07NA27344

2Water Cherenkov Monitor for ANtineutrinos
2:30PM K12.00006 The Atmospheric Neutrino Neutron Interaction Experiment (ANNIE)  
MATTHEW WETSTEIN, University of Chicago — Neutron tagging in Gadolinium-doped water may play a significant role in reducing backgrounds from atmospheric neutrinos in next generation proton-decay searches using Megaton-scale Water Cherenkov detectors. Similar techniques might also be useful in the detection of Supernova neutrinos. Accurate determination of neutron tagging efficiencies will require a detailed understanding of the number of neutrons produced by neutrino interactions in water, as a function of momentum transferred. In this talk we present the proposed Atmospheric Neutrino Neutron Interaction Experiment (ANNIE), designed to measure the neutrino yield of atmospheric neutrino interactions in gadolinium-doped water. We will introduce some of the physics motivations for this measurement as well as the novel technological aspects. One important component of the ANNIE design is the use of precision timing to localize interaction vertices in the small fiducial volume of the detector. To achieve this, we propose to use early prototypes of LAPPDs (Large Area PicoSecond Photodetectors), now in the commercialization phase. These photosensors and their status will also be discussed.

2:42PM K12.00007 Coherent Scattering Investigations at the Spallation Neutron Source (CISI)  
PHIL BARBEAU, Duke Univ — The Spallation Neutron Source (SNS) at Oak Ridge National Laboratory, Tennessee, provides an intense isotropic flux of neutrinos in the few tens-of-MeV range, with a sharply-pulsed timing structure which is beneficial for background rejection. This talk will describe how the SNS source can be used for a measurement of coherent elastic neutrino-nucleus scattering (CENNS), the physics reach of such a measurement, and status of the planned experimental program (CSI: Coherent Scattering Investigations at the SNS).

2:54PM K12.00008 The IceCube DeepCore Detector  
LAURA GLADSTONE, University of Wisconsin, ICECUBE COLLABORATION — The IceCube Neutrino Observatory, located at the geographic South Pole, has an infill array called DeepCore in the core of its instrumented volume. To date, DeepCore has recorded well over 10^7 neutrino interactions at energies of 10 to 300 GeV at trigger level. Analyzing signals in this energy range requires adjustments to standard IceCube tools, such as position and energy reconstruction and noise simulation. With these lower energies, the available science opportunities for IceCube include more sensitive studies of neutrino properties, including oscillations, and indirect dark matter searches from the Sun and Galactic Center. Atmospheric neutrino oscillations have been observed, and the current status of their ongoing study will be discussed.

3:06PM K12.00009 Determination of the neutrino mass hierarchy with PINGU  
TYCE DEYOUNG, Pennsylvania State University, ICECUBE-PINGU COLLABORATION — The Precision IceCube Next Generation Upgrade (PINGU) is a proposed low energy infill extension to the IceCube Neutrino Observatory, with the primary scientific goal of determining the neutrino mass hierarchy. With an effective neutrino target mass of several megaltons and an energy threshold of a few GeV, PINGU will be able to determine the mass hierarchy at a significance of 3σ with an estimated 3.5 years of data by measuring matter effects on atmospheric neutrinos traversing the Earth over a wide energy range and on a variety of baselines. PINGU will use technology similar to the existing IceCube instrumentation, enabling it to be deployed quickly and at a relatively modest cost.

Sunday, April 6, 2014 1:30PM - 3:06PM —
Session K13 GPMFC DPF: Dark Sector and Neutrino Theory  
101 - JoAnne Hewett, SLAC National Accelerator Laboratory

1:30PM K13.00001 Dark Matter Particles Interacting via a Higgs Field  
JURU DAREWYCH, ALEXANDER CHIGODAEEV, York Univ — We study a system of two dark-matter particles, treated as scalars, interacting via a Higgs-type mediating field. The variational method in a reformulated Hamiltonian formalism of Quantum Field Theory is used to derive relativistic two-body wave equations. The nature of the interactions is studied, including the non-relativistic limit. Approximate solutions of the two-body equations are presented.

1:42PM K13.00002 Viable dark matter via radiative symmetry breaking in a Higgs portal extension of the standard model  
ZHI-WEI WANG, TOM STEELE, University of Saskatchewan, ROBB MANN, DAGOBERTO CONTRERAS, University of Waterloo — We consider generation of dark matter mass via radiative electroweak symmetry breaking in an extension of the conformal Standard Model containing a singlet scalar field with a Higgs portal interaction. Generating the mass from a sequential process of radiative electroweak symmetry breaking followed by a conventional Higgs mechanism can account for less than 30% of the cosmological dark matter abundance. However in a dynamical approach where both Higgs and scalar singlet masses are generated via radiative electroweak symmetry breaking we obtain much higher levels of dark matter abundance: 10%–80% for a dark matter mass of 80 GeV when higher-order contributions are estimated. The dynamical approach also predicts a small scalar-singlet self-coupling, providing a natural explanation for the astrophysical observations that place upper bounds on dark matter self-interaction. The predictions in both methods are within the detection region of the next generation XENON experiment.

1:54PM K13.00003 Majorana Physics Through the Cabibbo Haze  
JENNIFER KILE, MICHAEL PEREZ, PIERRE RAMOND, JUE ZHANG, University of Florida, Department of Physics — We present a model in which the Supersymmetric Standard Model is augmented by the family symmetry $Z_2 \times Z_3$. Motivated by $SO(10)$, where the charge two-thirds and neutral Dirac Yukawa matrices are related, we propose, using family symmetry, a special form for the seesaw Majorana matrix; it contains a squared correlated hierarchy, allowing it to mitigate the severe hierarchy of the quark sector. It is reproduced naturally by the invariant operators of $Z_2 \times Z_3$, with the hierarchy carried by familon fields. In addition to relating the hierarchy of the $\Delta I_w = 1/2$ to the $\Delta I_w = 0$ sector, it contains a Gatto-Sartori-Tonin like relation, predicts a normal hierarchy for Tri-bimaximal and Golden Ratio mixings, and gives specific values for the light neutrino masses.

2:06PM K13.00004 Democratic Neutrino Paradigm  
DMITRY ZHURIDOV, Wayne State University — I will introduce a democratic neutrino theory, which sets the absolute scale of the neutrino masses at about 0.03 eV, and has only one free parameter in contrast to 7 (9) free parameters in the conventional model of Dirac (Majorana) neutrino masses and mixing. Taking into account the incoherence and matter effects, this democratic theory agrees with the atmospheric and solar neutrino data. I will discuss the predictions of this theory for low energy beta decays, magnetic moments, and neutrinoless double beta decays. Finally, I will introduce the fundamental basis for this theory and, in general, for all constituents of matter.

1Supported in part by the U.S. Department of Energy under contract DE-FG02-12ER41825
I will focus on the neutrino radiation properties of the disks including luminosities, optical depths, and annihilation efficiencies. M\textsubscript{plasma}, a likely outcome of black hole-neutron star mergers with remnant disks. We continue our study into the neutrino-driven outflows from realistic merger A. SCHEEL, BELA SZILAGYI, California Institute of Technology, SXS COLLABORATION — A gamma ray burst requires a relativistic outflow of low-density plasma, a likely outcome black hole-neutron star mergers with remnant disks. These waveforms will be compared with the post-Newtonian approximants to analyze the robustness of hybridizing long numerical relativity waveforms with post-Newtonian ones to generate long gravitational waveforms which cover the full aLIGO frequency band. 

Because matter and tidal effects are expected to influence the system only when the two bodies are extremely close together, I simulate binary black hole systems of mass ratio 7 as a proxy for BHNS systems during inspiral. I will carry out numerical relativity simulations, keeping the smaller (“neutron star”) object spinless testing various spins on the larger black hole. These waveforms will be compared with the post-Newtonian approximants to analyze the robustness of hybridizing long numerical relativity waveforms with post-Newtonian ones to generate long gravitational waveforms which cover the full aLIGO frequency band.

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2:18PM K13.00005 Accommodate the Neutrino Mixing Angle $\theta_{13}$ within SU(5)

JUE ZHANG, JENNIFER KILE, JAY PEREZ, PIERRE RAMOND, Univ of Florida - Gainesville — Tri-bimaximal, Golden Ratio or Bimaximal matrix has long been considered as a good leading order parametrization for the neutrino mixing matrix. However, the recent discovery of non-zero $\theta_{13}$ neutrino mixing angle requires corrections to these leading order parameterizations. Those corrections may come from the quark sector, as in Grand Unified Theories Yukawa couplings of quarks and leptons are closely related. To explore this possibility, we perform a numerical search with the guidance of SU(5), and indeed find some solutions that can accommodate current neutrino data.

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2:30PM K13.00006 Collective Neutrino Oscillations

SHASHANK SHALGAR, HUAIYU DUAN, Univ of New Mexico — The large neutrino flux emitted during core-collapse supernovae leads to neutrino self-interaction. The presence of neutrino self-interaction is the cause for interesting non-linear evolution of neutrino flavor. This offers a unique probe for neutrino properties. However, due to the non-linear nature, there are challenges in the computation of flavor evolution even in the simplest case. We discuss the physics impact of supernova neutrinos, the challenges involved, and potential improvements in methods for computation of neutrino flavor evolution in core-collapse supernovae.

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2:42PM K13.00007 Constraints on quark interactions with light dark matter

BOGDAN DOBRESCU, CLAUDIA FRUGIUELE, Fermilab — We explore how strongly can dark matter interact with quarks. We concentrate on dark matter particles of mass below 5 GeV, which are poorly constrained by direct detection searches. The theoretical constraints (such as those imposed by anomaly cancellation) are interwoven with experimental ones (such as those from searches for vector-like quarks). We present renormalization theories that alleviate those constraints, and then we propose some experimental tests using neutrino detectors.

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2:54PM K13.00008 Two Fundamental Principles of Nature’s Interactions

TIAN MA, Sichuan University, SHOUHONG WANG, Indiana University — In this talk, we present two fundamental principles of nature’s interactions, the principle of interaction dynamics (PID) and the principle of representation invariance (PRI). Intuitively, PID offers a completely different and natural way of introducing Higgs fields. PRI requires that physical laws be independent of representations of the gauge groups. These two principles give rise to a unified field model for four interactions, which can be naturally decoupled to study individual interactions. With these two principles, we are able to derive 1) a unified theory for dark matter and dark energy, 2) layered strong and weak interaction potentials, and 3) the energy levels of subatomic particles.

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Sunday, April 6, 2014 1:30PM - 3:06PM

Session K15 Numerical Relativity with Matter: Methods and Simulations I

1:30PM K15.00001 Gravitational Waveforms in the Early Inspiral of Black Hole-Neutron Star Systems

KEVIN BARKETT, California Institute of Technology, SXS COLLABORATION — One of the target systems for gravitational wave detection by aLIGO is a black hole-neutron star (BHNS) binary. For moderate to large black-hole spins, different post-Newtonian approximants disagree for BHNS systems even early in the inspiral, necessitating accurate yet computationally expensive numerical relativity simulations that cover many orbits in the inspiral regime. Because matter and tidal effects are expected to influence the system only when the two bodies are extremely close together, I simulate binary black hole systems of mass ratio 7 as a proxy for BHNS systems during inspiral. I will carry out numerical relativity simulations, keeping the smaller (“neutron star”) object spinless testing various spins on the larger black hole. These waveforms will be compared with the post-Newtonian approximants to analyze the robustness of hybridizing long numerical relativity waveforms with post-Newtonian ones to generate long gravitational waveforms which cover the full aLIGO frequency band.

1Supported in part by NSF, ONR and Chinese NSF.

1:42PM K15.00002 Black hole-neutron star mergers with a hot equation of state and neutrino cooling

FRANCOIS FOUCART, Univ of Toronto, SXS COLLABORATION — Black hole-neutron star (BHNS) and neutron star-neutron star mergers will be prime candidates for the joint detection of gravitational wave and electromagnetic (EM) signals once the Advanced LIGO/VIRGO/KAGRA detectors come online. For BHNS binaries, the result of the merger strongly depends on the parameters of the system. EM emissions from a post-merger disk (e.g. gamma-ray bursts) are only possible for low mass or high spin black holes. The amount of ejected neutron-rich material, which has important consequences for the emission of energetic gamma-rays and neutrinos, is an important parameter for determining the astrophysical outcome of the merger. To study the electromagnetic and neutrino emission from BHNS mergers, I will carry out numerical relativity simulations, keeping the smaller (“neutron star”) object spinless testing various spins on the larger black hole. These waveforms will be compared with the post-Newtonian approximants to analyze the robustness of hybridizing long numerical relativity waveforms with post-Newtonian ones to generate long gravitational waveforms which cover the full aLIGO frequency band.

1Supported in part by NSF, ONR and Chinese NSF.

1:54PM K15.00003 Neutrino-Driven Outflows From Realistic Black Hole-Neutron Star Mergers

M. BRETT DEATON, Washington State University, FRANCOIS FOUCART, Canadian Institute for Theoretical Astrophysics, MATTHEW D. DUEZ, Washington State University, EVAN O’CONNOR, Canadian Institute for Theoretical Astrophysics, CHRISTIAN D. OTT, California Institute of Technology, LAWRENCE E. KIDDER, CURRAN D. MUHLBERGER, Cornell University, HARALD P. PFEIFFER, Canadian Institute for Theoretical Astrophysics, MARK A. SCHEEL, BELA SZILAGYI, California Institute of Technology, SXS COLLABORATION — A gamma ray burst requires a relativistic outflow of low-density plasma, a likely outcome of black hole-neutron star mergers with remnant disks. We continue our study into the neutrino-driven outflows from realistic merger scenarios (7 $M_{\odot}$-10 $M_{\odot}$ black holes with high spin) by examining disks formed in general relativistic simulations using the LS220 equation of state and neutrino leakage. I will focus on the neutrino radiation properties of the disks including luminosities, optical depths, and annihilation efficiencies.

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1Supported in part by NSF, ONR and Chinese NSF.

This research is supported by the DOE grant No. DE-FG02-97ER41029 and CLAS Dissertation Fellowship.
2:06PM K15.00004 Mass ejection from black hole-neutron star binaries, KOUTAROU KYOTOKU, University of Wisconsin-Milwaukee, KUNIHITO IOKA, KEK (High Energy Accelerator Research Organization), MASARU SHIBATA, Kyoto University — Black hole-neutron star binaries are one of the most promising sources of gravitational waves for upcoming second-generation detectors. To confirm gravitational-wave detection and obtain as much information as possible, it is desirable to observe electromagnetic counterparts simultaneously. It has been pointed out by many authors that various electromagnetic signals are reasonably expected if substantial material is ejected during the binary merger. One plausible mechanism of mass ejection from black hole-neutron star binaries is tidal disruption of neutron stars by the tidal force exerted by black holes. A quantitative study of this dynamical mass ejection requires numerical-relativity simulations. We perform simulations of black hole-neutron star binaries focusing on the dynamical mass ejection for a range of binary parameters including equations of state of neutron star matter. We present important results such as masses and velocities of ejecta obtained by our simulations, and also discuss possible characteristics of electromagnetic counterparts to black hole-neutron star binaries. In particular, we focus on anisotropy and bulk velocity (i.e., the velocity component other than the expansion velocity) of the ejecta, and electromagnetic features resulting from them.

2:18PM K15.00005 GR simulations of binary black hole-neutron stars: Precursor electromagnetic signals,VASILIEOS PASCHALIDIS, University of Illinois at Urbana-Champaign, ZACHARIAH B. ETIENNE, NASA Goddard, University of Maryland and West Virginia University, STUART L. SHAPIRO, University of Illinois at Urbana-Champaign — We present a new computational method for smoothly matching general relativistic ideal magnetohydrodynamics (MHD) to its force-free limit. The method is based on a flux-conservative formalism for MHD and its force-free limit, and a vector potential formulation for the induction equation to maintain the zero divergence constraint for the magnetic field. The force-free formulation evokes the magnetic field and the Poynting vector. Our force-free code passes a robust suite of tests, performed both in 1D flat spacetime and in 3D curved (black hole) spacetimes. Our matching technique successfully reproduces the aligned rotator force-free solution. As an application, we performed the first general relativistic, force-free simulations of neutron star (NS) magnetospheres in orbit about spinning and non-spinning black holes with BH:NS mass ratio 3:1. We find promising precursor EM emission: typical Poynting luminosities at, e.g., an orbital separation of 6.6 times the NS radius, are \( L \sim 6 \times 10^{32} \text{erg/s} \) for a 1.4Ms⊙ NS endowed with a dipolar magnetic field with polar strength 10¹¹G. The Poynting flux peaks within a broad beam of 40 degrees in the azimuthal direction, establishing a possible lighthouse effect.

2:30PM K15.00006 General relativistic corrections to the pulsar spin-down luminosity, MILTON RUIZ, VASILIEOS PASCHALIDIS, STUART SHAPIRO, University of Illinois at Urbana-Champaign — Pulsar magnetospheres are typically modeled in flat spacetime. Adopting our new method for smoothly matching general relativistic ideal magnetohydrodynamics to its force-free limit, we perform the first systematic study of pulsar magnetospheres in general relativity. We endow the neutron star with a general relativistic dipole magnetic field, and model the dense interior with ideal magnetohydrodynamics, and assume force-free electrodynamics in the exterior. Normalizing the spin-down luminosity by its corresponding Minkowski value, we find that relativistic effects give rise to a modest enhancement: the maximum enhancement for \( n = 1 \) polytropes is \( \sim 25\% \), and for a rapidly rotating \( n = 0.5 \) polytrope we find an enhancement to \( \sim 35\% \). We expect stiffer equation of state and more rapidly rotating neutron stars to lead to even larger enhancements in the spin-down luminosity.

2:42PM K15.00007 Tidal disruption process for a Newtonian star and non-spinning black hole, ROSEANNE CHENG, TAMARA BOGDANOVIC, Center for Relativistic Astrophysics, Georgia Institute of Technology — In this study, we analyze the tidal process which disrupts a Newtonian star on a parabolic orbit about a non-spinning black hole and places the debris on bound and unbound trajectories. We implement a three dimensional hydrodynamics and self-gravity code which also calculates the relativistic tidal interaction in a local moving frame centered on a star. We characterize the mass tidally stripped from the star and estimate the orbital parameters of the debris by local to black hole frame transformations. We discuss the bound and unbound "kicks" to the star off of its initial orbit in weak and partially disruptive encounters. We show super-Eddington return rates of debris which closely follow the canonical \( t^{-5/3} \) fall-off. We also show results of encounters very close to the black hole (\( \lesssim 10M \)) and discuss the relativistic effects early in the return rate.

2:54PM K15.00008 Simulating extreme-mass-ratio systems in full general relativity: tidal disruption events, WILLIAM EAST, KIPAC/Stanford, FRANS PRETORIUS, Princeton University — Sparked by recent and anticipated observations, there is considerable interest in understanding events where a star is tidally disrupted by a massive black hole. Motivated by this and other applications, we introduce a new method for numerically evolving the full Einstein field equations in situations where the spacetime is dominated by a known background solution. The technique leverages the knowledge of the background solution to subtract off its contribution to the truncation error, thereby more efficiently achieving a desired level of accuracy. We demonstrate how the method can be applied to systems consisting of a solar-type star and a supermassive black hole with mass ratios \( \gtrsim 10^3 \). The self-gravity of the star is thus consistently modelled within the context of general relativity, and the star’s interaction with the black hole can be performed with minimal computational cost despite the order of magnitude difference in gravitational potential (as defined by the ratio of mass to radius). We study the tidal deformation of the star during infall, as well as the gravitational wave emission, and discuss ongoing work to understand the importance of strong-field gravity effects on tidal disruption events.

Sunday, April 6, 2014 1:30PM - 2:42PM – Session K16 Quantum Aspects of Gravitation II 104 - Parampreet Singh, Louisiana State University

1:30PM K16.00001 The Instability of Global de Sitter Space to Particle Creation, EMIL MOTTOLA, Los Alamos National Laboratory, PAUL ANDERSON, Wake Forest Univ. — Global de Sitter space is unstable to particle creation, even for a massive free field theory with no self-interactions. The O(4,1) de Sitter invariant state is a definite phase coherent superposition of particle and anti-particle solutions in both the asymptotic past and future, and therefore is not a true vacuum state. In the closely analogous case of particle creation by a constant, uniform electric field, a theory with no self-interactions. The O(4,1) de Sitter invariant state is a definite phase coherent superposition of particle and anti-particle solutions in both the

1:42PM K16.00002 Resummed Quantum Gravity Prediction for the Cosmological Constant and Constraints on SUSY GUTS, B.F.L. WARD, Baylor University, Waco, TX, USA — We use our resummed quantum gravity approach to Einstein’s general theory of relativity in the context of the Planck scale cosmology formulation of Bonanno and Reuter to estimate the value of the cosmological constant as \( \Omega \Lambda \approx (0.0024 \text{ ev})^4 \). We show that the closeness of this estimate to experiment constrains susy GUT models.

1Work supported in part by DoE grant DE-FG02-09ER41600 and by the CERN TH Unit
Sometimes cruel circumstances of their times. I will relate a few examples of how my own appreciation and teaching of physics has been enriched by exploring its roots. In this talk, which is intended for a non-specialist audience, I will also explore the history of our science. Exploring the history of our science also naturally leads to learning about the personalities and lives of its developers. In the context of the minisuperspace model, we confirm that, although the topological signature is Euclidean, both the spatial volume as a function of Euclidean time and the propagator for the fluctuations of the geometry as a function of Euclidean time agree well with Lorentzian de Sitter space. Comparing the spectral dimension of this ensemble with that of Lorentzian de Sitter spacetime in causal set theory offers possible additional evidence of the Lorentzian nature of the ensemble. This implies that the common picture of CDT’s ground state needs reexamination.

2:06PM K16.00004 Quantum fluctuations and the small scale structure of spacetime. STEVEN CARLIP, UC Davis — Quantum fluctuations of the stress-energy tensor almost certainly cause light rays to converge very rapidly at distances a bit above the Planck scale. I will explain why this is true, and offer some wild speculations about the implications for the small scale structure of spacetime.

1Supported in part by Department of Energy grant DE-FG02-91ER40674.

2:18PM K16.00005 On Resolutions of Cosmological Singularities in Higher-Spin Gravity. BENJAMIN BURRINGTON, Troy University, LEOPOLDO PANDO ZAYAS, NICHOLAS ROMBES, University of Michigan — Gravity in three dimensions is simpler than in four, due to the lack of gravitational waves, and can be recast as a Chern-Simons theory. In this context, it is straightforward to generalize Einstein’s gravity, with or without cosmological constant, by changing the gauge group. Using this, we study the resolution of certain cosmological singularities, and extend the singularity resolution scheme proposed by Krishnan and Roy. We discuss the resolution of a big-bang singularity in the case of gravity coupled to a spin-4 field realized as Chern-Simons theory with gauge group \( SL(4, \mathbb{C}) \). We show the existence of gauge transformations that do not change the holonomy of the Chern-Simons gauge potential and lead to metrics without the initial singularity. We argue that such transformations always exist in the context of gravity coupled to a spin-N field when described by Chern-Simons with gauge group \( SL(N, \mathbb{C}) \).

2:30PM K16.00006 Quantum Theory of Large Amplitude Gravitational Waves. DILLON SCOFIELD, Dept. Physics, Oklahoma State University — The standard development of small amplitude gravitational radiation theory is amended allowing the development of a theory of large amplitude gravitational waves. The further development of the resulting theory leads to a quantum theory of gravitation and mass-spacetime compatible with an SU(4) model of elementary particle interactions.

Here is a summary of the poster session:

**L1.000001 ASTROPHYSICS**

Session L1 APS: Poster Session II (14:00-17:00) Exhibit Hall -
L1.00002 Observation of freakish-asteroid-discovered-resembles support my idea that many dark comets were arrested and lurked in the solar system after every impaction1, DAYONG CAO, AEEA — New observations show that some asteroids are looked like comets. http://www.astrowatch.net/2013/11/freakish-asteroid-discovered-resembles.html, http://www.astrowatch.net/2013/11/asteroicn-puzzle-over-newfound.html. It supports my idea that “many dark comets with very special tilted orbits were arrested and lurked in the solar system” - “Sun’s companion-dark hole seasonal took its dark comets belt and much dark matter to impact near our earth. And some of them probability hit on our earth. So this model kept and triggered periodic mass extinctions on our earth every 25 to 27 million years. After every impaction, many dark comets with very special tilted orbits were arrested and lurked in the solar system. Because some of them picked up many solar matter, so it looked like the asteroids. When the dark hole-Tyche goes near the solar system again, they will impact near planets.” The idea maybe explains why do the asteroids looks like the comet? Where are the asteroids come from? What relationship do they have with the impositions and extinctions? http://meetings.aps.org/link/BAPS.2011.CAL.C1.7, http://meetings.aps.org/Meeting/CAL12/Event/181168, http://meetings.aps.org/link/BAPS.2013.MAR.H1.267. During 2009 to 2010, I had presented there are many dark comets like dark Asteroids near the orbit of Jupiter in ASP Meetings. In 2010, NASA’s WISE found them. http://meetings.aps.org/link/BAPS.2011.APR.K1.17, http://www.nasa.gov/mission_pages/WISE/news/wise20100122.html

1 Avoid Earth Extinction Association

L1.00003 Observation of asteroid 2013 TV_135 supports my idea that a new impaction will come in 20 years1, DAYONG CAO, AEEA — Asteroid 2013 TV135 who will impact in 2023 was newly discovered by Ukrainian astronomers in 2013. It supports my idea that a new impaction will come in 20 years. http://www.nasa.gov/mission_pages/asteroids/news/asteroid20130117.html, http://meetings.aps.org/link/BAPS.2011.DFD.LA.24, http://meetings.aps.org/link/BAPS.2012.APR.K1.78, http://meetings.aps.org/link/BAPS.2013.APR.S2.14. The Sun’s companion-dark hole, which is made of dark matter seasonal took its dark comets belt, dark matter, dark lives, and the pressed asteroids belt to impact near our earth. These impositions and dark matter’s killers caused seasonal extinctions and produced new species. By many dark comets and asteroids impacting, the dark impaction model is a high probability impaction model; the impaction would not change the orbit of the invisible dark hole, so that it could keep accurate periodicity impositions. With the space-time center, the dark hole system is a negative Einstein’s model by “mass-energy coordinate.” Sun and Dark hole build up the balance system. Through studying the model, the rule of the impaction can be calculated.

1 Avoid Earth Extinction Association

L1.00004 Mid-infrared Variability of the Low Mass Stellar Binary TWA 30 A and B, AISHWARYA IYER, ADAM BURGASSER, Department of Physics, University of California, San Diego — T Tauri stars represent the initial stages of stellar birth, characterized by jets, accretion, outflows and circumstellar disks. TWA 30 AB is one of the nearest (∼42 pc) low mass (both masses ∼ 0.12 Solar masses) binary T Tauris known, a well-separated (80’ on the sky) pair of mid-type M dwarfs in the ∼10 Myr TW Hydrae Association. Both sources exhibit strong spectral signatures of accretion, jets and stellar winds, and mid-infrared excess indicating the presence of circumstellar disks. These disks are nearly edge-on but with slightly different geometries. TWA 30A, an optical transient, exhibits strong variable optical extinction (A_V ≈ 1-8) from outer disk absorption, while TWA 30B is seen in reflection with an additional (variable) thermal component likely from the inner disk. The existing optical and near-infrared data predicts low variability for TWA 30A and high variability for TWA 30B in the mid-infrared. However, a single day of Wide-field Infrared Survey Explorer (WISE) mid-infrared monitoring reveals the opposite behavior. To investigate this contradiction, we have observed this system over a 40-day period with the Spitzer Space Telescope’s Infrared Array Camera at 3.6 and 4.5 microns. We present preliminary analysis of the imaging data and examine their physical implications in the context of disk geometries and evolution in these two sources.

L1.00005 Experimental creation of mini-cluster using photon-photon collision, MEGGIE ZHANG, AISRO — Our understanding of the universe is based on the observation of galactic objects with telescopes. But if we could somehow experimentally create these galactic objects in the lab which will help further our understanding of the formation of the galaxies, stars and planets. Using photon-photon collision we have successfully created mini-clusters system, stars and planets. Our work result is based on an reinterpretation of quantum physics and a modification of relativity theory.

L1.00006 Experimental observation of planet formation using low energy photon-photon collision, MEGGIE ZHANG, AISRO — Our current theory believes that planets were formed from aggregation of galactic gas. Our work in 2011 suggested there could be an alternative explanation on planet formation based on a reinterpretation of quantum physics, which suggested that planet formed at early stage through aggregation, then it grows through a different process other than aggregation. Using low energy photon-photon collision we have successfully observed this process. This result also cast doubt on the Big Bang theory.

L1.00007 Beyond the Standard Model with Cosmic Particle Accelerators, KEVIN TENNYSON, IAN MORGAN, TED TAO, ERIN DEPREE, St Mary’s College of Maryland — Gamma-ray bursts (GRBs) and active galactic nuclei (AGN) are among the most powerful cosmic particle accelerators and may therefore be excellent engines for producing particles beyond the standard model. We examine the physical conditions under which such collisions can occur within GRBs and AGNs. More specifically, we investigate the likelihood of producing the least massive Kaluza-Klein particle in these astrophysical systems as well as the potential associated observational signatures.

L1.00008 Progress with ALFALFA Follow-up Observations: Interesting HI Sources1, PARKER TROISCHT, STEVEN GRZESKOWIAK, KYLE MURRAY, NATHAN NICHOLS, Department of Physics, Hartwick College, Oneonta NY 13820, ALFALFA TEAM — The Underground ALFALFA Team (UAT) is a collaborative undertaking of faculty and students at 19 institutions, performing research using the massive ALFALFA blind HI survey and several follow-up observations. The follow-up observations include targeted observations with Arecibo Observatory’s L-Band Wide (LBW) receiver. The primary goal of the targeted LBW observations is to study several of the most interesting sources indicated by the 7000 square degree survey. This includes the following four categories: 1. dark galaxy candidates. 2. OH Megamasers Candidates. 3. extreme gas-dominated dwarf galaxy candidates and 4. statistical samples of low signal to noise sources associated with optical counterparts. Here we report on progress with deducting LBW data, including integrated fluxes of the positive detections and calculation of RMS noise for all spectra.

1This work has been supported by NSF grants AST-1211005 and AST-0725267.
L1.00009 Toward Connecting Core-Collapse Supernova Theory with Observations: Nucleosynthetic Yields and Distribution of Elements in a 15 M⊙ Blue Supergiant Progenitor with SN 1987A Energies, TOMASZ PLEWA, TIMOTHY HANDY, Florida State University, ANDRZEJ ODRZYWOLEK, Jagiellonian University — We compute and discuss the process of nucleosynthesis in a series of core-collapse explosion models of a 15 solar mass, blue supergiant progenitor. We obtain nucleosynthetic yields and study the evolution of the chemical element distribution from the moment of core bounce until young supernova remnant phase. Our models show how the process of energy deposition due to radioactive decay modifies the dynamics and the core ejecta structure on small and intermediate scales. The results are compared against observations of young supernova remnants including Cas A and the recent data obtained for SN 1987A.

3 The work has been supported by the NSF grant AST-1109113 and DOE grant DE-FG52-09NA29548. This research used resources of the National Energy Research Scientific Computing Center, which is supported by the U.S. DoE under Contract No. DE-AC02-05CH11231.

L1.00010 Neutrino-driven Convection and SASI in Three-Dimensional Core-Collapse Supernovae, CHRISTIAN D. OTT, ERNAZAR ABDIKAMALOV, ROLAND HAAS, CHRISTIAN REISSWIG, PHILIPP MOESTA, HANNAH KLION, TAPIR, Caltech, ERIK SCHNETTER, Perimeter Institute — The mechanism of core-collapse supernova explosions likely relies on support from two hydrodynamical instabilities: neutrino-driven convection and the standing accretion shock instability (SASI). We investigate under which conditions these instabilities develop. We perform 3D general-relativistic simulations of collapse and postbounce evolution of a 27-M⊙ star with a neutrino leakage scheme. We consider a range of neutron heating rates and find the development of the 3D SASI in models with weak neutrino heating that do not develop explosions. Models that explode are dominated by neutrino-driven convection.

L1.00011 Disk-outflow models as applied to high mass star forming regions through methanol and water maser observations, HONTAS FARMER, Northern Illinois University — As the recent publication by Breen et al (2013) found Class II methanol masers are exclusively associated with high mass star forming regions. Based on the positions of the Class I and II methanol and H₂O masers, UC H II regions and 4.5 μm infrared sources, and the center velocities (vLSR) of the Class I methanol and H₂O masers, compared to the vLSR of the Class II methanol masers, we propose three disk-outflow models that may be traced by methanol masers. In all three models, we have located the Class II methanol maser near the protostar, and the Class I methanol maser in the outflow, as is known from observations during the last twenty years. In our first model, the H₂O masers trace the linear extent of the outflow. In our second model, the H₂O masers are located in a circumstellar disk. In our third model, the H₂O masers are located in one or more outflows near the terminating shock where the outflow impacts the interstellar medium. Together, these models reiterate the utility of coordinated high angular resolution observations of high mass star forming regions in maser lines and associated star formation tracers.

L1.00012 The Effect of Sulfur on Interstellar Extinction, DHANESH KRISHNARAO, ULYSSES SOFIA, American University — We examine the prominence of sulfur in interstellar dust and any effects it may have on extinction. Sulfur is one of the most copious elements in the universe, so proper understanding of its role in the interstellar medium is crucial. Previous studies show little to no sulfur in interstellar dust, but recent evidence of observed interstellar grains and Glass Embedded with Metal and Sulphides (GEMS) suggest an abundance of sulfur. In support of this, sulfur's location on the flat part of the curve of growth results in the need for very careful modeling of the Voigt profile, which includes the utility of coordinated high angular resolution observations of high mass star forming regions in maser lines and associated star formation tracers.

L1.00013 Thermodynamics of Neutron Stars, ROBERT GEDIES, R.M. SATISH, SAMINA MASOOD, University of Houston Clear Lake — We examine finite temperature density (FTD) effects and corrections to the Thomas-Fermi model; also examined are the non-linear models of Boguta-Bodmer (BB) and Walecka coupled with the general relativistic Tolman-Oppenheimer-Volkoff (TOV) equations of state (EOS). The coupling of these equations of state with the BB and Walecka models helps analyze the thermodynamic properties of the neutron star system. In the Thomas-Fermi model, the introduction of finite temperature plasma effects (i.e., Coulomb effect) invites FTD corrections. In both the BB and Walecka model, the Baryon octet 2 different forms of lepton inclusion are included into the corresponding lagrangian density. The BB model includes various leptonic degrees of freedom; while the Walecka model includes the assumption of an ideal Fermi gas of electrons and negatively charged muons. Together with FTD corrections and use of the Sommerfeld approximation, we get a deeper knowledge of neutron star composition and its thermodynamic properties can be achieved.

L1.00014 Characterization of Silicon Photomultiplier Detectors using Cosmic Radiation, FAVIAN ZAVALA, JUAN CASTRO, REXAVALMAR NIDUAZA, ZACHARY WEDEL, SEWAN FAN, Hartnell College, STEFAN RITT, Paul Scherrer Institute, LAURA FATUZZO, Hartnell College — The silicon photomultiplier light detector has gained a lot of attention lately in fields such as particle physics, astrophysics, and medical physics. Its popularity stems from its lower cost, compact size, insensitivity to magnetic fields, and its excellent ability to distinguish a quantized number of photons. They are normally operated at room temperature and biased above their breakdown voltages. As such, they may also exhibit properties that may hinder their optimal operation which include a thermally induced high dark count rate, after pulse effects, and cross talk from photons in nearby pixels. At this poster session, we describe our data analysis and our endeavor to characterize the multipixel photon counter (MPPC) detectors from Hamamatsu under different bias voltages and temperature conditions. Particularly, we describe our setup which uses cosmic rays to induce scintillation light delivered to the detector by wavelength shifting optical fibers and the use of a fast 1GHz waveform sampler, the domino ring sampler (DRS4) digitizer board.

3 Department of Education grant number P031590007

L1.00015 Investigation of Cherenkov Light in an Oil Drum with Cosmic Radiation, ZACHARY WEDEL, REXAVALMAR NIDUAZA, JUAN CASTRO, FAVIAN ZAVALA, SEWAN FAN, LAURA FATUZZO, Hartnell College — Photomultiplier Tubes (PMTs) have been around for decades and have become well understood in their use as cosmic ray detectors. Multi-Pixel Photon Counters (MPPCs), on the other hand, are still being explored as more viable, cost-effective light detector for counting cosmic rays. To detect cosmic rays by the Cherenkov effect, we placed an acrylic cylinder, with wavelength-shifting fibers coiled around it and filled with distilled water, inside a light-tight box that was able to detect the weak light signals with PMTs (1 and 3 inch), an MPPC (3mm x 3mm), and with coincidence between different detectors. Additionally, we utilized an oil drum with approximate volume of 30 gallons as a light-tight vessel to conduct coincidence counts for detecting cosmic rays using the PMTs and MPPCs (3mm x 3mm and 1mm x 1mm). In this poster presentation, we would present our findings as a comparative analysis between the two different vessels and the efficiency thereof of the same to determine whether or not the MPPC is a viable instrument for detecting cosmic rays that produce Cherenkov light.

3 Department of Education grant number P031590007
L1.00016 Cosmic Ray Energetics and Mass for the International Space Station (ISS-CREAM), IAN HOWLEY, University of Maryland, ISS-CREAM COLLABORATION — The Cosmic Ray Energetics and Mass detector is designed to directly measure cosmic rays with energy between $10^{12}$ - $10^{15}$ eV and composition from proton to iron thereby investigating cosmic ray origins, acceleration and propagation. CREAM has four subsystems. The silicon charge detector consists of four identical layers each containing 2688 1.5 x 1.6 cm$^2$ pixels capable of measuring incident particle charge to about 0.2e. The calorimeter consists of a carbon target to induce interactions and alternating layers of tungsten plates and scintillating fibers used to measure incident particle energy, and provide triggering and particle tracking. The top and bottom counting detectors are scintillators with segmented read-out used for electron-proton separation. Finally, the boronated scintillator detector is a boron doped scintillator used to identify thermal neutrons emitted from interactions in the calorimeter, which can be used to separate electron and proton showers. Reconfiguring the payload for implementation on the ISS will provide an order of magnitude increase in exposure time and remove the atmospheric overburden as compared to previous balloon flights. In preparation for launch, the newly configured hardware must be tested, and remote monitoring and control capabilities must be established. The project overview, current status of testing, and preparations for launch in December 2014 will be presented.

L1.00017 Modeling RF Emissions from Particle Showers in Dense mediums, WILLIAM & Mary Coll, Konstantin Belov, Stephanie Wissel, University of California, Los Angeles, T-510 EXPERIMENT TEAM — The Antarctic Impulsive Transient Antenna (ANITA) experiment has recorded multiple Ultra High Energy Cosmic Ray (UHECR) events via radio-frequency emissions from secondary particle showers in the Earth’s atmosphere. The energy of these UHECR particles is reconstructed using Monte Carlo simulations based on first principles. The goal of the SLAC T-510 experiment is to validate these simulations and to provide an energy calibration for ANITA data analysis. We incorporated an RF emission simulation based on ZHS code into the GEANT4 toolkit, used for modeling the passage of particles in accelerator experiments. We predict strong radio emissions at the Cherenkov angle from a cascade of secondary particles in a polyethylene target in moderate magnetic fields. We see a strong dependence of the horizontally polarized component of the electric field on top of the Cherenkov cone on the magnetic field strength. We also observe a skewing of the Cherenkov cone as the magnetic field increases, which we believe to be an indication of the Askaryan effect.

L1.00018 Conformal Invariance, Dark Energy, and CMB Non-Gaussianity, Emil Motolla, Los Alamos National Laboratory, Ignatiou Antoniadis, CERN, Pawel Mazur, Univ. of So. Carolina — In addition to scale invariance, a universe dominated by dark energy naturally gives rise to correlation functions with full conformal invariance, due to the isomorphism between the conformal group of three dimensional slices of de Sitter space and the de Sitter isometry group SO(4,1). In the standard homogeneous, isotropic cosmological model the embedding of flat spatial sections in de Sitter space induces a conformal invariant perturbation spectrum and definite prediction for the shape of the non-Gaussian CMB bispectrum. If the density fluctuations are generated instead on the de Sitter horizon, conformal invariance of the $S^2$ horizon embedding implies a different but also quite definite prediction for the angular correlations of CMB non-Gaussianity on the sky. Each of these forms for the bispectrum is different from the predictions of single field slow roll inflation models, which rely on the breaking of de Sitter invariance. We propose a quantum origin for the CMB fluctuations in the scalar gravitational sector from the conformal anomaly that could give rise to these non-Gaussianities without a slow roll inflation field. Conformal invariance also leads to the relation $n_S -1 = n_T$ between the spectral indices of the scalar and tensor power spectrum.

L1.00019 Scalar Theory of Everything model correspondence to the Big Bang model and to Quantum Mechanics, John Hodge, Retired — We are at a special moment in our scientific evolution that requires the big of cosmology and the small of light and of particle physics be unified by a single model. The Scalar Theory of Everything model (STOE) suggests fundamental assumptions with consideration for the successful parts of current models and for the data inconsistent with current models. The STOE has been tested over the last 10 years with data concerning galaxy rotation curves; redshift at galactic, solar system, and earth scales; BH-galaxy disk properties; temperature of the universe; and light interference. The STOE is simpler, corresponds to both General Relativity and quantum mechanics, and solves many current mysteries and inconsistencies. Therefore, the STOE is founded on orthodox science. Data analysis in 2011 confirmed predictions of the STOE made in 2006 that no other model suggested.

L1.00020 Fluctuations in Cyclic Models, Riley Mayes, Loyola University New Orleans — Our research comprised of analyzing the turnaround phase (when expansion gives way to contraction) within the context of cyclic models of the Universe. To complete this task, we sought to observe the evolution of the fluctuations during the turnaround for a range of $k$ (inverse wavelength) values. This examination allows us to observe whether the fluctuations increase or diminish for smaller or larger values of $k$. This information is important to compare predictions of cyclic models to the observed anisotropies in the cosmic microwave background radiation.

L1.00021 A Frequency Hopping Code to calculate gravitational wave fluxes from nearly parabolic equatorial EMRI orbits around Kerr black holes, Jordan Stone, Univ. of Arkansas-Fayetteville, Sloan Ahrens, StackSearch Inc., Daniel Kennfick, Univ. of Arkansas-Fayetteville — One of the obstacles for calculating radiation reaction in highly eccentric around Kerr black holes is the broad range of gravitational wave frequencies which radiate away significant energy. A further complication is that the spectrum is assembled from different multipoles (l and m) with the main contributing harmonic (k) being quite different from multipole to multipole. Newtonian-order formulas for the complete spectrum enable us to roughly predict the harmonic k which will contribute most strongly for each multipole. Earlier work for eccentricity of up to 0.9 by various authors demonstrate how the varying harmonic contributions from each multipole go together to complete the full spectrum. We present a Teukolsky-based “frequency hopping” code which identifies the locations of these peaks while efficiently neglecting insignificant values of k. Along with proposed improvements to the Teukolsky-based code itself, we believe this new code will be capable of calculating the flux of energy and angular momentum for nearly parabolic orbits ($e > 0.99$) in extreme-mass-ratio inspirals.

L1.00022 The Third Fermi-LAT Catalog of High-Energy Gamma-ray Sources, Toby Burnett, University of Washington, FERMI-LAT COLLABORATION — The Fermi Gamma-ray Space Telescope Large Area Telescope (LAT) has been gathering science data since August 2008, surveying the full sky every three hours. The second source catalog (2FGL, Nolan et al 2012, ApJS 199, 31) was based on 2 years of data. We are preparing a third source catalog (3FGL) based on 4 years of reprocessed data. The reprocessing introduced a more accurate description of the instrument, which resulted in a narrower point spread function. Both the localization and the detection threshold for hard-spectrum sources have been improved. The new catalog also relies on a refined model of Galactic diffuse emission, particularly important for low-latitude soft-spectrum sources. The process for associating LAT sources with those at other wavelengths has also improved, thanks to dedicated multiwavelength follow-up, new surveys and better ways to extract sources likely to be gamma-ray counterparts. We describe the construction of this new catalog, its characteristics, and its remaining limitations.
measurements were carried out at the EMSL user facility at PNNL. The analysis of these data different photocathode candidates. Angle-resolved photoemission spectroscopy (ARPES), used widely in surface science, has been proposed [H. Padmore (private communication)] as a method to measure the photocathode intrinsic emittance. A promising novel photocathode, a thin layer of MgO on Ag [K. Nemeth et al, PRL 104, 046801 (2010)] was recently fabricated and ARPES measurements were carried out [T.C. Droubay et al, PRL (in press)]. The analysis of these data and resulting emittance will be presented. Implications for its use in simulations and design of future photoinjectors will also be presented.

PRL 104, 046801 (2010) was recently fabricated and ARPES measurements were carried out [T.C. Droubay et al, PRL (in press)]. The analysis of these data different photocathode candidates. Angle-resolved photoemission spectroscopy (ARPES), used widely in surface science, has been proposed [H. Padmore (private communication)] as a method to measure the photocathode intrinsic emittance. A promising novel photocathode, a thin layer of MgO on Ag [K. Nemeth et al, PRL 104, 046801 (2010)] was recently fabricated and ARPES measurements were carried out [T.C. Droubay et al, PRL (in press)]. The analysis of these data and resulting emittance will be presented. Implications for its use in simulations and design of future photoinjectors will also be presented.

This work was supported by NASA Grant NNX13AB96G.

L1.00023 Latest Results from the Gamma Ray Polarimeter Experiment (GRAPE)\textsuperscript{1}, M. MC- CONNELL, P. BLOSER, C. ERTLEY, J. LEGERE, J. RYAN, S. WASTI, University of New Hampshire — The Gamma Ray Polarimeter Experiment (GRAPE) is a balloon borne instrument designed for measuring the polarization of sources from 50-500 keV. It was first flown on a 26-hour balloon flight in the fall of 2011 from Ft. Sumner, NM. The payload consists of an array of independent Compton polarimeter modules based on scintillation technologies. The ultimate goal of our program is to operate GRAPE in a wide FoV configuration on a LDB flight to study GRBs. For the first balloon flight, GRAPE was configured in a collimated mode to facilitate observations of known point sources so that the polarization measurement capability of GRAPE could be demonstrated. The Crab nebula/pulsar, the active Sun, and Cygnus X-1 were the primary targets for the first flight. Although the Crab was detected, the polarization sensitivity was worse than expected, in part because of a lower-than-expected altitude for much of the flight. Only upper limits on the Crab polarization were obtained. Two M-class solar flares were also observed, with null results that indicate less than 30% polarization levels. This paper will describe the GRAPE payload, review the latest results from the first balloon flight, and present plans for the next GRAPE balloon flight, scheduled to take place in the fall of 2014.

\textsuperscript{1}This work was supported by NASA Grant NNX13AB96G.

L1.00024 Fermion distribution in hot and dense media and applications to astrophysics, R.M. SATISH, R. GEDIES, S. MASOOD, University of Houston Clear Lake — Properties of fermions with the relativistic energies are determined by the Fermi-Dirac distribution in a hot and dense medium. It has been noticed that the energy integration of the distribution function always give a set of functions, identified by Masood in different limits of temperatures and chemical potentials. In this situation we study the behavior of Masood’s $a_n$ functions in different statistical backgrounds which are relevant to physical systems such as the early universe or the stellar interiors. We mainly focus on the study of the early universe at high temperatures and the highly dense systems of compact stars such as supernovae and neutron stars.

L1.00025 GRAVITATION — What’s wrong with relativity theory\textsuperscript{2}?, MEGGIE ZHANG, AJSRO — Relativity theory is the most successful theory in modern physics but insofar we have not be able to reconcile relativity theory and quantum physics. Through reevaluation results in literature we found hints leading to a new understanding of the basics of quantum physics. By reinterpretation quantum physics we have successfully conduced a photon-photon collision experiment which gives us support on our reinterpretation of quantum physics which in turn suggested relativity theory is in-complete and fell into a paradoxical trap. This helps us a new understanding of mass and gravity.

L1.00026 Mechanical design of the University of Florida Torsion Pendulum for testing the LISA Gravitational Reference Sensor, RYAN SHELLEY, ANDREW CHILTON, TAIWO OLATUNDE, GIACOMO CIANI, GUIDO MUELLER, JOHN CONKLIN, University of Florida — The Laser Interferometer Space Antenna (LISA) requires free falling test masses, whose acceleration must be below 3 fm/s$^2$/rtHz in the lower part of LISA’s frequency band ranging from 0.1 to 100 mHz. Gravitational reference sensors (GRS) house the test masses, shield them from external disturbances, control their orientation, and sense their position at the nm/rtHz level. The GRS torsion pendulum is a laboratory test bed for GRS technology. By decoupling the system of test masses from the gravity of the Earth, it is possible to identify and quantify many sources of noise in the sensor. The mechanical design of the pendulum is critical to the study of the noise sources and the development of new technologies that can improve performance and reduce cost. The suspended test mass is a hollow, gold-coated, aluminum cube which rests inside a gold-coated, aluminum housing with electrodes for sensing and actuating all six degrees of freedom. This poster describes the design, analysis, and assembly of the mechanical subsystems of the UF Torsion Pendulum.

L1.00028 UV-LED-based charge control for LISA, TAIWO OLATUNDE, RYAN SHELLEY, ANDREW CHILTON, GIACOMO CIANI, GUIDO MUELLER, JOHN CONKLIN, University of Florida — The test masses inside the LISA gravitational reference sensors (GRS) must maintain almost pure geodesic motion for gravitational waves to be successfully detected. The residual accelerations have to stay below 3 fm/s$^2$/rtHz at all frequencies between 0.1 and 3 mHz. One of the well known noise sources is associated with the charges on the test masses which couple to stray electrical potentials and external electro-magnetic fields. The LISA pathfinder (LPF) will use Hg-discharge lamps emitting mostly around 253 nm to discharge the test masses via photoemission in its 2015/16 flight. A future LISA mission launched around 2030 will likely replace the lamps with next UV-LEDs. UV-LEDs have a lower mass, a better power efficiency, and are smaller than their Hg counterparts. Furthermore, the latest generation produces light at 240 nm, with energy well above the work function of pure gold. I will describe a preliminary design for effective charge control through photoelectric effect by using these LEDs. The effectiveness of this method is verified by taking Quantum Efficiency (QE) measurements which relate the number of electrons emitted to the number of photons incident on the Au test mass surface. This presentation addresses our initial results and future plans which includes implementation and testing in the UF torsion pendulum and space-qualification in a small satellite mission which will launch in the summer of 2014, through a collaboration with Stanford, KACST, and NASA Ames Research Center.

L1.00029 Beam emittance from ARPES for photoinjectors\textsuperscript{1}, KATHERINE HARKAY, Argonne National Laboratory, LINDA SPENTZOURIS, KAROLY NEMETH, Illinois Institute of Technology, TIMOTHY DROUBAY, SCOTT CHAMBERS, ALAN JOLY, WAYNE HESS, Pacific Northwestern National Laboratory — A commonly used beam emittance measurement for photoinjector sources involves accelerating a low-chage beam to a few megavolts in an electron gun, then using a pepper-pot emittance diagnostic to image the transverse charge distribution. The emission distribution at the cathode surface could in principle be deduced through simulations, but cannot be measured directly with this method. In the quest to develop ultra-bright photoinjectors, it would be advantageous to be able to measure the emission distribution directly, and use this as a screening process to characterize different photocathode candidates. Angle-resolved photoemission spectroscopy (ARPES), used widely in surface science, has been proposed [H. Padmore (private communication)] as a method to measure the photocathode intrinsic emittance. A promising novel photocathode, a thin layer of MgO on Ag [K. Nemeth et al, PRL 104, 046801 (2010)] was recently fabricated and ARPES measurements were carried out [T.C. Droubay et al, PRL (in press)]. The analysis of these data and resulting emittance will be presented. Implications for its use in simulations and design of future photoinjectors will also be presented.

\textsuperscript{1}This work was supported by the U.S. DOE Office of Science (DE-AC02-06CH11357) and the National Science Foundation (No. PHY-0969898). The measurements were carried out at the EMSL user facility at PNNL.
L1.00030 General Relativity Is Only A Fallacy Wrong Concept That Is Not Based On Any Reality And Is Not A Real Correct Science, RONALD KOTAS, Grand Quantum Research — The concept of General Relativity is not compatible with Quantum Mechanics. General Relativity is not real science, only a fallacy concept with no definitive proofs. It is not based on reality. Light and other radiation are not bent by General Relativity, only by Newtonian Refractions in the Sun’s very hot Corona. The planet Mercury orbital precession is not a proof of General Relativity; it is fully and logically explained by Newtonian Mechanics. The dynamic 2/3ths ratio of Mercury’s day-to-year ratio is profound and a Nuclear Quantum Gravitational function, not General Relativity. The Red Shift is a Nuclear Quantum Gravitational effect, not General Relativity. The so-called gravitational lens is also where refraction of gaseous matter, dust or real objects are not considered. No “gravity waves” have ever been detected by any LIGO site in the world. No material “frame dragging” has been detected by the Gravity B probe. The reason is that there is no space fabric to cause these effects. It should be perfectly clear that General Relativity has no definitive proofs and is not a real or correct description of Science. Nuclear Quantum Gravitation is a clear explanation of Gravity/Gravitation with 31 proofs and indications, and is compatible with Quantum and Newtonian Mechanics.

L1.00031 Radiated Quantities in Binary Black Hole Collisions1, LORENA MAGANA ZERTUCHE, Center for Relativistic Astrophysics, School of Physics, Georgia Institute of Technology, USA, JAMES HEALY, Center for Computational Relativity and Gravitation, Rochester Institute of Technology, USA, DEIRDRE SHOEMAKER, Center for Relativistic Astrophysics, School of Physics, Georgia Institute of Technology, USA — One of the more interesting and exotic systems in the universe is a system of two black holes. When black holes orbit each other, they will eventually collide, forming a single black hole with a mass almost equal to the sum of the two initial masses. This missing “mass,” up to ten percent, is converted into gravitational waves making these systems one of the most energetic in the universe. The systems also radiate angular momentum as they settle down to a Kerr black hole. I present work toward modeling the radiated angular momentum and energy as functions of the binary system’s initial parameters for generic binaries.

1NSF PHY 0955825

L1.00032 Galactic Rotation Curves from Yang-Mills Gravity1, DANIEL KATZ, University of Massachusetts Lowell — Yang-Mills Gravity (YMG) is a gauge field theory based on the T4 group in flat spacetime. In its macroscopic limit, it modifies the trajectories of classical objects such that it serves as an alternative to General Relativity (GR). Since YMG is relatively new and unknown, a brief review of the general theory is given and a more comprehensive list of references is provided. In the present work, we find that the Schwarzschild-like solution to YMG supports a term like αr with constant α. This translates into an r-term in the effective gravitational potential of classical objects. We use this modified potential to predict the shape of the rotation curves of spiral galaxies, and then use data from SDSS to constrain α, which seems to be a free parameter in YMG.

1This work was supported the NSF’s GK12 Vibes and Waves Fellowship.

L1.00033 Short Range Tests of Gravity, CRYSTAL CARDENAS1, ANDREW HARTER, C.D. HOYLE, HOLLY LEOPARDI, DAVID SMITH, Humboldt State University — Gravity was the first force to be described mathematically, yet it is the only fundamental force not well understood. The Standard Model of quantum mechanics describes interactions between the fundamental strong, weak and electromagnetic forces while Einstein’s theory of General Relativity (GR) describes the fundamental force of gravity. There is yet to be a theory that unifies inconsistencies between GR and quantum mechanics. Scenarios of String Theory predicting more than three spatial dimensions also predict physical effects of gravity at sub-millimeter levels that would alter the gravitational inverse-square law. The Weak Equivalence Principle (WEP), a central feature of GR, states that all objects are accelerated at the same rate in a gravitational field independent of their composition. A violation of the WEP at any length would be evidence that current models of gravity are incorrect. At the Humboldt State University Gravitational Research Laboratory, an experiment is being developed to observe gravitational interactions below the 50-micron distance scale. The experiment measures the twist of a parallel-plate torsion pendulum as an attractor mass is oscillated within 50 microns of the pendulum, providing time varying gravitational torque on the pendulum. The size and distance dependence of the torque amplitude provide means to determine deviations from accepted models of gravity on untested distance scales.

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L1.00034 Supernova Constraints on Modified Theories of Gravity, NATHAN PRINS, JAMES OVERDUIN, Towson University, JOOHN LEE, University of Seoul, Korea — Most attempts to unify gravitation with the standard model of particle physics involve new fields and/or additional (usually compact) dimensions. The dynamics of these compact dimensions can, however, act back on the dynamics of macroscopic space and time. We investigate a particular class of models with n compact dimensions plus a scalar field with negative kinetic energy (“phantom”), and show that they can be constrained by recent data on the magnitudes of Type Ia supernovae.

L1.00035 Quantum evaporation of flavor-mixed particles1, MIKHAIL V. MEDVEDEV, U. Kansas — Particles whose propagation (mass) and interaction (flavor) bases are misaligned are mixed, e.g., neutrinos, quarks, Kaons, etc. We show that interactions (elastic scattering) of individual mass-eigenstates can result in their inter-conversions. Most intriguing and counter-intuitive implication of this process is a new process, which we refer to as the “quantum evaporation.” Consider a mixed particle trapped in a gravitational potential. If such a particle scatters off something (e.g., from another mixed particle) elastically from time to time, this particle (or both particles, respectively) can eventually escape to infinity with no extra energy supplied. That is as if a “flavor-mixed satellite” hauled along a bumpy road puts itself in space without a rocket, fuel, etc. Of course, the process at hand is entirely quantum and has no counterpart in classical mechanics. It also has nothing to do with tunneling or other known processes. We discuss some implications to the dark matter physics, cosmology and cosmic neutrino background.

1Supported by grant DOE grant DE-FG02-07ER4140 and NSF grant AST-1299665.

L1.00036 Flavour Symmetry as a Gauge Invariance, RAUSUKHOZHA S. SHARAFIADDINOV, Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan — A classification of leptonic currents with respect to C-operation requires the separation of elements of the particles into the two classes of vector C-even and axial-vector C-odd character. The nature has been created so that each type of lepton corresponds a kind of neutrino. Such pairs are united in families of a different C-parity. Unlike the neutrino of a vector type, any C-noninvariant Dirac neutrino must have his Majorana neutrino. They constitute the purely neutrino families. We discuss the nature of a corresponding mechanism responsible for the availability in all types of axial-vector particles of a kind of flavour which distinguishes each of them from others by a true charge characterized by a quantum number conserved at the interactions between the C-odd fermion and the field of emission of the corresponding types of gauge bosons. This regularity expresses the unidirectionality of truly neutral neutrino and antineutrino, confirming that an internal symmetry of a C-noninvariant particle is described by an axial-vector space. Thereby, a true flavour together with the earlier known lepton flavour predicts the existence of a flavour symmetrical mode of neutrino oscillations as a unity of flavour and gauge symmetry laws.
L1.00037 Study of isolated photon production in association with bottom quarks at the Tevatron, ASHISH KUMAR, State University of New York, Buffalo, D0 COLLABORATION — The study of prompt photons produced in association with heavy quarks provides a crucial test of perturbative QCD predictions as well as constraints on parton distribution functions. We present first measurements of the cross section of photon plus bottom quark pair production in proton-antiproton collisions at $\sqrt{s} = 1.96$ TeV using 8.7 fb$^{-1}$ of Tevatron data collected by the D0 experiment. The measurements are compared with theoretical calculations and predictions from Monte Carlo generators.

L1.00038 CEEX EW Corrections for $f \bar{f} \rightarrow f' \bar{f}'$ at LHC and Muon Colliders as Realized in KK MC 4.22, B.F.L. WARD, Baylor University, Waco, TX, USA, S. JADACH, Z. WAS, Institute of Nuclear Physics, Krakow, Poland — With an eye toward the precision physics of the LHC and possible high muon colliders, we present the extension of the CEEX (coherent exclusive exponentiation) realization of the YFS approach to resummation in our KK MC to include the processes $f \bar{f} \rightarrow f' \bar{f}'$, $f = e, \mu, \tau, q, q'$, $q = u, d, c, b, t, \ell = e, \mu, \tau$ with $f \neq f'$. After giving a brief summary of the CEEX theory in comparison to the older EEX (exclusive exponentiation) theory, we illustrate theoretical results relevant to the LHC and possible muon collider physics programs.

1Work supported by the CERN TH Unit, by the Polish National Science Centre grant DEC-2011/03/B/ST2/02632, and by the Dean of the Baylor College of Arts and Sciences

L1.00039 PARTICLES AND FIELDS —

L1.00040 ABSTRACT MOVED TO D1.030 —

L1.00041 Measuring directionality in double-beta decay and neutrino interactions with kiloton-scale scintillation detectors, ANDREY ELAGIN, University of Chicago, CHRISTOPH ABERLE, University of California, Los Angeles, HENRY FRISCH, MATTHEW WETSTEIN, University of Chicago, LINDSEY WINSLOW, University of California, Los Angeles — We present initial studies of a technique for separating scintillation and Cherenkov light in a large liquid scintillator detector in order to reconstruct directionality for electrons with energies typical of neutrino-electron scattering (5 MeV) and double-beta decay (2.1 MeV and 1.4 MeV). On average scintillation light is delayed with respect to the direct Cherenkov light due to chromatic dispersion and at the finite time of the scintillation processes; early light thus contains directional information. Using a GEANT4 simulation of a 6.5-m sphere with 99.9% coverage of photodetectors having transit-time-range (TTS) of 100 ps, we have shown that a time cut on the light is effective at isolating the directional light, improving the ratio of Cherenkov to scintillation light from 0.02 to 0.63 for 5 MeV electrons originating in the detector center. This ratio is degraded by a factor of 2.5 if typical photomultipliers with TTS = 1000 ps are used. The ratio for TTS = 100 ps can be further improved by a factor of 1.6 by using red-enhanced photocathodes, or by 1.4 by using narrow-emission photodetectors.

L1.00042 Absolute $\bar{\nu}_e$ Detection Efficiency of the Daya Bay Experiment, BRYCE LITTLEJOHN, University of Cincinnati, DAYA BAY COLLABORATION — The Daya Bay reactor $\bar{\nu}_e$ experiment has provided the most sensitive measurement of the neutrino mixing parameter $\theta_{13}$ ever recorded, $\sin^2 2\theta_{13} = 0.090 \pm 0.009$, by measuring relative differences in neutrino interaction rates between near and far detectors. In addition to measuring relative differences between detectors, the Daya Bay experiment can also make high-statistics measurements of the absolute reactor $\bar{\nu}_e$ flux and spectrum with its near site detectors. An essential input to any absolute measurement of the reactor flux normalization is the absolute efficiency in detecting $\bar{\nu}_e$. After giving a brief summary of the CEEX theory in comparison to the older EEX (exclusive exponentiation) theory, we illustrate theoretical results relevant to the LHC and possible muon collider physics programs.

L1.00043 High-Density, Scintillating, Fluoride Glass Calorimeters, UGUR AKGUN, QIUCHEN XIE, Coe College — The unprecedented radiation levels in current Large Hadron Collider runs, and plans to even increase the luminosity creates a need for new detector technologies to be investigated. Here, we propose to use high density, scintillating, fluoride glasses as active media in calorimeters. CHG3 is a special example of this glass family, which has been developed specifically for hadron collider experiments, and is known for fast response time, in addition to high light yield. In this presentation, the results from a computational study on the performances of the two different designs of CHG3 glass calorimeters are reported. First design reads the signal directly from the edge of the glass plate; the second design utilizes wavelength-shifting fibers to carry the signal out of the glass plate. Each simulation model is a sampling calorimeter with 20 alternating layers of glass and iron absorber. By changing the absorber thickness we tested hadronic as well as electromagnetic capabilities of the calorimeter models.

L1.00044 ACCELERATOR SYSTEMS —

L1.00045 Non-Invasive Beam Detection in a High-Average Power Electron Accelerator, JOEL WILLIAMS, SANDRA BIEDRON, JOHN HARRIS, JORGE MARTINEZ, STEPHEN MILTON, Colorado State University, S. BENSON, P. EVTUSHENKO, G NEIL, S. ZHANG, Jefferson National Labs — For a free-electron laser (FEL) to work effectively the electron beam quality must meet exceptional standards. In the case of an FEL operating at infrared wavelengths the critical phase space tends to be in the longitudinal direction. Achieving high enough longitudinal phase space density directly from the electron injector system in an FEL is difficult due to space charge effects, thus one needs to manipulate the longitudinal phase space once the beam energy reaches a sufficiently high value. However, this is fraught with problems. Longitudinal space charge and coherent synchrotron radiation can both disrupt the overall phase space, furthermore, the phase space disruption is exacerbated by the longitudinal phase space manipulation process required to achieve high peak current. To achieve and maintain good FEL performance, one needs to investigate the longitudinal emittance during operation, preferably in a non-invasive manner. Using electro-optical (EO) methods, we plan to measure the bunch longitudinal profile of an energy ($\sim 10kW$ or more average FEL output power) beam. Such a diagnostic could be critical in efforts to diagnose and help mitigate deleterious beam effects for high output power FELs.

L1.00046 THz-based electron bunch length monitoring at the quasi-cw SRF accelerator ELBE, BERTRAM GREEN, SERGEY KOVALEV, HZDR, ALAN FISHER, SLAC, CHRISTIAN BÄUER, MICHAEL KUNTZSCH, ULF LEHNERT, RICO SCHURIG, HZDR, TORSTEN GOLTZ, DESY, NIKOLA STOJANOVIC, DESY, MICHAEL GENSC, HZDR — In the past few years the quasi-cw SRF electron accelerator ELBE has been upgraded so that it now allows to compress electron bunches to the sub-picosecond regime. The actual optimization and control of the electron bunch form represents one of the largest challenges of the coming years. In particular with respect to the midterm goal to utilize the ultra-short electron bunches for Laser-Thomas scattering experiments or high field THz experiments. Current developments of THz based electron bunch diagnostic are discussed and an outlook into future developments is given.
L1.00047 Pulsed-Wire Method for Characterization of Undulator Magnet . ALEX D’AUDNEY, Colorado State University — The performance of a Free Electron Laser (FELs) depends in part on the integrity of the magnetic field in the undulator. The magnetic field on the axis of the undulator is transverse and sinusoidally varying due to the periodic sequence of dipoles. The ideal trajectory of a relativistic electron bunch, inserted along the axis, is sinusoidal in the plane of oscillation. Phase errors are produced when the path of the electron is not the ideal sinusoidal trajectory, due to imperfections in the magnetic field. The result of such phase errors is a reduction of laser gain impacting overall FEL performance. A pulsed-wire method can be used to determine the profile of the magnetic field. This is achieved by sending a square current pulse through the wire, which will induce an interaction with the magnetic field. Measurement of the displacement in the wire over time using a motion detector yields the first or second integrals of the magnetic field. Dispersion in the wire can be corrected using algorithms resulting in higher accuracy. Once the fields are known, magnetic shims are placed where any corrections are needed. This pulsed-wire method will be used to characterize an undulator which has 50 periods of 25 mm each. The undulator has a K value of 1 and a betatron wavelength of 300 nm for an electron beam of 6 MeV.

L1.00048 POSTDEADLINE –

L1.00049 The mass composition of ultra-high energy cosmic rays measured by the Telescope Array experiment1 , TOSHIHIRO FUJII, Kavli Institute for Cosmological Physics, University of Chicago, TELESCOPE ARRAY COLLABORATION — Measurements of the mass composition and its energy dependence are necessary to understand sources and propagations of cosmic rays and to exclude several theoretical models. A longitudinal development of an extensive air shower reaches its maximum at a depth, Xmax, that depends on the species of the primary cosmic ray. Using a technique based on Xmax, we report the mass composition of ultra-high energy cosmic rays from analyses of data observed by fluorescence detectors of the Telescope Array experiment. We summarize results analyzed by three different types of reconstruction procedures which are stereo, monocular and hybrid mode.

1 JSPS Postdoctoral Fellowship for Research Abroad

L1.00050 Self-completeness and the generalized uncertainty principle , MAXIMILIANO ISI, JONAS MUREIKA, Loyola Marymount University, PIÈRO NICOLINI, Frankfurt Institute for Advanced Studies, J.W. Goethe-Universität — The generalized uncertainty principle discloses a self-complete-characteristic of gravity, namely the possibility of masking any curvature singularity behind an event horizon as a result of matter compression at the Planck scale. In this paper we extend the above reasoning in order to overcome some current limitations to the framework, including the absence of a consistent metric describing such Planck-scale black holes. We implement a minimum-size black hole in terms of the extremal configuration of a neutral non-rotating metric, which we derived by mimicking the effects of the generalized uncertainty principle via a short scale modified version of Einstein gravity. In such a way, we find a self-consistent scenario that reconciles the self-complete character of gravity and the generalized uncertainty principle.

L1.00051 Gravity slows light , IAN O’SULLIVAN, No Company Provided — The speed of light is measured as a constant number of metres per second. However, a meter is a measure of how far light travels in a second. That is, light always travels as far as it does in a second every second. This is a circular definition. When measured against other things, light speed must change. Gravity is usually described as a consequence of a curve in spacetime. The word “space” has two distinct meanings. In geometry, space is a continuous area. In relativity, “space” refers exclusively to geometric spaces measured with light. “Time” in a relativistic sense also refers exclusively to the passage of time as measured against light. So a curve in spacetime (a relativistic concept) is a gradual deviation in the thing we use to measure geometric spaces and the passage of time, i.e. the speed of light. I show how Newtonian gravity can explain observable phenomena if the speed of light is inversely proportional to the strength of the gravitational field. For example, we would also expect light to refract as it changes speed passing near massive bodies. Boundary conditions are also discussed, for example, very high gravity will slow light to a stop, making it impossible to measure anything against light, giving a gravitational singularity.

L1.00052 The JENSA Gas Jet Target1 , K.A. CHIPPS, Univ of Tennessee, Knoxville/Oak Ridge National Laboratory, JENSA COLLABORATION — With the construction of next-generation radioactive ion beam (RIB) facilities, the study of many rare and unstable isotopes previously unattainable will be made possible. In order to take full advantage of possible measurements with these new isotope beams, improvements in detectors and targets are necessary. The Jet Experiments in Nuclear Structure and Astrophysics (JENSA) gas jet target is a new and cutting-edge target system, designed to provide a target of light gas, such as hydrogen or helium, that is localized, dense, and pure. In order to accomplish this, the JENSA system involves nearly two dozen vacuum pumps, differential pumping stages, a custom-built industrial compressor, and vacuum chambers designed to incorporate large arrays of both charged-particle and gamma-ray detectors. The JENSA gas jet target was originally constructed and characterized at ORNL, and has now moved to the ReA3 hall at the NSCL. Tests at ORNL show the JENSA system is capable of producing the most dense helium jet target for RIB studies in the world. JENSA will form the main target for the proposed SEparator for CApture Reactions (SECAR), and together the two comprise the equipment necessary to facilitate the studies which form the focus of the U.S. experimental nuclear astrophysics community.

1 Work funded by US DOE Office of Science and the NSF

L1.00053 Primary Beam Steering Due To Field Leakage From Superconducting SHMS Magnets , MICHAEL MOORE, Thomas Jefferson National Accelerator Facility, Old Dominion University, SILVIU COVIRIG, ROGER CARLINI, BUDDHINI WAIYAWANSA, JAY BENESCH, Thomas Jefferson National Accelerator Facility — The Super High Momentum Spectrometer (SHMS) was designed for the 12 GeV/c physics program in Hall C at Thomas Jefferson National Accelerator (JLab). At JLab an electron beam impinges on a fixed target and scattered particles are analyzed with magnetic spectrometers. The SHMS angular acceptance is 5.5° ≤ θ ≤ 40°. When positioned at θ = 5.5° and full field strength the external fields from the magnets are large enough to steer the unscattered primary beam away from the beam dump window located 51.8 m from the target. The effects of these magnetic fields on the primary beam line downstream of the target are studied using Opera 3-D and TOSCA. A solution is presented that uses passive elements to shape these fields and assure that the primary beam is steered onto the beam dump window.

L1.00054 The Majorana Demonstrator: Status and Prospects , JOHNNY GOETT, Los Alamos National Laboratory, MAJORANA COLLABORATION — The continuing search for neutrinoless double beta decay, a rare process that may inform the absolute mass scale of the neutrino, is challenged by a persistent continuum background at energies below 5 MeV. The goal of the Majorana Demonstrator is to show the feasibility of reducing these backgrounds below 1 count/tone*year in the 4keV ROI around the Q-value at 2039 keV. The demonstrator will field an array of highly purified point contact germanium detectors to demonstrate the effectiveness of a suite of materials assay, construction and analysis techniques. We provide an overview of the experimental requirements, design and expected sensitivity. A brief summary of the demonstrator status will be given for further elaboration in following talks.
new analysis, as RedMapper clusters probe as high as $z$. To break this degeneracy, we made a direct measurement of the mean occupation function (MOF) at redshift $z$. Preliminary results show that the MOF increases monotonically with halo mass. The variance appears to be too shallow for good statistics. To circumvent this limitation, we repeat our measurement using clusters drawn from the RedMapper catalog. A limitation of our measurement is that two interferometers can measure correlated position noise in the light output of the each interferometer. Verification of the ability to correctly detect small correlations in a noisy signal can be done using blackbody photons passing through a beamsplitter. The correlated intensity variations from a blackbody emitter will be used to test the Holometer photodiodes, electronics and front-end software. We will describe the verification equipment and procedure. Science runs for the Holometer will commence in early 2015.

Investigation into the Nano-Structured Surface of the Daguerreotype. EMILY THOMPSON, University of Rochester — The purpose of this project was to advance conservation techniques used on the daguerreotype and gain a better understanding of its nanoparticle covered surface. We specifically looked at how light, heat, moisture, and biology affected the daguerreotype. In addition, we altered the steps of creating a daguerreotype (iodizing, exposing, developing, and gilding) to study the effects on the surface. We found that the gilding can create a double void and a porous region below the surface, and it is now believed to be the reason for exfoliation. We found that UV light affected all areas of the daguerreotype, while visible light only affected tarnished areas. Nanoparticles were synthesized using biological materials and used to create biology on a daguerreotype. In the future, we plan to continue investigating the gilding process and biology on daguerreotypes. This project was supported in part by NSF award PHY-1156339.

Breaking Degeneracies between Quasar Halo Occupation Distribution Models : Extending Direct Measurements to Redshift 0.6. MY NGUYEN, University of Wyoming, SUCHETANA CHATTERJEE, Presidency University, Kolkata, ADAM MYERS, University of Wyoming, ZHENG ZHENG, University of Utah, EDUARDO ROZO, ELI RYKOFF, Stanford University — Recent work on quasar clustering suggests a degeneracy in the halo occupation distribution (HOD) constrained from two-point correlation function. To break this degeneracy, we made a direct measurement of the mean occupation function (MOF) at redshift $z \sim 0.2$ from cross-matching SDSS DR7 quasars with galaxy clusters drawn from the MaxBCG catalog. A limitation of our measurement is that $z \sim 0.2$ appears to be too shallow for good statistics. To circumvent this limitation, we repeat our measurement using clusters drawn from the RedMapper catalog. The number of matched quasars increases significantly in this new analysis, as RedMapper clusters probe as high as $z \sim 0.6$. Preliminary results show that the MOF increases monotonically with halo mass. The variance of the HOD closely resembles a Poisson distribution. The radial distribution of quasars within dark matter halos is described by a power law with a slope of $\sim -1$. The conditional luminosity function (CLF) and conditional black hole mass function (CMF) of quasars show no evidence of evolution with host halo mass, similar to inferences drawn from measurements of the two-point correlation function.

Application of conservation laws in electron-positron annihilation, BIJAYA ARYAL, University of Minnesota-Rochester — Electron-positron annihilation and creation of gamma rays involve various conservation principles. The least possible number of gamma rays produced in an annihilation event for low energy case can be generally explained using energy and momentum conservation. For this purpose, we choose a convenient frame of reference in which the system has zero linear momentum just before the annihilation event occurs. A learning activity was designed to help introductory level physics students understand and apply some of these conservation principles in the context of electron-positron annihilation. This study presents the students’ spontaneous application of prior learning resources while explaining the annihilation process and predicting the least possible number of gamma rays produced in an annihilation event. Qualitative and quantitative data were gathered from students’ interviews and written responses from several semesters. Data analysis has revealed students’ use of macroscopic analogies during these applications. Moreover, this study has shown that analogical mechanical models seemed to improve student performance. However, a majority of the students using such models provided incorrect reasoning in their explanations.

Sunday, April 6, 2014 2:30PM - 3:30PM – Session L14 APS: Tutorial for Authors and Referees

2:30PM L14.00001 Tutorial for Authors and Referees — Editors from Physical Review Letters and Physical Review will provide information and tips for less experienced referees and authors. This session is aimed at anyone looking to submit to or review for any of the APS journals, as well as anyone who would like to learn more about the authoring and refereeing processes. Topics for discussion will include advice on how to write good manuscripts, similarities and differences in writing referee reports for PRL and PR, and other ways in which authors, referees, and editors can work together productively. Following a short presentation from the editors, there will be a moderated discussion. Light refreshments will be served.

Sunday, April 6, 2014 3:30PM - 5:18PM – Session M2 DPF: Invited Session: Flavor Physics

3:30PM M2.00001 Recent Results on $B_{\ell}(S) \rightarrow \mu^+\mu^-$ and Other Rare B Meson Decays. ANTONIO PELLEGRINO, Nikhef, The National Institute for Subatomic Physics, Amsterdam (NL) — Recent results on key measurements of rare B meson decays will be reviewed. The main focus will be on the study of the decay $B_{\ell}(S) \rightarrow \mu^+\mu^-$ and its implications in the search for new physics beyond the Standard Model. Other rare decays relevant to this search will also be considered, like recent measurements of angular observables in the decays $B \rightarrow K(892)^0\mu^+\mu^-$ including one exhibiting a discrepancy with Standard Model predictions corresponding to 3.7 Gaussian standard deviations.
4:06PM M2.00002 Latest Results on Experimental Heavy Flavor Physics, BRAD ABBOTT, University of Oklahoma — Heavy flavor physics continues to be a major area of study with new results from various experiments appearing almost daily. Studies of the charm and bottom quarks allow probes of CP violation, searches for new physics, exploration of new states and provide excellent tests of various theoretical models. I will present some of the latest results from heavy flavor physics that explore these interesting topics.

4:42PM M2.00003 Theory of Inclusive B Decays, GIL PAZ, Wayne State University — Inclusive semileptonic and radiative B decays play a prominent role in the extraction of fundamental parameters such as the CKM matrix elements Vcb and Vub and the b-quark mass, and in constraining models of new physics. Near-future experiments such as Belle II are expected to improve the experimental precision of such decays. To match the new experimental era, progress on the theory side is needed. The experimentally implemented theoretical calculations for inclusive B decays are at an “NLO” level. Namely, they include first order perturbative corrections to the leading power term and first order power corrections. The goal of the future advances in the theory of inclusive B decays is to strive for an “NNLO” description, namely incorporating second order perturbative corrections to the leading power term and first order perturbative corrections to the first order power corrections. In this talk I will review the current theoretical status and the future theoretical progress.

Sunday, April 6, 2014 3:30PM - 5:18PM –
Session M3 DNP GFB: Invited Session: Orbiting Quarks

3:30PM M3.00001 Theory of #D partonic distributions, BARBARA PASQUINI, University of Pavia — No abstract available.

4:06PM M3.00002 Studies of Transverse Momentum Distributions of Partons, HARUT AVAGYAN, Jefferson Lab — The detailed understanding of the orbital structure of partonic distributions, encoded in Transverse Momentum Dependent (TMD) parton distributions, has been widely recognized as key objective of the JLab 12 GeV upgrade, the polarised pp program at RHIC, and a driving force behind the construction of the Electron Ion Collider. Several proposals have been already approved by the JLab PAC to study TMDs using different spin-azimuthal asymmetries at JLab12 and were awarded the highest physics rating. Although the interest in TMDs has grown enormously we are still in need of fresh theoretical and phenomenological ideas. One of the main challenges still remaining is the extraction of actual 3D parton distribution functions from hard scattering processes in nucleons and nuclei. In this talk, we present an overview of the latest developments and future studies of the TMDs.

4:42PM M3.00003 Experimental studies of Generalized Parton Distributions, SILVIA NICCOLAI, IPN Orsay — Generalized Parton Distributions (GPDs) are nowadays the object of an intense effort of research, in the perspective of understanding nucleon structure. They describe the correlations between the longitudinal momentum and the transverse spatial position of the partons inside the nucleon and they can give access to the contribution of the orbital momentum of the quarks to the nucleon spin. Deeply Virtual Compton scattering (DVCS), the electroproduction on the nucleon, at the quark level, of a real photon, is the process more directly interpretable in terms of GPDs of the nucleon. Depending on the target nucleon (proton or neutron) and on the DVCS observable extracted (cross sections, target- or beam-spin asymmetries,...), different sensitivity to the various GPDs for each quark flavor can be exploited. This talk will be focused on recent promising results, obtained at Jefferson Lab, on cross sections and asymmetries for DVCS, and their link to the Generalized Parton Distributions. These data have opened the way to a “tomographic” representation of the structure of the nucleon, allowing the extraction of transverse-space densities of the quarks at fixed longitudinal momentum. The extensive experimental program to measure GPDs at Jefferson Lab with the 12-GeV-upgraded electron accelerator and the complementary detectors that will be housed in three experimental Halls (A, B, C), will also be presented.

Sunday, April 6, 2014 3:30PM - 5:18PM –
Session M4 DAP: Invited Session: Hot Topics in Astrophysics

3:30PM M4.00001 Hot News from the Milky Way’s Central Black Hole, DARYL HAGGARD, Northwestern University/CIERA — The recent discovery of a dense, cold cloud (dubbed “G2”) approaching the supermassive black hole at our Galactic Center (Sgr A*) offers an unprecedented opportunity to test models of black hole accretion and its associated feedback. G2’s orbit is eccentric and the cloud already shows signs of tidal disruption by the black hole. High-energy emission from the Sgr A*/G2 encounter will likely rise toward pericenter (Spring 2014) and continue over the next several years as the material circularizes. This encounter may also enhance Sgr A*’s flare activity across the electromagnetic spectrum. I will present the detailed understanding of the orbital structure of partonic distributions, encoded in Transverse Momentum Dependent (TMD) parton distributions, has been widely recognized as key objective of the JLab 12 GeV upgrade, the polarised pp program at RHIC, and a driving force behind the construction of the Electron Ion Collider. Several proposals have been already approved by the JLab PAC to study TMDs using different spin-azimuthal asymmetries at JLab12 and were awarded the highest physics rating. Although the interest in TMDs has grown enormously we are still in need of fresh theoretical and phenomenological ideas. One of the main challenges still remaining is the extraction of actual 3D parton distribution functions from hard scattering processes in nucleons and nuclei. In this talk, we present an overview of the latest developments and future studies of the TMDs.

4:06PM M4.00002 Hot News from NuSTAR about black hole spin, DOMINIC WALTON, Caltech — Measurement of black hole spin has the potential to enhance our understanding in a wide variety of key astrophysical topics, including galaxy formation and the growth of supermassive black holes, supernova/GRB explosions, and relativistic jets. The best methods for measuring black hole spin currently available are anchored in X-ray spectroscopy, and ultimately rely on constraining the radius of the innermost stable circular orbit (ISCO), which relates directly to spin. Although such measurements are in their relative infancy, substantial progress has been made over the last few years. NuSTAR has undertaken a major program, coordinated with XMM, Swift and Suzaku, to obtain the highest-quality broad band X-ray spectra from AGN and BH binaries to date, with the aim of obtaining spin constraints. The quality of the data not only allows us to make robust constraints, but also challenge the physical assumptions inherent in the relativistic reflection models primarily utilized for these measurements. We review the current status of this program, highlighting in particular some of the early observational results obtained.

1This work is supported by Chandra X-ray Observatory Awards GO3-14121X and GO3-14099X and Swift Proposal Number 9120132.

3On behalf of the NuSTAR team.
4:42PM M4.00003 Hot News from the HAWC Gamma-Ray Observatory, PETRA HUENTEMEYER, Michigan Technological University — The High-Altitude Water Cherenkov (HAWC) TeV Gamma-Ray Observatory is currently under construction at a site about two hours’ drive east of Puebla, Mexico on the Sierra Negra plateau (4100 m a.s.l.). HAWC is unique among TeV gamma-ray instruments in that it can observe large portions of the sky simultaneously, and covers half the sky every 24 hours. Therefore, the detector is particularly well-suited to measure extended and large-scale structures in the sky such as diffuse galactic gamma-ray emission and large- and small-scale anisotropies. Discoveries of other extended unidentified objects at TeV energies, for example colloccated with the “Fermi Bubbles,” and the observation of transient phenomena such as GRBs, are also possible. The construction of HAWC funded through NSF, DoE, and CONAcYT, is expected to be complete by Fall 2014. Data are already being collected during construction with an increasingly sensitive detector allowing for synchronous observations with instruments at other wavebands like the Fermi Space Telescope. Analysis of the data set reveals significant anisotropies in the arrival directions of cosmic rays, both on small (below 10s of degrees) and large angular scales. A number of gamma-ray hot spots are also observed along the Galactic plane and the data have been searched for high-energy emission from GRBs detected at lower energies. I will present first results and scientific potential of the experiment.

We acknowledge the support from: US National Science Foundation (NSF); US Department of Energy Office of High-Energy Physics; The Laboratory Directed Research and Development (LDRD) program of Los Alamos National Laboratory; CONAcYT, Mexico; Red de Física de Altas Energías, Mexico; DGAPA-UNAM, Mexico; and the University of Wisconsin Alumni Research Foundation.

Sunday, April 6, 2014 3:30PM - 4:54PM
Session M6 DNP: Nuclei with 40 ≤ A ≤ 100 200 - Jeremy Holt, University of Washington


1Supported by the National Science Foundation.

3:42PM M6.00002 Inverse Kinematic Proton Scattering of 49Ca, D.M. MCPHERSON, P.D. COTTLE, K.W. KEMPER, Department of Physics, Florida State University, L.A. RILEY, M.L. AGIORGOUSIS, F.G. DEVONE, M.T. GLOWACKI, B.V. SADLER, Department of Physics and Astronomy, Ursinus College, T.R. BAUCHER, D. BAZIN, M. BOWRY, A. GADE, E.M. LUNDERBERG, S. NOJI, F. RECCHIA, M. SCOTT, D. WEISSHAAR, R.G.T. ZEGERS, National Superconducting Cyclotron Laboratory, Michigan State University — An inverse kinematic proton scattering experiment was performed using the Ursinus College liquid hydrogen target and a rare isotope beam containing 48Ca and recorded using the GRETINA-S800 detector system at the NSCL. A preliminary cross section measurement for the lowest lying octupole excitation in 49Ca was measured using efficiency corrected gamma ray counts yielded by fitting GEANT simulations to the measured GRETINA spectra.

3:54PM M6.00003 Polarized photon scattering of 52Cr: Determining the parity of dipole states, FNU KRISHICHAYAN, M. BIKE, W. TORMOW, TUNL, Duke University — Observation of dipole states in nuclei are important because they provide information on various collective and single-particle nuclear excitation modes, e.g., pgymly dipole resonance (PDR) and spin-flip M1 resonance. The PDR has been extensively studied in the higher and medium mass region, whereas not much information is available around the low mass (A ~ 50) region where, apparently, the PDR starts to form. The present photoresponse of 52Cr has been investigated to test the evolution of the PDR in a nucleus with a small number of excess neutrons as well as to look for spin-flip M1 resonance excitation mode. Spin-1 states in 52Cr between 5.0 to 9.5 MeV excitation energy were excited by exploiting fully polarized photons using the (γ, γ′) nuclear resonance fluorescne technique, a completely model-independent electromagnetic method. The de-excitation γ-rays were detected using a HPGe array. The experiment was carried out using the HIGS facility at TUNL. Results of unambiguous parity determinations of dipole states in 52Cr will be presented.

4:06PM M6.00004 Shapes and structures in the neighborhood of 68Ni: levels in 68Cu, WILLIAM WALTERS, University of Maryland — The study of the level structure of 68Ni during the last 15 years has been intense, fueled by the presence of two excited 0+ levels and a single excited 2+ level below 2.6 MeV. [C. J. Chiara et al., Phys. Rev. C 86, 041304 (R) (2012)] Recently, Tsunoda et al., have performed a series of experiments that calculated spherical, oblate, and prolate shapes for the ground, first excited 0+ level at 1604 keV, and second excited 0+ level at 2511 keV. [Y. Tsuchida, T. Otsuka, N. Shimizu, M. Honna, and Y. Utsuno, arXiv:1309.5851v1] One approach to gaining additional insight into these ideas is to examine the structure of 69Cu that has a single proton coupled to 68Ni. In this presentation, new levels and transitions will be presented for 69Cu and discussed in the context of these three proposed shapes. Excited states in these nuclei were populated through multinucleon-transfer reactions using beams provided by the ATLAS facility at Argonne National Laboratory and studied with Gammasphere. From these data, an estimate of the barrier height separating the oblate and prolate shapes will be deduced.

1This work was supported in part by the US DoE under DEFG02-94-ER40834 & DE-AC02-06CH11357.
4:18PM M6.00005 New Decay Studies of $^{66}$Ga. Suresh Kumar, University of Delhi, India and Argonne National Laboratory, I. Ahmad, M.P. Carpenter, J. Chen, J.P. Greene, F.G. Kondev, S. Zhu, Argonne National Laboratory — High-energy $\gamma$-rays with energies up to 5.0 MeV are emitted in the radioactive decay of $^{66}$Ga ($T_{1/2} = 9.49$ h). Thus, this radionuclide appears to be a suitable candidate for energy and efficiency calibrations of high-resolution, $\gamma$-ray spectrometers that are employed in studies of very neutron-rich nuclei which have large $Q \gamma$ values. In addition, accurate emission probabilities of this isotope are of interest to medical imaging applications, owing to the existence of large $\beta^+ \rightarrow$ decay branches, which need to be characterized with better accuracy. Decay studies of $^{66}$Ga were initiated using the $\gamma$-ray spectroscopy technique. The source was produced by means of the $^{60}$Zn($p, n\gamma$) reaction at a beam energy of 12 MeV. Singles and $\gamma - \gamma$ coincidences measurements were carried out using a single Ge detector and Gammasphere, respectively. The previously known $^{66}$Ga decay scheme was extended and many new $\gamma$ rays were placed in the daughter nuclide $^{66}$Zn.

The work at ANL was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357. S. Kumar acknowledges support from the Indo-US Science and Technology Forum for the award of a Research Fellowship.

4:30PM M6.00006 Transition from collectivity to single-particle degrees of freedom from magnetic moment measurements in $^{82}$Sr and $^{90}$Sr$^1$. Gerfried J. Kubmartzki, Noemibenczer-Koller, Andrew Ratkiewicz, Yitzhak Y. Sharon, Samantha Rice, Sean Bürcher, Rutgers University, Diego A. Torres, University Nacional de Colombia, Karl-Heinz Speidel, University Bonn, Gulhan Gurdal, Millsaps College, Steven D. Pain, ORNL, Matthew McCleskey, Mike Henry, Antti Saastamoinen, Alexandra Spiridon, Michael Slater, Andrew Cudd, Vladimir Zherebchevskii, Sergey Torilov, Texas A&M University — The $g$ factors of excited states in the unstable isotopes $^{82}$Sr and $^{90}$Sr were measured by the transient field technique. Beams of $^{78}$Kr and $^{86}$Kr from the K500 cyclotron at Texas A&M University were accelerated to energies just above the Coulomb barrier on carbon to produce the strontium isotopes via an $\alpha$ particle pickup. We report on the $\alpha$ transfer reaction and on the simultaneous $g$ factor measurements of the Coulomb-excited $\alpha$ isotopes.

The work was supported in part by the U.S. National Science Foundation.

3:30PM M7.00001 Parity-violating asymmetry in $^7d \rightarrow np$. Matthias Schindler, University of South Carolina, Jared Vanasse, Duke University — Ongoing experimental and theoretical efforts try to measure, analyze, and interpret hadronic parity violation in few-nucleon systems, such as the NPDGamma experiment at the Spallation Neutron Source at Oak Ridge National Laboratory. Important information on parity-violating nuclear reactions can be gained from experiments in the break-up reaction $^7d \rightarrow np$, which might be measurable at a future high-intensity photon source such as the proposed upgraded HIGS facility. We will discuss recent theoretical calculations of this parity-violating asymmetry based on effective field theory, how they contribute to the planning of the corresponding experiment, and the impact of such a measurement on our understanding of hadronic parity violation.

3:42PM M7.00002 Configuration space Faddeev formalism for system of non-identical particles: three-body model for $^3$He$^1$. Igor Filikhin, Vladimir Suslov, Branislav Vlahovic, North Carolina Central University — We study structure of energy spectrum of light hypernucleus $^3$He using cluster $a + \Lambda + n$ model. In particular, the spin doublet $(1^- - 2^-)$ of $^3$He is of interest for the testing the spin dependence of hyperon-nucleon potentials. Experimental value for $1^-$ ground state energy of $^3$He has been reported to be $-0.17$ MeV below the threshold $^3\text{He} + n$. Our study is based on the configuration-space Faddeev equations for a system of three non-identical particles. The analytical continuation method in a coupling constant is applied for calculation of resonance parameters. The results of calculations for low-lying spectra of the system $a + \Lambda + n$ are presented. Within our model, the $a + n$ potential is constructed to reproduce the results of $R$-matrix analysis for $a + n$ scattering data. This potential simulates the Pauli exclusion for $a + n$ in the s-state with repulsive core. We use phenomenological $a + \Lambda$ potential and for the $\Lambda + n$ interaction the s-wave potential simulating model NSC97f. We calculated energies of the low-lying $1^-, 2^-, 2^+$, $0^-$ states. Obtained results are discussed and compared with other calculations (T. Motoba et al. Prog. Theor. Phys. 70, 189 (1983)).

This work is supported by NSF CREST (HRD-0833184) and NASA (NNX09AV07A)

3:54PM M7.00003 Quantum Monte Carlo calculations of electromagnetic transitions in low-lying states of $^8$Be$^1$. Satori Pastore, University of South Carolina, Robert Wirtinga, Argonne National Laboratory, Rocco Schiavilla, Old Dominion University and Jefferson Laboratory. Steven Pieper, Argonne National Laboratory — We present quantum Monte Carlo calculations of electromagnetic transitions in low-lying states of $^8$Be. The Hamiltonian utilized to generate nuclear wave functions includes the Argonne-v18 two-nucleon and the Illinois-7 three-nucleon interactions. The M1 transition operator accounts for two-body contributions of one- and two-pion range, as well as contact terms, derived from chiral effective field theory. We find that two-body corrections are significant and always bring the theory in a better agreement with the experimental data. We also present E2 transition calculations, evaluated in impulse approximation, with emphasis on transitions involving the resonant excited states at $\sim 3$ MeV and $\sim 11$ MeV.

This work is supported by NSF Grant No. PHY-1068305 and U.S. DOE under contracts No. DE-AC02-06CH11357 and No. DE-AC05-060R23177.
corresponding institutional motivation and commitment are the key features of successful physics teacher education programs.

Sustained components tend to which programs have been sustained and to identify what features should be prioritized for building sustainable physics teacher education programs. Most PhysTEC legacy sites studied have sustained their production of physics teachers. A few sites studied have thriving physics teacher education programs, that is, programs that have continued to substantially increase their production of teachers since the PhysTEC award. All of the studied sites that sustained their production of physics teachers are the key features of successful physics teacher education programs.

The results of our calculations are in agreement with results of Barnea et al. The experimental evidences to support theoretical predictions are discussed. This research is supported by CUNY Research Grant Program C1TRG.

for studies on morphology, developmental biology, and plant physiology. We will introduce the basic concepts of growth analysis using rice as a model since it is easily cultivated and its growth is easily monitored.

The results of our calculations are in agreement with results of Barnea et al. The experimental evidences to support theoretical predictions are discussed. This research is supported by CUNY Research Grant Program C1TRG.

The number of sustained components does not appear to correspond to teacher production; that is, sites that have sustained more (or fewer) components of physics teacher education programs, such as recruitment, early teaching experiences, and a teacher in residence. Sustained components tend to which programs have been sustained and to identify what features should be prioritized for building sustainable physics teacher education programs. Most PhysTEC legacy sites studied have sustained their production of physics teachers. A few sites studied have thriving physics teacher education programs, that is, programs that have continued to substantially increase their production of teachers since the PhysTEC award. All of the studied sites that sustained their production of physics teachers are the key features of successful physics teacher education programs.

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4:42PM M10.00003 Research on U.S. physics teacher education, DAVID E. MELTZER, Arizona State University — College and university physics departments have long been the primary source of physics-specific education received by the nation’s high school physics teachers, who now number nearly 30,000. Since the 1880s, U.S. physicists have set out specific expectations and recommendations for the education of physics teachers, and various methods and programs have been utilized to prepare these teachers. However, relatively little research has been done regarding the effectiveness of the various instructional methods. Only rarely have there been investigations of links between physics teacher education programs, and the learning outcomes of students taught by teachers who were educated in those programs. The available evidence suggests that physics teacher education programs that utilize materials and methods developed and validated through physics education research (PER) have been particularly effective in preparing well-qualified teachers. I will give an up-to-date review of the research in this area, and discuss relevant details of the investigation recently reported by the APS/AAPT/AIP Task Force on Teacher Education in Physics (T-TEP) [D. Meltzer, M. Plisch, and S. Vokos, editors, Transforming the Preparation of Physics Teachers: A Call to Action (APS, College Park, 2012)].

Sunday, April 6, 2014 3:30PM - 5:18PM —
Session M11 GGR: Invited Session: Progress Toward the Advanced Detector Era  Oglethorpe Auditorium - Laura Cadonati, University of Massachusetts Amherst

3:30PM M11.00001 The Status of Advanced LIGO: Light at the End of the Tunnels!, JEFFREY KISSEL 1, California Institute of Technology — After six years of construction and installation, two of the Advanced LIGO gravitational wave detectors are on the cusp of completion. Early results from integrated testing show that these second-generation interferometers are well on their way to unprecedented strain sensitivity. It has been a fantastic journey of single-goal-oriented teamwork, intense organization, and an exciting exercise of cutting edge physics and technology. We present here this journey, demonstrating that all major subsystems have met the needed performance independently; we show the promising results from the early integrated testing phases of complete portions of the interferometers; and finally we discuss the schedule for commissioning the fully-operational interferometers to their designed performance. At such performance, we carve out new regions of strain sensitivity with these observatories, and begin to crack open the field of gravitational wave astrophysics.

3 for the LIGO Scientific Collaboration

4:06PM M11.00002 Preparing to analyze Advanced LIGO data: from detectors to first observations, JESSICA MCIVER, University of Virginia Amherst — Direct observation of gravitational waves (GWs) will open a new window to the Universe, directly probing the dynamics of high-energy astrophysical events. The US-based Advanced Laser Interferometer Gravitational-wave Observatory (aLIGO) detectors are now online, with the first observing runs commencing next year. The improved instrument reduces the presence of detector technology and increases the likelihood of GW observation over previous searches. This talk reviews ongoing efforts for testing instrument and software infrastructure in preparation for the search of GW transients in the advanced detector era. Particular emphasis will be placed on non-Gaussian noise artifacts and how new technologies and hardware are expected to improve the sensitivity of GW searches. I will outline current plans for the mitigation of predicted and undiscovered noise sources in the new Advanced LIGO instruments, and our progress toward readiness for rapid, confident gravitational wave detections.

4:42PM M11.00003 Multi-messenger Observations of Gravitational-Wave Sources in the Advanced Detectors Era1, RUSLAN VAULIN, Massachusetts Institute of Technology — In the near future the advanced ground-based gravitational-wave detectors will open a new direction in observational astronomy. Detection of gravitational waves will allow us to perform the first unambiguous observations of coalescence of compact binaries consisting of neutron stars and stellar-mass black holes. The multi-messenger and multi-wavelength observations of such transient gravitational-wave events with other instruments will help us to identify their location, understand their environment and examine their hypothesized connection with the short gamma-ray bursts. They will also provide a wealth of complementary data from which we can infer new information about compact objects and various physical processes taking place during or after the coalescence. In addition to coalescing binaries, we should also be prepared to discover completely new classes of gravitational-wave transients, for which verification and understanding the multi-messenger observations at other wavelengths would be equally important. In this talk I will give an overview of the observing plans for the advanced detectors in the second half of this decade, and their projected capabilities in discovering and localizing the transient gravitational-wave sources. I will describe the main challenges in performing the multi-messenger observations of such sources and what we do to overcome them in preparation for future observational campaigns. I will conclude by presenting the initiative led by the LIGO and Virgo collaborations to involve a wider astronomical community in the follow-up multi-messenger observations starting with the very first advanced detectors science run in 2015.

1 for the LIGO Scientific Collaboration and the Virgo Collaboration

Sunday, April 6, 2014 3:30PM - 5:18PM —
Session M12 DPF: Dark Matter II 100 - Robin Erbacher, University of California, Davis

3:30PM M12.00001 Recent Results from The Cryogenic Dark Matter Search II (CDMSII), PETER REDL, Stanford University, CRYOGENIC DARK MATTER SEARCH COLLABORATION — The Cryogenic Dark Matter Search II (CDMS II) operated a 4.75 kg array of Ge and Si ZIP detectors at the Soudan Underground Laboratory. Recent results using the Si detectors provide 3 events which are consistent with being from low-mass (<10 GeV/c^2) dark matter. To explore further this interesting region of parameter space we use Geant4 simulations, that demonstrate excellent agreement with recent SuperCDMS data, to simulate the CDMS II surface-event background. An accurate low-energy background model is constructed from the simulation in order to test a low-mass dark matter hypothesis in the lowest-energy Ge recoils using a maximum-likelihood technique. I will present results from this model that demonstrate a good understanding of our low-energy backgrounds. Additionally, I will discuss results obtained from extending the CDMS II background-free (higher-threshold) WIMP searches by lowering the energy thresholds for both the Ge and Si detectors (while maintaining near-zero background) to gain additional sensitivity to low-mass dark matter. The improvements in background modeling and analysis techniques presented here give important insights moving forward to the next generation of direct detection experiments.
3:42PM M12.00002 Energy Scale for Nuclear Recoils in CDMS II Silicon Detectors1, MICHAEL BOWLES, Syracuse University — Weakly Interacting Massive Particles (WIMPs) are a favored candidate for the dark matter in the Universe. The Cryogenic Dark Matter Search (CDMS) collaboration employs Z-sensitive Si and Ge crystals instrumented with Ionization and athermal Phonon sensors (ZIPs) attempting to directly detect WIMPs when they produce nuclear recoils. It is necessary to calibrate the detector response with low-energy nuclear recoils to translate results into an allowed WIMP region in mass and cross-section. We present measurements of the energy scale for nuclear recoils for the Si ZIP detectors, determined by comparing the observed energy spectra in Si detectors for 252-Cf neutron calibrations to those expected from Monte Carlo simulations. We quantify uncertainties in both the nuclear recoil spectra Monte Carlo input and results to estimate the nuclear recoil energy scale uncertainty. Implications on regions allowed by previous CDMS Si results are shown.

3:54PM M12.00003 ABSTRACT WITHDRAWN —

4:06PM M12.00004 Low energy threshold analysis of LUX data, JEREMY MOCK, University of California, Davis, ON BEHALF OF THE LUX COLLABORATION — LUX, a dual phase xenon time projection chamber with fiducial target mass greater than 100 kg, is currently the most sensitive direct dark matter search experiment. The initial null result limit on WIMP-nucleon cross section was released in late 2013. Signals from this type of detector include the primary scintillation light (S1) and a follow-up charge response (S2). In the initial analysis of the data, S1 pulses were required to have a signal in at least two PMTs and a total area larger than 2 photoelectrons. Additionally, the S2 size was required to have an area larger than 200 photoelectrons. If these thresholds are lowered, the sensitivity of the detector is expected to change. Here we present the investigation of lowering the thresholds.

4:18PM M12.00005 LUX HV Conditioning, RACHEL MANNINO, Texas A&M University, LUX COLLABORATION — The discrimination between nuclear and electron recoils in the LUX experiment’s two-phase Xe dark matter search detector is influenced by the achievable voltages and electric fields on the grid wires. To improve the sensitivity of the detector, a series of high voltage conditioning tests have been performed to increase the grid voltages. Results from both the conditioning of the grids in liquid xenon prior to Run03 and the conditioning of the grids in gaseous xenon prior to Run04 will be presented in this talk.

4:30PM M12.00006 An analysis of LUX data in the S2-only mode, SERGEY UVAROV, Univ of California - Davis, LUX COLLABORATION — LUX is the world’s largest two-phase Xe time-projection chamber, with an active fiducial target mass in excess of 100 kg. In 2013, we reported a null result from our search for WIMP dark matter and set the most stringent limits on WIMP-nucleon cross section for a wide range of WIMP masses. As the energy of the recoiling Xe nucleus decreases below a few keV, the primary scintillation signal is often too small to detect. An S2-only technique, which relies on detecting the liberated electrons that escape recombination and drift to the liquid surface, allows us to lower the energy threshold, albeit at the cost of rejection power. We will present techniques developed for this study, including novel pulse-finding algorithms and simulation methods. The prospects for LUX sensitivity in this search mode will be outlined.

4:42PM M12.00007 Two Years of SuperCDMS at Soudan, BRADFORD WELLIVER, Univ of Florida - Gainesville, SUPERCDMS COLLABORATION — There is much cosmological evidence and theoretical motivation for particle dark matter. One such candidate is so-called Weakly Interacting Massive Particle (WIMP) dark matter. For two years of nearly continuous operation at the Soudan Underground Lab, the SuperCDMS experiment has been taking data with 15 state-of-the-art germanium interdigitated Z-sensitive Ionization and Phonon (IZIP) sensors in a direct-detection experiment. The iZIP has proven to be a versatile detector capable of discriminating against backgrounds over a wide energy range allowing searches for both low- and high-mass WIMPs. We will present a brief overview of the iZIP detector itself, illustrating its background rejection capabilities and the mass range it is capable of probing. Constraints on low-mass WIMPs from a high-voltage operation mode called CDMSlite will be presented, and the status and future plans of an on-going high-mass WIMP search will also be discussed.

4:54PM M12.00008 Backgrounds and Discrimination Algorithms for Low-energy SuperCDMS Soudan Data, ADAM ANDERSON, Massachusetts Institute of Technology, SUPERCDMS COLLABORATION — The SuperCDMS experiment at Soudan uses an array of cryogenic germanium detectors called IZIPs to search for weakly interacting massive particles (WIMPs), a leading dark matter candidate. A key feature of the iZIP is its measurement of athermal phonons from WIMP interactions, which provides some position sensitivity and background rejection at energies near the ~1.6 keV threshold of the experiment. This talk describes the detector and background models that allow us to simulate the expected WIMP signal and backgrounds for a dedicated low-mass (5-15 GeV/c²) WIMP search. We then optimize background discrimination using rectangular cuts and boosted decisions tree classifiers. These algorithms are used to maximize the sensitivity of an analysis of low-energy SuperCDMS Soudan data.

5:06PM M12.00009 Dark matter search results from the first analysis of SuperCDMS Soudan low-threshold data, KRISTIANA SCHNECK, Stanford University, SUPERCDMS COLLABORATION — Recent dark matter search results from CDMS-II Si, CoGeNT, CRESST-II, and DAMA may be interpreted to favor the existence of weakly interacting massive particles (WIMPs) with masses in the 5-20 GeV range. We report results from the first search for low-mass WIMPs from the SuperCDMS Soudan iZIP detectors. This dataset employs 7 germanium iZIP detectors with an analysis threshold of ~1.6 keV/ν and a raw exposure of ~800 kg-days. We present the results of a blinded WIMP-search analysis of this exposure and the resulting constraints on the WIMP-nucleon cross-section.

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Sunday, April 6, 2014 3:30PM - 5:18PM —
Session M13 GPMFC DPF: Neutrinos: Experimental Methods 101 -

3:30PM M13.00001 Electron-neutrino charged-current quasi-elastic scattering in MINERvA, JEREMY WOLCOTT, University of Rochester, MINERVA COLLABORATION — The electron-neutrino charged-current quasi-elastic (CCQE) cross-section on nuclei is an important input parameter to appearance-type neutrino oscillation experiments. Current experiments typically work from the muon neutrino CCQE cross-section and apply corrections from theoretical arguments to obtain a prediction for the electron neutrino CCQE cross-section, but to date there has been no precise experimental verification of these estimates at an energy scale appropriate to such experiments. We present the current status of a direct measurement of the electron neutrino CCQE differential cross-section as a function of the squared four-momentum transfer to the nucleus, Q², in MINERvA. This talk will discuss event selection, background constraints, and the flux prediction used in the calculation.

3:42PM M13.00002 Cosmic Background in Detection of Low Energy Neutrinos in Liquid Argon Detectors, ZEPENG LI, KATE SCHOLBERG, Duke University, LBNE COLLABORATION — This talk will describe a study of cosmic background in detection of neutrinos in the few tens of MeV range in liquid argon time-projection chambers detectors at different depths.
3:54PM M13.00033 Calibration of the NOvA Far Detector. KANIKKA SACHDEV, Univ of Minn - Minneapolis — NOvA, currently under construction, is a long-baseline neutrino oscillation experiment that will use the NuMI beam originating at Fermilab. NOvA enables the study of two oscillation channels: $\nu_e$ disappearance and $\nu_\mu$ appearance and their CP conjugates. It consists of two functionally identical detectors; the Near Detector (ND) at FNAL is 100 m underground and the Far Detector (FD) near International Falls in Northern Minnesota is on the surface. The modular design of the detectors allows us to commission and calibrate sections of the detectors independently of others. The location of the FD on surface facilitates the use of cosmic rays as a tool to calibrate it. This talk will describe the methods used to calibrate the NOvA far detector.

4:06PM M13.00044 Liquid Xenon Purity Studies for nEXO. MICHAEL JEWELL, Drexel Univ, ENRICHED XENON OBSERVATORY/EXO COLLABORATION — The EXO collaboration is currently searching for neutrinoless double-beta decay using the scintillation and ionization responses of a liquid xenon time projection chamber (TPC). To optimize the signal of such a detector, the xenon needs to be kept free of electron-negative impurities which could interact with drifting electrons and limit energy resolution. The current 200kg prototype detector, EXO-200, achieves electron lifetimes above 1ms to limit charge attenuation. With the next generation ton scale detector nEXO, more stringent limits will be needed to achieve expected energy resolution. In addition there is a need for real-time monitoring to allow for timely response in the event that xenon purity begins to show signs of degradation. This talk will discuss research and development of new purity monitoring techniques that will directly measure electron lifetime in liquid xenon. The results of this research will have direct applications for nEXO as well as other large noble liquid detectors.

4:18PM M13.00055 Development of a Photon Detection System in Liquid Argon for the Long-Baseline Neutrino Experiment. DENVER WHITTINGTON, BRICE ADAMS, BRIAN BAPTISTA, BRIAN BAUGH, MARK GEBHARD, MICHAEL LANG, STUART MUFSON, JAMES MUSSER, PAUL SMITH, JON URHEIM, Indiana University, LONG-BASELINE NEUTRINO EXPERIMENT COLLABORATION1 — The Long-Baseline Neutrino Experiment (LBNE) will be a premier facility for exploring long-standing questions about the boundaries of the standard model. Acting in concert with the liquid argon time projection chambers underpinning the far detector design, the LBNE photon detection system will capture ultraviolet scintillation light in order to provide valuable timing information for event reconstruction. The team at Indiana University is exploring a design based on acrylic waveguides coated with a wavelength-shifting compound, combined with silicon photomultipliers, to collect and record scintillation light from liquid argon. Large-scale tests of this design are being conducted at the “Tailo” liquid argon detector facility at Fermilab, where performance studies with cosmic ray events are helping steer decisions for the final detector design. We present an overview of the design and function of this photon detection system and the latest results from the analysis of data collected during these tests.

1Photon Detector R&D Team at Indiana University

4:30PM M13.00066 ABSTRACT WITHDRAWN –

4:42PM M13.00077 Utilizing Neutron Capture on Hydrogen to Measure $\theta_{13}$ at Daya Bay. LOGAN LEBANOWSKI, Tsinghua University, THE DAYA BAY COLLABORATION — The Daya Bay Reactor Neutrino Experiment has provided the most precise determination of the neutrino mixing angle, $\theta_{13}$. The precision of this determination is crucial for future measurements of CP violation in the lepton sector. Now, Daya Bay is performing a largely independent measurement of $\sin^2 2\theta_{13}$ utilizing neutron capture on hydrogen. Previous results use six 20-ton Gd-loaded scintillating targets while the new measurement uses six additional 22-ton scintillating targets that are not Gd-loaded. This talk introduces the basic differences between the two determinations, including a discussion of their correlations. This talk also gives an illustration of how the new, statistically-independent measurement of $\sin^2 2\theta_{13}$ is significantly systematics-independent, and is expected to improve the uncertainty from Daya Bay.

4:54PM M13.00088 Fast Neutron Detection with the Double Chooz Time Projection Chamber. MARJON MOULAI, Massachusetts Institute of Technology, MASSACHUSETTS INSTITUTE OF TECHNOLOGY TEAM — The Double Chooz Time Projection Chamber (DCTPC) is a directional fast neutron detector that measures background neutron production at the Double Chooz reactor-based neutrino oscillation experiment’s near (120 mve) and far (300 mve) halls. DCTPC will provide data at modest depths, tying near-surface measurements to those from deep underground laboratories. DCTPC will be used to search for a correlation between fast neutron production and rainfall and will provide valuable neutron measurements as a function of depth, direction, and energy. Calibration data will be presented, as well as preliminary findings from operation at Double Chooz.

5:06PM M13.00099 Lightguide-based Light Collection System for LArTPCs. ALEXANDER MOSS, Massachusetts Inst of Tech-MIT — This talk will describe progress on establishing a lightguide-based light collection system for LArTPCs, including the LBNE and LAr1 experiments. Recent developments have resulted in over an order of magnitude improvement in these detectors compared to the first published systems.

Sunday, April 6, 2014 3:30PM - 5:06PM –

Session M15 Numerical Relativity in Vacuum: Methods and Simulations II 103 - Roseanne Cheng, Georgia Institute of Technology

3:30PM M15.00001 Numerical Relativity in Spherical Polar Coordinates. THOMAS BAUMGARTE, Bowdoin College — Spherical polar coordinates have many desirable properties for simulations in relativistic astrophysics. In the absence of symmetry conditions, however, numerical relativity simulations in spherical polar coordinates have been hampered by associated with the coordinate singularities. In this talk I will discuss a new approach that does not require regularization of the singular terms, and instead employs a reference-metric formulation of the BSSN equations, a proper rescaling of the dynamical variables, and a partially-implicit Runge-Kutta integration scheme. I will briefly review these ingredients, and will then present some tests and early applications.

3:42PM M15.00002 Modeling large remnant kicks for the mergers of unequal mass black hole binaries. YOSEF ZLOCHOWER, CARLOS LOUSTO, Rochester Inst of Tech — Recoils from the mergers of supermassive black hole binaries can be large enough to eject the remnant black hole out of the host galaxy. The actual recoil will depend on the size and orientation of the black-hole spins and the mass ratio of the binary. Here we discuss how relatively few simulations can be used to model the recoil for astrophysically interesting mass ratios, spin magnitudes, and spin orientations.

3:54PM M15.00003 On the dynamics of spinning binary black holes and some astrophysical consequences. CARLOS LOUSTO, MANUELA CAMPANELLI, JAMES HEALY, IAN RUCHLIN, YOSEF ZLOCHOWER, Rochester Institute of Technology — We numerically study the final inspiral orbital dynamics of highly spinning binary black holes. In particular the effects of precession on the total radiated gravitational energy, angular and linear momentum. We discuss the main astrophysical and observational consequences of the spin dynamics and recoils when the black hole binary is immersed in gaseous environment.
4:06PM M15.00004 The Final Spin of a Binary Black-Hole System, KARAN JANI, DEIRDRE SHOEMAKER, Georgia Institute of Technology — The coalescence of a binary black-hole (BBH) results in a space-time described by the Lorentz boosted Kerr metric. The final BH thus purely lies in a 7-dimensional parameter space consisting of the mass, spin and recoil velocity. The initial BBH system however, even in the regime of being a quasi-circular orbit, is described by 14 parameters, namely the two masses, their spins and their momenta. As a one-one map between the initial and final parameter space cannot exist, several attempts have been made in the past to provide an analytical formula that maps a set of initial binary BH parameters to a given value of final mass and final spin. In this study, we test the validity of the most used analytical spin formula listed in Barausse & Rezzolla (2009) using the extensive, 484 simulations of generic BBH configurations, catalog from the Georgia Tech Numerical Relativity group.

4:18PM M15.00005 Modeling the Richness of Ringdown: From Spheroidal Decomposition to Beyond the Fundamental and First Order Quasinormal Modes, LIONEL LONDON, Georgia Inst of Tech, JAMES HEALY, Rochester Inst Tech, DEIRDRE SHOEMAKER, Georgia Inst of Tech, GATECH CRA TEAM — Numerical relativity waveforms are traditionally decomposed into the orthogonal spin -2 spherical multipoles. The ringdown of black holes, however, is more naturally described by the non-orthogonal spin -2 spherical multipoles. As a consequence, numerical relativity ringdown waveforms consist of a superposition of spheroidal modes. Upon implementing a method that identifies the spheroidal multipole content in numerical relativity waveforms, we find not only the fundamental QNM amplitudes, but also overtones, and long lived 2nd order QNMs in a series of unequal-mass systems. We use a Post-Newtonian inspired model to present new fitting formulas for the related QNM excitations. Finally, we discuss the relevance of our results to advanced gravitational wave detectors by considering the SNR of ringdown only temples in an example scenario.

4:30PM M15.00006 Scattering of force-free electrodynamic waves by spacetime curvature, FAN ZHANG, SEAN MCMILLIANS, West Virginia University — The electromagnetic fields \( E \) and \( B \) are vectors that couple to spacetime curvatures via Ricci identities, and so force-free electrodynamic waves will in general be scattered. However, Brennan, Gralla and Jacobson found a family of exact solutions that escape scattering. We analytically and numerically study these solutions and their alterations, in order to provide more details as to what features allow them to possess this property. We hope our results will be useful when searching for other solutions of this type. We also provide physical intuition for some commonly encountered theoretical constructs.

4:42PM M15.00007 Black Hole Superradiance, FRANS PRETORIUS, Princeton University, WILLIAM EAST, Kavli Institute for Particle Astrophysics and Cosmology, FETHI RAMAZANOGLU, Princeton University — I will present results from a numerical study of the superradiant scattering of gravitational waves by a nearly extremal black hole. The full vacuum Einstein equations are solved, thus allowing us to study the back-reaction of the interaction on the black hole, and confirming that the amplification of the wave is balanced by energy and angular momentum loss of the black hole. To explore the nonlinear phase of the interaction we consider gravitational wave packets with initial energies up to 10 percent that of the mass of the black hole. We find that as the incident wave energy increases, the amplification of the scattered waves, as well as the energy extraction efficiency from the black hole, is reduced. During the interaction the apparent horizon geometry undergoes sizable non-axisymmetric oscillations. The largest amplitude excitations occur when the peak frequency of the incident wave packet is above where superradiance occurs, but close to the dominant quasi-normal mode frequency of the black hole.

4:54PM M15.00008 Chaos in the general relativistic three-body problem, DAVID NEILSEN, JARED JAY, TAYLOR MORGAN, Brigham Young University — The three-body problem in classical gravity is known to have chaotic solutions. We are investigating chaos in the three-body problem in general relativity using post Newtonian equations. We model a binary system that interacts with an incoming star. We solve the post-Newtonian evolution equations in the Hamiltonian formalism to order 2.5. We present results of these interactions that display features of chaos, such as sensitivity to initial conditions and scale invariance.

Sunday, April 6, 2014 3:30PM - 5:18PM –
Session M17 DPB DNP: Invited Session: Accelerators for the Future of Nuclear Physics 105-106

3:30PM M17.00001 Tools for the Future of Nuclear Physics, DONALD GEESAMAN, Argonne National Laboratory — The challenges of Nuclear Physics, especially in understanding strongly interacting matter in all its forms in the history of the universe, place ever higher demands on the tools of the field, including the workhorse, accelerators. These demands are not just higher energy and higher luminosity. To recreate the matter fleetingly was formed in the origin of the heavy elements, we need higher power heavy-ion accelerators and creative techniques to harvest the isotopes. We also need high-current low-energy accelerators deep underground to detect the very slow rate reactions in stellar burning. To explore the three dimensional distributions of high-momentum quarks in hadrons and to search for gluonic excitations we need high-current CW electron accelerators. Understanding the gluonic structure of nuclei and the three dimensional distributions of partons at lower \( x \), we need high-luminosity electron-ion colliders that also have the capabilities to prepare, preserve and manipulate the polarization of both beams. A search for the critical point in the QCD phase diagram demands high luminosity beams over a broad range of species and energy. With advances in cavity design and construction, beam manipulation and cooling, and ion sources and targets, the Nuclear Physics community, in the U.S. and internationally has a coordinated vision to deliver this exciting science.

1This work is supported by DOE, Office of Nuclear Physics, under contract DE-AC02-06CH11357

4:06PM M17.00002 Electron-Ion Colliders Worldwide, OLIVER BRUNING, CERN — The first ever build lepton-proton collider HERA at DESY stopped operation in 2007. Several laboratories around the world are currently studying options for future electron-ion collider projects. The presentation will give an overview of the different projects under study and highlight the technical challenges associated with the different projects.

4:42PM M17.00003 Rare Isotope Beams worldwide, THOMAS GLASMACHER, FRIB — No abstract available.

Sunday, April 6, 2014 4:30PM - 5:30PM –
Session N4 LGBT Roundtable Discussion on LGBT+ Issues in Physics Jasper Boardroom -

4:30PM N4.00001 LGBT Roundtable Discussion on LGBT+ Issues in Physics — The LGBT+ Physicists group welcomes those who identify as gender sexual minorities, as LGBTQQIAAP+, or as allies to participate in a round-table discussion on mentoring physicists. The session will provide an opportunity to learn and discuss successful mentoring strategies at different career stages for physicists in all environments, including academia, industry, etc. Attendees are encouraged to attend a social event to follow the panel to continue to network. Allies are especially welcome at this event to learn how to support and mentor LGBT+ physicists.
Sunday, April 6, 2014 3:30PM - 5:00PM –
Session M30 APS: Meet the APS Journal Editors  Georgia International Gallery –

3:30PM M30.00001 Meet the APS Journal Editors — The Editors of the APS Journals invite you to join them for conversation and refreshments. The Editors will be available to answer questions, hear your ideas, and discuss any comments you may have about the journals. Light refreshments will be served.

Sunday, April 6, 2014 5:45PM - 6:45PM –
Session N1 APS: APS Prizes and Awards Ceremonial Session  Oglethorpe Auditorium - Malcolm Beasley, Stanford University

5:45PM N1.00001 APS Prizes and Awards Ceremonial Session –

Sunday, April 6, 2014 6:30PM - 8:00PM –
Session N2 Diversity Reception  Hyatt Regency Savannah Scarbrough 3-4 –

6:30PM N2.00001 Diversity Reception — After a long day of sessions, relax and unwind at the Education & Diversity Reception. We will be recognizing the new Forum on Education Fellows, the recipients of the Committee on Education’s Award for Improving Undergraduate Physics Education, as well as female and minority physicists that have received APS prizes, awards and fellowship.

Sunday, April 6, 2014 8:00PM - 9:30PM –
Session N3 A Staged Reading of the Play: Uranium + Peaches  Hyatt Regency Savannah Regency Ballroom A –

8:00PM N3.00001 A Staged Reading of the Play: Uranium + Peaches — In the dramatic and fateful confrontation between Einstein’s protege, Leo Szilard, and Truman’s mentor, Jimmy Byrnes, science battles politics in the timeless struggle against the corruption of human ingenuity. Redemption, salvation, catastrophe, and hope itself are the stakes as one man’s logic and reason clash with another’s pure human emotion. But which is which? Does history repeat because science and politics speak different languages? Do good and evil have a place in the course of “inevitable” events? Join us for a dramatic staged reading of Uranium + Peaches, a play by William Lanouette and Peter Cook, performed by The Savannah Community Theatre Company. After the performance, the director, actors, and playwrights will be available for audience discussion.

Monday, April 7, 2014 8:30AM - 10:18AM –
Session Q1 APS: Plenary Session II: Treasures From the Cosmic Frontier  Chatham Ballroom A/B -
Ian Shipsey, Purdue University

8:30AM Q1.00001 Cosmic Neutrinos in the IceCube Detector , NAOKO KURAHASHI NEILSON, University of Wisconsin, Madison — High-energy neutrinos are thought to be emitted by astronomical objects such as active galactic nuclei, gamma-ray bursts, and supernova remnants. However, due to their small predicted flux and large backgrounds from neutrinos and muons made in the Earth’s atmosphere, they had not been observed until now. The IceCube Neutrino Observatory instruments a cubic kilometer of ice at the South Pole to detect neutrinos mostly above 100 GeV. In a dataset from the first couple of years of the completed detector, a new veto technique was employed to find a pure sample of very high energy neutrinos (above 30 TeV). An excess is observed above atmosphere-created backgrounds that is incompatible in energy spectrum and arrival direction, leading to the first observation of astrophysical neutrinos. Studies on the arrival direction were performed to search for clustering of events that would indicate individual sources, signaling the birth of neutrino astronomy.

9:06AM Q1.00002 Tales from the Twitterverse , NEIL DEGRASSE TYSON¹, American Museum of Natural History — The public’s access to science has historically occurred through traditional conduits of communication such as television documentaries, and media reports. But in the past five years social media has arisen as a means of attracting people who would have never imagined they had an interest in the universe, or in science at all. The results are stunning and unexpected, with millions of people responding to various offerings of the universe made in these media. Twitter and Facebook lead the way, but other internet social media have proven potent as well, including YouTube, Reddit, Google+, and more broadly, the blogosphere. We give first-hand stories and accounts of forays on this landscape and offer suggestions on how such efforts may benefit the long-term health of science in America, by cultivating public support at its deepest levels.

¹Tyson is a member of the Department of Astrophysics at New York City’s American Museum of Natural History, where he also serves as Director of the Hayden Planetarium.
implications will be discussed.

Largest-scale shell-model calculations have been able to describe the evolution of transition strength across the isotopic chain without varying effective charges.

The collectivity, sensitive to the presence of shell gaps, nuclear deformation, and nucleon-nucleon correlations, for example. In the Sn isotopes, this transition strength has been reported from the MINERvA, MiniBooNE, T2K and ArgoNeuT collaborations will be reviewed.

Beyond the very neutron-rich doubly magic nucleus \( ^{100}A=100 \), formidable testing ground for nuclear models as some spectroscopic data is available from the development of a comprehensive model of the atomic nucleus with predictive power across the nuclear chart. Of particular importance for the development to address these signals by employing accelerator, reactor and radioactive source experiments are in the planning stages or underway worldwide. In this talk some of these will be reviewed, with emphasis on the accelerator programs.

11:57AM R2.00003 Neutrino Physics: Theory, Lisa Everett, University of Wisconsin-Madison — This talk will provide an overview of recent developments in neutrino physics theory, including the fermion mass puzzle in light of the reactor angle measurement, the status of sterile neutrinos, and CP violation in the lepton sector.

11:21AM R2.00002 Experimental Anomalies in Neutrino Physics, Ornela Palamara, Yale University, New Haven (CT) — Laboratory Nazionali del Gran Sasso (Italy) — In recent years, experimental anomalies ranging in significance (2.8-3.3σ) have been reported from a variety of experiments studying neutrinos over baselines less than 1 km. Results from the LSND and MiniBooNE short-baseline \( \nu_e/\bar{\nu}_e \) appearance experiments show anomalies which cannot be described by oscillations between the three standard model neutrinos (the "LSND anomaly"). In addition, a re-analysis of the anti-neutrino flux produced by nuclear power reactors has led to an apparent deficit in \( \bar{\nu}_e \) event rates in a number of reactor experiments (the "reactor anomaly"). Similarly, calibration runs using \(^{51}\text{Cr}\) and \(^{40}\text{Ar}\) radioactive sources in the Gallium solar neutrino experiments GALLEX and SAGE have shown an unexplained deficit in the electron neutrino event rate very short distances (the "Gallium anomaly"). The puzzling results from these experiments, which together may suggest the existence of physics beyond the Standard Model and hint at exciting new physics, including the possibility of additional low-mass sterile neutrino states, have raised the interest in the community for new experimental efforts that could eventually solve this puzzle. Definitive evidence for sterile neutrinos would be a revolutionary discovery, with implications for particle physics as well as cosmology. Proposals to address these signals by employing accelerator, reactor and radioactive source experiments are in the planning stages or underway worldwide. In this talk some of these will be reviewed, with emphasis on the accelerator programs.

10:45AM R3.00001 Quadropole Collectivity in Neutron Deficient Sn Isotopes\(^1\), Alexandra Gade, NSCL and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824 — One of the overarching goals of nuclear physics is the development of a comprehensive model of the atomic nucleus with predictive power across the nuclear chart. Of particular importance for the development of nuclear models is experimental data that consistently track the effect of isospin and changed binding, for example. The chain of Sn isotopes has been a formidable testing ground for nuclear models as some spectroscopic data is available from \( N = Z = 50 \) \(^{100}\text{Sn}\) in the proximity of the proton drip-line to \(^{135}\text{Sn}\), beyond the very neutron-rich doubly magic nucleus \(^{132}\text{Sn}\). In even-even nuclei, the electromagnetic quadrupole excitation strength is a measure of quadrupole collectivity, sensitive to the presence of shell gaps, nuclear deformation, and nucleon-nucleon correlations, for example. In the Sn isotopes, this transition strength has been reported from \(^{102}\text{Sn}\) to \(^{130}\text{Sn}\), spanning a chain of 14 even-even Sn isotopes. The trend is asymmetric with respect to midshell and not even the largest-scale shell-model calculations have been able to describe the evolution of transition strength across the isotopic chain without varying effective charges. Implications will be discussed.

\(^1\)This work was supported by the National Science Foundation under Grant No. PHY-1102511.

11:21AM R3.00002 Shape Co-existence at \( N=60 \): Single Particle Structure of \(^{95}\text{Sr}\)\(^\text{+1}\), Reiner Krücken, TRIUMF — The shape coexistence and shape transition at \( N=60 \) in the Sr, Zr region is of subject of substantial current experimental and theoretical effort. An important aspect in this context is the evolution of single particle structure for \( N<60 \) leading up to the shape transition. One-neutron transfer reactions are an ideal tool to study single-particle energies as well as occupation numbers which can be compared to results of modern large scale shell model calculations using a \(^{78}\text{Ni}\) core. Here we report on the study of the single-particle structure in \(^{94}\text{Sr}\) via the one-neutron transfer reaction \(^{95}\text{Sr}(p,\gamma)^{94}\text{Sr}\) in inverse kinematics. The experiment was performed at TRIUMF’s ISAC facility using the TIGRESS gamma-ray spectrometer in conjunction with the SHARC charge particle detector and a fusion veto detector. The charge state of the singly charged \(^{94}\text{Sr}\) beam extracted from the ISAC UC\(_{+}\) target was increased to 15\(^+\) in an ECR source before acceleration to 5.5 AMeV. Gamma-rays as well alight charged particles are detected to extract energies, cross-sections, and proton angular distributions for the low-lying states in \(^{95}\text{Sr}\). Initial results of this experiment will be discussed in the context of the evolution of single-particle structure in this region.

\(^1\)Support from NSERC, DOE, and STFC is acknowledged.
11:57AM R3.00003 Inelastic proton scattering of Sn isotopes studied with GRETINA
d, CHRISTOPHER CAMPBELL, Lawrence Berkeley National Laboratory — The chain of semi-magic Sn nuclei, with many stable isotopes, has been a fertile ground for experimental and theoretical studies. Encompassing a major neutron shell from N=50 to 82, the properties and structure of these nuclei provided important data for the development of the pairing-plus-quadrupole model. Recent experimental information on B(E2) for 106,108,110,112Sn came as a surprise as it indicated a larger collectivity than the predicted parabolic trend of quadrupole collectivity. These data, instead, show an unexpectedly flat trend even as the number of valence particles is reduced from 12 to 6. To fully understand how collectivity is evolving in these isotopes, 108,110,112Sn have been studied using thick-target, inelastic proton scattering with GRETINA tagging inelastic scattering events by detecting gamma-rays from the prompt decay of states excited in the reaction. We will present the trend of 2+ excitation cross-sections, the deduced quadrupole deformation parameters, and observations of other low-lying collective states. Comparison of these (p,p') quadrupole deformation parameters with B(E2) data will provide new insights into the relative importance of proton and neutron contributions to collectivity in these nuclei.

11:21AM R4.00002 CMB Lensing Cross Correlations, LINDSEY BLEEM, Argonne National Labs — A new generation of experiments designed to conduct high-resolution, low-noise observations of the Cosmic Microwave Background (CMB) —including ACTpol, Planck, POLARBEAR and SPTpol— are producing exquisite measurements of the gravitational lensing of the CMB. Such measurements, covering large fractions of the sky, provide detailed maps of the projected mass distribution extending to the surface of the CMB’s last scattering. Concurrently, a large number of deep, wide-area imaging and spectroscopic surveys (e.g., the Dark Energy Survey (DES), WISE all-sky survey, Subaru HyperSuprimeCam Survey, LSST, MS-DESI, BigBoss, etc.) are, or will soon be, providing maps of the distribution of galaxies in the Universe. Correlations of such tracer populations with lensing data allows new probes of where and how galaxies form in the dark matter skeleton of the Universe. Recent correlations of maps of galaxy and quasar densities with lensing convergence maps have produced significant measurements of galaxy bias. The near-term prospect for improvements in such measurements is notable as more precise lensing data from CMB polarization experiments will help to break cosmological and astrophysical parameter degeneracies. Work by the Planck, SPT, and POLARBEAR collaborations has also focused on the correlation of the Cosmic Infrared Background (CIB) with CMB lensing convergence maps. This correlation is particularly strong as the redshifts of the CIB and CMB lensing kernel are well matched. Such correlations probe high-redshift structure, constraining models of star-formation and the characteristic mass scale for halos hosting CIB galaxies and have also been used to demonstrate the first detection of CMB B-mode polarization — an important milestone in CMB observations. Finally, combining galaxy number density, cosmic shear and CMB lensing maps has the potential to provide valuable systematic tests for upcoming cosmological results from large optical surveys such as LSST.

11:09AM R6.00003 Induced magnetic moment in effective models of quarks in a magnetic field, EFRAIN J. FERRER, The University of Texas at El Paso — The generation of magnetic moment condensates in NJL-type effective models of quarks in the presence of a magnetic field is investigated. It will be shown how for particle-antiparticle pairs, the magnetic moment condensate significantly increases the critical temperature for chiral restoration. For diquark pairs, it will be proved that the magnetic moment condensate enhances the condensation energy and the system magnetization.

This work has been supported in part by DOE Nuclear Theory grant de-sc0002179.
11:21 AM R6.00004 Do the superfluid vortices in CFL quark matter spontaneously decay? 1, S.
KUMAR MALLAVARAPU, MARK ALFORD, Washington University in Saint Louis — It has been suggested in literature that the usual superfluid vortices/strings in high density color superconducitvity are actually unstable. The idea is that there could be more fundamental strings namely the non-Abelian semi-superfluid strings which have color gauge flux tube. A combination of three such semi-superfluid strings which have zero net color flux is more stable than a single superfluid string, provided that the separation between the semi-superfluid strings is much larger than the size of each one. Is the semi-superfluid string configuration more stable than the superfluid string even for small separations? Does the single superfluid string spontaneously break into semi-superfluid strings? In this talk we offer some results that would help us answer these questions.

11:33 AM R6.00005 Quantum Electrodynamics Interpolated Between Instant Form and Front
Form, ZYJUE LI, MURAT AN, CHUENG-RYONG JI, North Carolina State University — Among the three forms of relativistic dynamics proposed by Dirac in 1949, the front form of relativistic dynamics now known as the light-front dynamics (LFD) appears to have definite advantages over the instant form dynamics, when it deals with the hadronic processes where the relativistic effects are significant. In particular, LFD may save a substantial dynamical effort put in the instant form dynamics with respect to getting the QCD solutions that reflect the full Poincaré symmetries, due to the built-in boost invariance and simpler vacuum property. As an effort to understand how the familiar instant form dynamics (IFD) transforms to LFD, we interpolate the two forms of dynamics by introducing an interpolation angle that changes the ordinary time $t$ to light front time $(t + z/c)/\sqrt{2}$. In this presentation, we report our derivation of the polarization vectors for photon and the helicity spinors for spin-1/2 fermion that interpolate between IFD and LFD and the application of our results to the lowest-order QED scattering amplitudes. Our analysis makes clear the distinction between the infinite momentum frame (IMF) and the LFD.

11:45 AM R6.00006 An Introduction to Euclidean Relativistic Quantum Mechanics1, PHILIP KOPP, WAYNE POLYZOU, University of Miami — In nuclear physics, sub-nuclearic degrees of freedom are expected to become relevant at the few-GeV scale. Models at this scale require a relativistic treatment. The Euclidean formulation of relativistic quantum mechanics offers an efficient framework to model systems of a finite number of degrees of freedom at this scale. At the same time, the input Euclidean Green’s functions are closely related to Green functions of Euclidean field theory. We discuss the formulation of the relativistic theory. We also develop scattering theory in this formalism. A solvable model is utilized to show the usefulness of this method.

1 supported in part by the U.S. Dept. of Energy

11:57 AM R6.00007 Branched Hamiltonians and Supersymmetry, THOMAS CURTRIGHT, University of Miami, COSMAS ZACHOS, Argonne National Laboratory — Some examples of branched Hamiltonians are explored both classically and in the context of quantum mechanics, as recently advocated by Shapere and Wilczek. These are in fact cases of switchback potentials, albeit in momentum space, as previously analyzed for quasi-Hamiltonian chaotic dynamical systems in a classical setting, and as encountered in analogous renormalization group flows for quantum theories which exhibit RG cycles. A basic two-worlds model, with a pair of Hamiltonian branches related by supersymmetry, is considered in detail.

12:09 PM R6.00008 The Electron as a Heisenberg Fluid - Linking Quantum Behavior with Relativity1, SHANTIKUMAR NAIR2, Amrita Centre for Nanosciences, Amrita Vishwa Vidyapeetham (University) — In this paper, the previous work by this author to address the quantum relativity connection is further extended The electron here is modeled as a fluid obeying the Uncertainty Principle of Heisenberg. Such a Heisenberg fluid would exhibit the same electromagnetic coupling to the nucleus as predicted by electromagnetism; however, the fluid also satisfies the Einstein’s equation of General Relativity for a curved space-time, demonstrating that space-time geometry within the atom may not be flat. The model relates uncertainty to a particular curved space-time structure. The possibility of curved space-times within the atom generated by Heisenberg pressures provides a subtle link between quantum theory and General Relativity and suggests that quantum theory can be a background dependent model. The geodesic force from the curved space-time generated by the fluid is the same as the electromagnetic force between the electron and the nucleus thus providing internal consistency to the model. The Energy-Momentum-Stress Tensor governing this fluid has an analogy to the tensor used to model Cosmic Microwave Radiation. The uncertainty appears to be largely related to the time transformation resulting from the curved space-time geometry of the fluid.

1 Support of Amrita Vishwa Vidyapeetham is gratefully acknowledged
2 Professor and Director

12:21 PM R6.00009 The nature of magnetic phenomena is the electric phenomenon new interpretation, YONGQUAN HAN, 15611860790 — The nature of magnetic phenomena is the electric phenomenon, that is the result of the negative and positive charge of the regular “matrix,” also a positive, negative charge spread by the form of the “matrix,” but also can be said to be the waves of electric current (the current spread by the form of wave but only transfer form, the form is not move with wave), its characteristics are: magnetic field plane and the current plane is perpendicular to each other (make up the current wave), inside the material, it performance the current wave (electric field $<\,\rangle$, magnetic field). Sent to outer space it become an electromagnetic wave, an electromagnetic wave particle (positive, negative particle move in a circle)is the smallest needle, it is unified with Maxwell electromagnetic theory, magnetic monopoles do not exist. The mechanism of information between cable transmission and wireless transmission is the same.

Monday, April 7, 2014 10:45AM - 12:33PM — Session R7 Instrumentation | 201 - Dipangkar Dutta, Mississippi State University

10:45 AM R7.00001 Development of Spin-Exchange Polarized 3He Target Cells that Incorporate both Glass and Metal, MADUKA M. KALUARACHCHI, YUNXIAO WANG, DANIEL J. MATYAS, WILLIAM A. TOBIAS, YUAN ZHENG, VLADIMIR NELYUBIN, GORDON D. CATES, Univ of Virginia — Approved experiments at Jefferson Lab following the 12 GeV upgrade will include a measurement of the elastic electric form factor of the neutron using a polarized $^3$He target at a luminosity more than ten times higher than previous experiments. Historically, polarized $^3$He targets at JLab have been made out of glass. At higher beam currents, it will be desirable to incorporate metal windows through which the electron beam can enter and exit. There is only limited data on nuclear spin relaxation due to metal surfaces and the alkali metal we use in spin-exchange optical pumping (the technique we use to polarize the $^3$He) has adverse effects on certain metal surfaces causing it to be more relaxing over time. For this reason we have been studying spin relaxation on a variety of metals that may be incorporated in our targets. Measurements from Maimi show, under significantly different conditions, that gold is a promising candidate [A. Deninger et. al., Eur. Phys. J. D 38, 439 (2006)]. Among the results we will present are spin-relaxation measurements of cells made of glass and OFHC copper in which the copper has been plated with gold. Our measurements show considerable promise for a new generation of high-luminosity polarized $^3$He targets.
10:57AM R7.00002 Development of a Thin-Walled Tritium Gas Target System for ($\gamma,p$) Measurements1. FORREST FRIESEN, CALVIN HOWELL, TUNL — The planned $^3$H($\gamma,p)n$ experiment at the TUNL High Intensity Gamma-ray Source will provide data that test three-nucleon ab-initio calculations, and will enable a determination of the $^1S_0$ neutron-neutron scattering length. This experiment will involve measurement of the emitted protons with energies down to about 1.5 MeV, and requires an overall uncertainty in energy measurements of less than 250 keV in the region of interest. The target will be approximately 230 Ci of gaseous tritium contained in a series of thin-walled cylindrical cells, constructed from 2.5-µm thick Havar foil. We report on methods for building, filling, handling, and leak testing the target cells.

1This work is supported in part by US DOE Grant No. DE-FG02-97-ER41033.

11:09AM R7.00003 Cross calibration of the JLab, Hall C, Compton and Møller polarimeters and a study of systematic uncertainties of the Compton electron detector1. AMRENDRA NARAYAN, Mississippi State University, HALL C COMPTON TEAM — A Compton polarimeter was commissioned at Jefferson Lab, Hall C, for continuous non-invasive measurement of the electron beam polarization. It uses $\sim 1.5 \text{ kW}$ of green light for the $e^-\gamma$ scattering. The polarimeter has several planes of diamond micro-strip detectors to detect the Compton scattered electrons and a $\text{PbWO}_4$ crystal for detecting back-scattered photons. It was successfully used to measure the electron beam polarization for precision imaging of charged tracks close to the collision point by the standard Møller polarimeter. The diamond micro-strip electron detector provided a standalone measurement of the beam polarization with < 1% statistical uncertainty per hour, for a 1.16 GeV, 180 $\mu$A electron beam. The systematic uncertainties are projected to be better than 1%. We will discuss the various contributions to the systematic uncertainties for the detector electron. We also collected data at low current for a Møller-Compton cross calibration. The preliminary results from the analysis of these data will be presented.

1This work was supported by DOE grant number: DE-FG02-07ER41528 for "Precision Measurements at Medium Energy."

11:21AM R7.00004 Improving the quantum efficiency of the CLAS12 LTCC PMTs with a p-Terphenyl wavelength shifter1. SYLVESTER JOOSTEN, BRANDON ELMAN, KYLE JOHNSTON, ZEIN-EDDINE MEZIANI, NIKOLAOS SPARVERIS, MICHAEL PAOLONI, WHITNEY ARMSTRONG, EDWARD KACZANOWICZ, Temple Univ — An improved version of the CLAS Cherenkov detector tracker will be used as the Low-Threshold Cherenkov Counter (LTCC) for the CLAS12 spectrometer at JLAB. The original detector used 216 UV-glass PMTs, which have a poor quantum-efficiency (QE) below 300nm due to the UV-glass transparency. The application of a p-Terphenyl wavelength shifter to the face of these PMTs dramatically improves the QE for short wavelengths, rivaling that of a much more expensive quartz PMT. This translates into an improved detector performance for the LTCC, especially in the higher-energetic regimes in the CLAS12 spectrometer. We will discuss the coating process, as well as the performance testing taking place at Temple University.

1Work supported in part by the US Department of Energy

11:33AM R7.00005 Improved Detection of Cherenkov Radiation using Wavelength-Shifting Paints1. BARAK SCHMOOKLER, LONGWU OU, Massachusetts Institute of Technology — Photomultiplier Tubes (PMTs) are often used to detect Cherenkov radiation in accelerator-based physics experiments. Since the Cherenkov spectrum is inversely proportional to the square of the photon’s wavelength, PMTs with relatively good quantum efficiencies in the ultraviolet region can produce on average a higher number of photoelectrons. The application of certain paints, which absorb light at ultraviolet wavelengths and emit in the visible spectrum, to the surface of some PMTs allows for better sampling of the Cherenkov spectrum. The effects of various wavelength-shifting (WLS) paints designed by Eljen Technologies were tested on ET Enterprises, Model: 9390KB PMTs. Using a $^{106}\text{Ru} \beta$-source, Cherenkov light was produced in disks of fused silica. The charge spectrums of the PMTs were measured before and after application of the paint. The average number of photoelectrons produced from the Cherenkov radiation could be determined by knowing the value of the single-photoelectron peak and the mean of the charge spectrum. Four paints were tested, and the gain in the number photoelectrons produced varied from 10-35% for the different paints.

1Work Conducted at Thomas Jefferson National Accelerator Facility

11:45AM R7.00006 Online SVT Commissioning and Monitoring using a Service-Oriented Architecture Framework. JUSTIN RUGER, Christopher Newport University, YURI GOTRA, DENNIS VEGYAND, VERONIQUE ZIEGLER, Jefferson Lab, DAVID HEDDLE, DAVID GORE, Christopher Newport University — Silicon Vertex Tracker detectors are devices used in high energy experiments for precision imaging of charged tracks close to the collision point. Early detection of faulty hardware is essential and therefore code development of monitoring and commissioning software is essential. The computing framework for the CLAS12 experiment at Jefferson Lab is a service-oriented architecture (SOA) approach. High-quality measurements of this fundamental nuclear process can be compared with the theoretical predictions. Initial results will be presented.

11:57AM R7.00007 Measuring the Rate of Muon Capture on the Deuteron. LUIS IBANEZ, Boston University, MUSUN COLLABORATION — The goal of the MuSun experiment is to measure the rate of nuclear muon capture on the deuteron with a precision of 1.5%. This rate will be used to fix the low-energy constant that describes the two-nucleon weak axial current in effective field theory models. It will therefore be compared with the theoretical predictions. Initial results will be presented.

12:09PM R7.00008 Near-Threshold Measurement of $\gamma n \rightarrow p\pi^-$ at MAX-lab1. GRANT O’RIELEY, University of Massachusetts Dartmouth, PIONS@MAXLAB COLLABORATION — One of the outstanding questions in nuclear science is to be able to describe the dynamical properties of the nucleus using the framework provided by QCD. Pion photoproduction near threshold is one process where both experimental measurements and theoretical calculations can produce valid and useful results. Consequently, high-quality measurements of this fundamental nuclear process can be used to test the predictions of various theoretical approaches. These measurements also provide data to improve the SAID and MAID partial-wave analyses used in the interpretation of other measurements. The Photon Tagging Facility at MAX-lab in Lund, Sweden is uniquely suited to perform measurements of pion photoproduction at energies between threshold and the $\Delta$-resonance. The PIONS@MAXLAB Collaboration is performing a measurement of the $\gamma n \rightarrow p\pi^-$ channel very close to threshold. Using a $\text{LD}_2$ target and the reaction $\gamma d \rightarrow pp\pi^-$, the $\pi^-$ is captured on another deuteron creating a high-energy photon which was detected using three large NaI spectrometers. These new near-threshold data will be used to better evaluate the threshold $E^t_{\gamma}(\pi^-p)$ amplitude, which can be compared with the theoretical predictions. Initial results will be presented.

1This work supported by NSF OISE/IRES award 0553467.
A measurement of two-photon exchange in unpolarized elastic electron-proton scattering, MIKHAIL YUROV, Univ of Virginia, E05-017 Collaboration — Jefferson Lab experiment E05-017 was designed to study 2-photon exchange contributions to elastic electron-proton scattering over a wide kinematic range. By detecting the scattered proton instead of the electron these measurements will be very sensitive to the $\epsilon$ dependence of the cross section and consequently the ratio $\frac{G_E}{G_M}$. The goals of the experiment, the experimental technique and the kinematic range will be presented. The analysis sequence and results of the early steps will be outlined.

10:45AM R8.00001 IceCube Results for Diffuse Muon Neutrinos, CHRISTOPHER WEAVER, University of Wisconsin, Madison, ICECUBE COLLABORATION — Recent results from the IceCube Neutrino Observatory provide evidence for high energy astrophysical neutrinos in an analysis using events whose interactions occurred within the detector volume. In this talk I will show the results of a complimentary analysis using neutrino-induced muon events which enter the detector from outside, with a focus on the region of energies around 100 TeV where the hypothetical best-fit astrophysical flux corresponding to the contained event data begins to dominate over the conventional atmospheric muon neutrino flux.

10:57AM R8.00002 Search for diffuse extraterrestrial contained neutrino-induced cascades using IceCube 79- and 86-string configurations, MARIOLA LESIAK-BZDAK, JOANNA KIRYLUK, Stony Brook University, ICECUBE COLLABORATION — IceCube, a cubic kilometer detector at the South Pole, is the largest neutrino telescope currently taking data. Utilizing the transparent ice of Antarctica as a detection medium, IceCube digital optical sensors observe Cherenkov radiation from secondary particles produced in neutrino interactions inside or near the detector. Charged current $\nu_e$ interactions create muon tracks, while charged current $\nu_x$ interactions, and neutral current interactions of all flavors initiate electromagnetic and hadronic showers (cascades). The goal of this study is to search for extraterrestrial neutrino-induced cascades, contained within the detector volume, with energies in the tens of TeV to a few PeV neutrino energy range and characterize the diffuse neutrino flux measured in IceCube. The analysis uses 662 days of livetime of the data taken from May 2010 to May 2012 with 79- and 86-string IceCube configurations. The analysis method and results of the likelihood fits to the cascade energy spectra from the fully unblinded datasets will be presented.

11:11AM R8.00003 Searches for Point Sources of Astrophysical Neutrinos with the IceCube Neutrino Telescope, JACOB FEINTZEIG, University of Wisconsin-Madison, ICECUBE COLLABORATION — IceCube, a cubic kilometer cherenkov detector at the South Pole, has recently found evidence for a diffuse flux of astrophysical neutrinos in the TeV - PeV energy range. These neutrinos are likely produced in high-energy cosmic ray interactions near their acceleration sites. To elucidate the sources of these cosmic rays, we search for point-like emission of astrophysical neutrinos from specific cosmic ray acceleration sites. We looked for excesses in the measured event rate above the background expectation for all possible angular separations from a given direction, including data from the first year of the completed detector, which will be shown. We will also describe point source analyses using contained-vertex events. These analyses more effectively reduce the atmospheric muon background, lowering the energy threshold in the southern hemisphere to below ~ 100 TeV.

11:21AM R8.00004 Measurement of the cosmic ray energy spectrum with IceCube, BAKHTIYAR RUZBYAYEV, University of Delaware, ICECUBE COLLABORATION — We report on the measurement of the all-particle cosmic ray energy spectrum with IceCube. The presented spectrum is in the energy range from 1.58 PeV to 2.5 EeV using the 3 years of data from the IceTop air shower array, compared to the previously reported data from a single year. IceTop is the surface component of the IceCube Neutrino Observatory at the South Pole. The measured energy spectrum exhibits clear deviations from a single power law above the knee around 4 PeV and below 1 EeV.

11:33AM R8.00005 Muon-induced spallation backgrounds for MeV astrophysical neutrino signals in Super-Kamiokande, WEISHI LI, JOHN BEACOM, The Ohio State University — When muons travel through matter, their energy losses lead to nuclear breakup (“spallation”) processes. The subsequent decays of unstable daughter nuclei produced by cosmic-ray muons are important background to astrophysical neutrino signals. The Cherenkov light produced in charged current interactions of stable nuclei contains information on their mass. With the detector's current mass sensitivity, the remaining rate is much larger than the signal rates for energies 8 - 18 MeV. We show how muons induce showers in water, produce secondary particles, and how these secondaries produce isotopes. We outline how to implement more effective background rejection techniques using this information. This could lead to new physics results, as both solar and Diffuse Supernova Neutrino Background studies are background-limited, and reducing backgrounds by even a factor of a few could quickly lead to new discoveries.

11:45AM R8.00006 The Cherenkov Telescope Array, VALERIE CONNAUGHTON, University of Alabama in Huntsville, CTA CONSORTIUM COLLABORATION — The Cherenkov Telescope Array (CTA) is a large collaborative effort dedicated to the design and operation of the next-generation ground-based very high-energy gamma-ray observatory. CTA will improve by about one order of magnitude the sensitivity with respect to the current major arrays (VERITAS, H.E.S.S., and MAGIC) in the core energy range of 100 GeV to 10 TeV, and will extend the viability of the imaging atmospheric Cherenkov technique (IACT) down to tens of GeV and above 100 TeV. In order to achieve such improved performance at both a northern and southern CTA site, four 23m diameter Large Size Telescopes (LST) optimized for low energy gamma rays will be deployed close to the centre of the array. A larger number of Medium Size Telescopes (MST) will be optimized for the core IACT energy range. The southern site will include 25 12m single-mirror MSTs and a US contribution of up to 24 novel dual-mirror design Schwarzschild-Couder (SC) type MSTs with a primary mirror of 9.5m diameter, and will also include an array of Small Size Telescopes (SST) to observe the highest-energy gamma rays from galactic sources. The SSTs can be smaller and more widely separated because more energetic gamma rays produce a larger Cherenkov light pool with many photons. The SSTs achieve a large collection area by covering a wide (10 sq km) footprint on the ground. The CTA project is finishing its preparatory phase, and the pre-production phase will start this year. I will review the status and the expected performance of CTA as well as the main scientific goals for the observatory.

11:57AM R8.00007 HAWC Observations of Galactic TeV Gamma-Ray Sources, HAO ZHOU, Michigan Technological University, HAWC COLLABORATION — The High Altitude Water Cherenkov experiment, HAWC, is a ground based TeV gamma-ray observatory being built in Sierra Negra, Mexico at an altitude of 4100 meters above sea level. When complete it will be an array consisting of 300 water Cherenkov detectors, each equipped with four photomultiplier tubes that detect the Cherenkov light produced by the secondary particles of extensive air showers. One third of the array has been operating and collecting data since summer 2013 and the full array is expected to come online in fall 2014. I will present HAWC observations of known galactic gamma-ray objects, with a focus on pulsar wind nebulae, especially the pulsar wind nebula of the Geminga pulsar, which is the first pulsar that was discovered via gamma-ray observations.
12:09PM R8.00008 Excess of Diffuse Gamma-ray Emission from the Inner Galaxy: Bubbles, Jets, Dark Mater, MENG SU, Massachusetts Inst of Tech-MIT — I will first talk about recent progress on the study of Galactic diffuse gamma-ray emission, with the focus on the discovery of Fermi gamma-ray bubbles and multi-wavelength observations on this structure. I will further show evidence for collimated jet/coconoon structure in the inner Galaxy. Our numerical simulation demonstrates that the bubble structure could be evidence for past accretion events of the central supermassive black hole. I will then summarize the current state of dark matter search with Fermi Gamma-ray Space Telescope data, with the focus on gamma-ray line searching from the Galactic center, galaxy clusters, and dwarf galaxies. I will also discuss possible instrumental systematics of the Fermi-LAT instrument that might contaminate the line searching with a overview of the future prospective. Finally, we have recently proposed to change the survey strategy of Fermi to increase the exposure at Galactic center by more than a factor of 2 over 2014. This survey strategy has been initiated since December 2013.

12:21PM R8.00009 The Search for Annihilating Dark Matter with The High Altitude Water Cherenkov (HAWC) Observatory, J. PATRICK HARDING, Los Alamos National Laboratory, HIGH ALTITUDE WATER CHERENKOV (HAWC) COLLABORATION — The High Altitude Water Cherenkov (HAWC) observatory is a wide field-of-view detector sensitive to 100 GeV - 10 TeV gamma rays and cosmic rays. Located at an elevation of 4100 m on the Sierra Negra mountain in Mexico, HAWC observes extensive air showers from gamma and cosmic rays with an array of water tanks which produce Cherenkov light in the presence of air showers. With a wide field-of-view observing 2/3 of the sky each day and a sensitivity of 1 Crab/day, HAWC has the ability to probe many sources for the signals of TeV-mass dark matter. I will show some results from the portion of the HAWC detector already built, HAWC-111, as well as the predicted sensitivity to dark matter for the full detector.

Monday, April 7, 2014 10:45AM - 12:09PM — Session R9 Education - Practice and Research I

10:45AM R9.00001 A flaw in a textbook derivation of Faraday’s law, BERND BERG, Florida State University — It is found that the derivation of Faraday’s law in Jackson applies only to special situations, which leave, for instance, already out the important case of a loop rotating in a constant magnetic field. A derivation of the general case is given borrowing some arguments from Landau, Lifshitz and Pitaevskii.

10:57AM R9.00002 Periscope: Looking into learning in best-practices physics classrooms, RACHEL SCHERR, Seattle Pacific University — Periscope is a set of materials to support university instructors in observing, discussing, and reflecting on best practices in university instruction. Periscope is organized into short “video workshops,” each introducing a significant topic in the teaching and learning of physics, such as formative assessment or cooperative learning. The workshops are appropriate for university professors, two-year college faculty, graduate student teaching assistants, and undergraduate learning assistants. Key topics in teaching and learning are introduced through captioned video episodes of introductory physics students in the classroom, chosen to prompt collaborative discussion. Video episodes from exemplary sites (including the University of Maryland, University of Colorado – Boulder, Harvard University, and Florida International University) showcase a variety of research-tested instructional formats such as Peer Instruction and Tutorials in Introductory Physics. Discussion questions prompt participants who view the episode to reflect on their pedagogical beliefs, on their own practice, and on the results of physics education research. Periscope materials may be flexibly adapted for settings ranging from brief introductory sessions to all-day workshops or weekly meetings.

11:09AM R9.00003 Clickers don’t always help: Classroom context and goals can mitigate clicker effects on student learning1, AMY SHAPIRO, GRANT O’RIELLY, JUDITH SIMS-KNIGHT, University of Massachusetts Dartmouth — Clickers are commonly used in large-enrollment introductory courses in order to encourage attendance, increase student engagement and improve learning. We report the results from a highly controlled study of factual and conceptual clicker questions in calculus-based introductory physics courses, on students’ performance on the factual and conceptual exam questions they targeted. We found that clicker questions did not enhance student performance on either type of exam question. The use of factual clicker questions actually decreased student performance on conceptual exam questions, however. Directing students’ attention to surface features of the course content may distract them from the important underlying concepts. The conceptual clicker questions were likely ineffective because the practice students got on homework questions had a stronger effect than the single question posed in class. Interestingly, the same studies in general education biology and psychology courses show a strong, positive effect of clickers on student learning. This study suggest that the usefulness of clickers should be weighed in the context of other course activities and goals. Secondary analyses will explore the effect of students’ GPA, motivation and study strategies on the results.

11:21AM R9.00004 Teaching Vectors Through an Interactive Game Based Laboratory, JAMES O’BRIEN, GERGELY SIROKMAN, Wentworth Institute of Technology — In recent years, science and particularly physics education has been furthered by the use of project based interactive learning [1]. There is a tremendous amount of evidence [2] that use of these techniques in a college learning environment leads to a deeper appreciation and understanding of fundamental concepts. Since vectors are the basis for any advancement in physics and engineering courses the cornerstone of any physics regimen is a concrete and comprehensive introduction to vectors. Here, we introduce a new turn based vector game that we have developed to help supplement traditional vector learning practices, which allows students to be creative, work together as a team, and accomplish a goal through the understanding of basic vector concepts.

11:33AM R9.00005 Teaching Scientific Reasoning to Liberal Arts Students, LOUIS RUBBO, Coastal Carolina University — University courses in conceptual physics and astronomy typically serve as the terminal science experience for the liberal arts student. Within this population significant content knowledge gains can be achieved by utilizing research verified pedagogical methods. However, from the standpoint of the University, students are expected to complete these courses not necessarily for the content knowledge but instead for the development of scientific reasoning skills. Results from physics education studies indicate that unless scientific reasoning instruction is made explicit students do not progress in their reasoning abilities. How do we complement the successful content based pedagogical methods with instruction that explicitly focuses on the development of scientific reasoning skills? This talk will explore methodologies that actively engages the non-science students with the explicit intent of fostering their scientific reasoning abilities.
11:45 AM R9.00006 The Higgs bridge: a tutorial for students and teachers\textsuperscript{1} , ROLAND ALLEN, Texas A&M University, SUZY LIDSTROM, Physica Scripta, Royal Swedish Academy of Sciences, Stockholm — In this talk we summarize the very broad significance of the recent Higgs boson discovery and Higgs-Englert Nobel Prize (with further discussion in R. E. Allen, Physica Scripta 89, 018001(2014)). The particle recently discovered at the Large Hadron Collider near Geneva is almost certainly this long-sought completion of the Standard Model of particle physics. But this discovery, an achievement by more than six thousand scientists (including students), is actually much more than a mere capstone of the Standard Model. It instead represents a bridge from the Standard Model to exciting discoveries of the future, at higher energies or in other experiments, and to the properties of matter at very low temperatures. The mere existence of a particle with zero spin implies a need for new physics, with the most likely candidate being supersymmetry, which requires that every known particle has a superpartner yet to be discovered. And phenomena similar to the Higgs are seen in superconducting metals and superfluid gases at low temperatures, which extend down to a millionth or even a billionth of a degree Kelvin. So the discovery of a Higgs boson has a central place in our attempts both to achieve a true understanding of Nature and to harness Nature in practical applications.

\textsuperscript{1}Supported by Physica Scripta, Royal Swedish Academy of Sciences

11:57 AM R9.00007 Framing the Questions: the Freshman Approach to Special Relativity\textsuperscript{1} , ELAINE TENNANT, Blinn College, HAMILTON CARTER, Texas A&M University — Two inertial frames move at relativistic speeds with respect to one another. What does an observer in one of the frames see? This is often times the only question students answer in their freshman physics course. Could a more fundamental understanding of special relativity be instilled if a larger variety of insightful questions were asked? Examples of questions from a question pool designed to expose students to the many different aspects of special relativity during the freshman course will be presented along with anecdotal experiences related to our first deployment of the pool.

\textsuperscript{1}Supported by Physica Scripta, Royal Swedish Academy of Sciences

Monday, April 7, 2014 10:45AM - 12:33PM

10:45 AM R10.00001 Office of Science Accelerator R&D Programs , L.K. LEN, U.S. Department of Energy, Office of Science — The Office of Science within the Department of Energy supports accelerator R&D to develop technologies needed for building next generation particle accelerators for discovery science facilities. The near-to-midterm, facility-driven R&D is supported by each of the respective program offices, namely, BES, NP and HEP. In addition, HEP also supports directed accelerator R&D under the LHC Accelerator Research Program and the Muon Accelerator Program, as well as the long-range exploratory research aimed at developing new accelerator concepts, understanding the science underlying the technologies used in particle accelerators, and the fundamental physics of charged particle beams. This paper describes the research activities that are currently of interest to and supported by these programs.

In collaboration with Glen Crawford, Manouchehr Farkhondeh, and Eliane Lessner, US Department of Energy.

11:21 AM R10.00002 DOE Office of Science Accelerator Stewardship Program\textsuperscript{1} , MICHAEL ZISMAN, U.S. Department of Energy — Since the Accelerators for America's Future (AfAF) Symposium in 2009, the Office of High Energy Physics, U.S. Dept. of Energy (DOE-HEP), has worked toward broadening its accelerator R&D activities beyond supporting only discovery science to include medicine, energy and environment, defense and security, and industry. Accelerators play a key role in many aspects of everyday life, and improving their capabilities will enhance U.S. economic competitiveness and the scientific research that drives it. In 2011, a community task force was initiated by DOE-HEP to develop more fully the information from the original AfAF Symposium. Subsequently, a DOE-HEP concept (coordinated with the other cognizant Office of Science program offices) was developed for long-term accelerator R&D stewardship. Here, we describe the evolution of the stewardship task starting from its origins in the ongoing DOE-HEP accelerator R&D program, the mission of the new program, the broad criteria for participation, and initial steps being taken to implement it. Several initiatives are currently being considered to launch the program, and these will be indicated. Involvement of the accelerator community in developing ideas for future stewardship activities will be crucial to the ultimate success of the program.

In collaboration with Eric Colby, Manouchehr Farkhondeh, and Eliane Lessner, US Department of Energy.

\textsuperscript{1}Supported by U.S. Dept. of Energy, Office of Science.

11:57 AM R10.00003 Office of Science Detector R&D Programs\textsuperscript{1} , H. MARISISKE, U.S. Department of Energy, Office of Science — Innovation in instrumentation is central to any discovery science. Scientific progress in many fields has been achieved largely through technological advances in instrumentation. The technologies developed for accelerators and detectors, often driven by the needs of high energy physics, have frequently benefited other fields of the physical and applied sciences, medicine, security, and industry. In turn, detector development is increasingly informed by advances in the understanding of the underlying science coming from fields like material science, photonics, and nanotechnology. Technology research and development (R&D) needs to take place across a spectrum of time scales and levels of risk, i.e., from focused short-term low-risk R&D that provides incremental improvements to existing technologies to generic long-term high-risk R&D that result in transformative advances that are broadly applicable. This presentation describes the current detector R&D programs within the Offices of High Energy Physics, Nuclear Physics, and Basic Energy Sciences; notable technological achievements in these fields as well as applications outside; and efforts needed to continue progress into the future.


\textsuperscript{1}Supported by U.S. Department of Energy, Office of Science.
10:45AM R11.00001 Primordial deuterium at the per cent level1, Ryan Cooke, University of California at Santa Cruz — We are currently in an exciting era of precision cosmology. With the release of the cosmic microwave background data recorded by the Planck satellite, we are now in a position to accurately test the standard model of cosmology and particle physics. In this talk, I will present new, precise measures of the primordial abundance of deuterium—the most accurate measurements to date—derived from redshift ~ 3 near-pristine damped Lyman-alpha systems. In light of these new measurements, we have performed a careful reanalysis of the best literature systems where the primordial deuterium abundance can be estimated. These precise measures, when analyzed in conjunction with the Planck data, now place strong limits on the effective number of neutrino species in the early Universe, and offers new insight into physics beyond the standard model. I will also discuss the future prospects of this technique and our ongoing survey to obtain new precision measures of the primordial deuterium abundance.

1Partially supported by NSF grant AST-1109447

11:21AM R11.00002 A Bitter Pill: The Cosmic Lithium Problem1, Brian Fields, University of Illinois — Primordial nucleosynthesis describes the production of the lightest nuclides in the first three minutes of cosmic time. We will discuss the transformative influence of the WMAP and Planck determinations of the cosmic baryon density. Coupled with nucleosynthesis theory, these measurements make tight predictions for the primordial light element abundances: deuterium observations agree spectacularly with these predictions, helium observations are in good agreement, but lithium observations (in ancient halo stars) are significantly discrepant—this is the “lithium problem.” Over the past decade, the lithium discrepancy has become more severe, and very recently the solution space has shrunk. A solution due to new nuclear resonances has now been essentially ruled out experimentally. Stellar evolution solutions remain viable but must be finely tuned. Observational systematics are now being probed by qualitatively new methods of lithium observation. Finally, new physics solutions are now strongly constrained by the combination of the precision baryon determination by Planck, and the need to match the D/H abundances now measured to unprecedented precision at high redshift.

1Supported in part by NSF grant PHY-1214082

11:57AM R11.00003 Quark mass variations of nuclear forces, BBN, and all that1, Ulfg Meissner, University of Bonn and Forschungszentrum Juelich — In this talk, I discuss the modifications of the nuclear forces due to variations of the light quark masses and of the fine structure constant. This is based on the chiral nuclear effective field theory, that successfully describes a large body of data. The generation of the light elements in the Big Bang Nucleosynthesis provides important constraints on these modifications. In addition, I discuss the role of the anthropic principle in the triple-alpha process that underlies carbon and oxygen generation in hot stars. It appears that a fine-tuning of the quark masses and the fine structure constant within 2 to 3 per cent is required to make life on Earth viable.

1Supported in part by DFG, HGF and the BMBF

Monday, April 7, 2014 10:45AM - 12:33PM
Session R12 DPF: Axion and Dark Matter II 100 - Mike Tuts, Columbia University

10:45AM R12.00001 Results of a Microwave Cavity Search for Dark Matter Axion-Like-Particles, A.T. Malagon, O.K. Baker, J.L. Hirshfield, Y. Jiang, Yale, G. Kazakevitch, Moons Inc, S. Kazakov, M.A. Lapointe, A.J. Martin, S. Shchelkunov, P.L. Slocum, A.E. Szymkowiak, Yale — There is a strong physics case for new particles with very weak couplings and sub-eV mass, such as axions, axion-like particles (ALPs), and hidden photons. These particles arise naturally in many beyond the Standard Model theories, and as well, have the correct properties to form part or all of the cold dark matter. The Yale Microwave Cavity Experiment (YMCE) uses a microwave cavity in a strong magnetic field to search for these new particles to photons, if they form part of the galactic dark matter. YMCE has conducted axion-like-particle searches in the mass range 140.2 - 142.7 µeV (33.9-34.5 GHz). In this talk, we present preliminary results from this search.

1Prajwal Mohanmurthy*, Dipankar Dutta, Nicholas Fowler, Mikhail Gaerlan, Kris Madsen, Adam Powers, Amy Ray, David Reed, Robertsen Riehle, Mitra Shabestari, Zachary Windham, Zach Short

10:57AM R12.00002 Mississippi State Axion Search, John Madsen, Mississippi State Univ. MISSISSIPPI STATE AXION SEARCH (MASS) COLLABORATION1 — The Mississippi State Axion Search (MASS) is an attempt to improve the limit on the mass coupling parameter of the Axion. The design features a sealed cavity partitioned by a lead wall into which RF power is transmitted. Another antenna on the far end of the cavity serves as the detector. The signal acquired by this antenna is fed through an integrator and a series of pre-amps and lock-ins before reaching the data acquisition system. The data acquisition system, written in the LabView front end DASYLab, operates at 1kHz in synchronicity with a TTL pulse that resets the integrator. The value recorded by the DAQ is, therefore, the maximum voltage of integration in the millisecond period. The Axion signal would appear in the data as a voltage excess. Several measures have been implemented with more being developed to ensure the validity of detections. Large excesses are cut by an electronics system, and smaller anomalies will be excised in the data analysis. Results will also compared to a complete Monte Carlo simulation currently in development.

1Supported in part by NSF grant PHY-1109447

10:09AM R12.00003 Progress on the Axion Dark Matter eXperiment - High Frequency (ADMX-HF)1, Karl Van Bibber, University of California Berkeley — The Axion Dark Matter eXperiment - High Frequency (ADMX-HF) is a microwave cavity experiment at Yale specifically designed to be both a pathfinder for first data in the 4-10 GHz (20-100 microelectronvolt) range, and an innovation test-bed for new concepts with promise to dramatically increase the sensitivity, mass range and scanning rate, with the aim to migrate technology developments to ADMX. Built around a 9T superconducting magnet (16.5 cm I.D. x 40 cm long) and dilution refrigerator, ADMX-HF will utilize Josephson Parametric Amplifiers (JPA) from the outset, and is projected to achieve sensitivity within the axion model band, despite its small volume. It will explore concepts such as hybrid superconducting cavities to improve the cavity Q by an order of magnitude, and operation in squeezed-state mode to reduce the amplifier noise temperature below the quantum limit. The experiment, a collaboration of Yale, UC Berkeley, JILA/Colorado and LLNL is in final stages of integration and nearing commissioning phase.

1Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE- AC52-07NA27344, DE-AC03-76SF00098, NSF grants PHY-1067242 and PHY-1306729, and the Livermore LDRD program.
11:21AM R12.00004 ADMX High-Frequency Microwave Cavity Development1, I. STERN, Univ of Florida - Gainesville, ADMX COLLABORATION, ADMX-HF COLLABORATION — The Axion Dark Matter eXperiment (ADMX), a direct-detection axion search, has just begun taking data with a redesigned system. Earlier phases conducted axion searches in the mass range of 1.9 – 3.5 &mu;eV (460 – 850 MHz) setting upper limits below the theoretical KSVZ coupling strength of the axion to two photons. The current upgrades will allow ADMX to detect axions with even the most pessimistic couplings in this frequency range and in the GHz regime. In order to expand its mass reach, ADMX is developing next-generation microwave cavities that will enable the search for axions with masses up to 12 &mu;eV (3 GHz) at the more weakly interacting DFSZ coupling value. Testing and analysis has been performed on photonic band-gaps, regulating multi-vanes, segmented resonators, and slow wave cavities. Results of recent testing and future development plans will be presented.

1Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF Grant 1067242, and the Livermore LDRD program.

11:33AM R12.00005 Progress towards a Hybrid Superconducting Microwave Cavity for ADMX1, GIANNPAOLO CAROSI, Lawrence Livermore National Laboratory, ADMX COLLABORATION, ADMX-HF COLLABORATION — Axions are a well motivated dark matter candidate and can be detected by their resonant conversion into photons using a microwave resonant cavity in an axial magnetic field. This is the basis of both the ADMX and ADMX-HF experiments. The axion-photon conversion power is directly related to the quality factor (Q = resonant frequency over bandwidth) of the microwave cavity used. To date copper cavities have been used with Q ~ 109 at frequencies of 1 GHz. As one scales to higher frequencies this Q degrades substantially. Superconducting cavities can regularly be made with Q > 1012 but would be driven normal in the high magnetic field of ADMX. Here we describe progress of R&D efforts to make hybrid cavities with regular copper endcaps and a thin-film superconducting barrel that can maintain its superconducting properties in the presence of a strong axial magnetic field. This hybrid cavity system has a potential Q great than copper by an order of magnitude (or more) thus greatly increasing the sensitivity of the system to axions.

1Supported by DOE Grants DE-FG02-97ER41029, DE-FG02-96ER40956, DE-AC52-07NA27344, DE-AC03-76SF00098, NSF grants PHY-1067242 and PHY-1306729, and the Livermore LDRD program.

11:45AM R12.00006 Status of the MiniCLEAN Dark Matter Experiment, THOMAS CALDWELL, University of Pennsylvania — The MiniCLEAN dark matter experiment is an ultra-low background single phase liquid argon and neon detector with a fiducial mass of 150 kg. The ability to exchange targets, the background rejection offered by noble liquids, and the scalability of the single phase approach allow MiniCLEAN to demonstrate the technologies required for the construction and operation of next generation multi-ton WIMP dark matter and precision low-energy solar neutrino experiments. MiniCLEAN utilizes a modular design with cold photomultiplier tubes in a spherical geometry to maximize light yield which allows highly efficient rejection of nuclear recoils from electronic recoil backgrounds using pulse shape discrimination (PSD) techniques. To demonstrate the effective reach of single phase PSD, MiniCLEAN will be spiked with additional 39Ar. MiniCLEAN’s inner detector has recently completed construction underground at SNOLAB, and the detector is being commissioned for operation at room temperature under vacuum and with purified argon gas. An update on the inner detector commissioning and construction of the infrastructure to operate the detector in the liquid phase will be given.

11:57AM R12.00007 Mini-LENS: developing a charged-current approach to measuring CNO and pp solar neutrinos1, R. BRUCE VOGELAAR, Virginia Tech, LENS COLLABORATION — The Low-Energy Neutrino Spectroscopy (LENS) experiment is based on neutrino detection via a charged-current interaction with In. In and offers the ability to cleanly observe both pp and CNO neutrinos. In contrast, elastic-scattering detectors, such as Borexino and SNO+ suffer from virtually inseparable backgrounds. Thus, LENS might be uniquely positioned to resolve the solar metallicity question via measurement of the CNO neutrino flux, as well as test the predicted equivalence of solar luminosity as measured by photons versus neutrinos. The mini-LENS program is testing the performance of the optically-segmented 3D lattice geometry unique to LENS. This first-of-a-kind lattice design is also suited for a range of other applications where high segmentation and large light collection are required (eg: sterile neutrinos with sources, double beta decay, and surface detection of reactor neutrinos). The current status and recent design changes of miniLENS at KURF will be presented.

1funded by NSF: 1001394

12:09PM R12.00008 A search for WIMPs and tests of local dark matter velocity distributions with the CoGeNT public dataset, MATTHEW BELLIS, Siena College, CHRIS KELSO, University of Utah, JUAN COLLAR, NICOLE FIELDS, University of Chicago — Since December 2009, the CoGeNT experiment has recorded interactions in the detector with the goal of either detecting dark matter or setting stringent limits on the mass and cross-section of these particles, assuming that dark matter is a form of WIMP (Weakly Interacting Massive Particle). The collaboration has made public this dataset to the broader community and this analysis is based on that dataset. We perform an unbinned, maximum likelihood fit to the data, accounting for known backgrounds and systematic effects. We model the WIMP signal, parametrized by energy deposition and time of year, mass, cross-section, and choice of local WIMP velocity distribution. The velocity distribution is modeled with a Maxwellian-Boltzman distribution, as well as more directional streams. The current status of this analysis will be presented.

12:21PM R12.00009 The DRIFT Directional Dark Matter Experiments, JOHN HARTON, Colorado State University, DRIFT COLLABORATION — The DRIFT dark matter collaboration aims to detect the sidereal modulation of the dark matter signal through measurement of spatial components of the recoil nuclei, and the recoiling nuclei, from a standard WIMP halo, would typically leave a millimeter-scale ionization track in the chamber. The rotation of the Earth on its axis combined with the motion of the solar system through the WIMP halo creates the sidereal modulation. This sidereal (“daily”) modulation is the change in average direction of the recoils over the course of the sidereal day, which for the DRIFT detector, located in England, changes from generally down to south once a (sidereal) day. Recent advances in background rejection are allowing DRIFT-IId to run background free. And measurement of the interaction location along the ion drift direction has recently been enabled by adding a small amount of oxygen to the drift gas. This talk will report on these recent advances and show current limits, as well as describe plans for future DRIFT detectors.

1Supported by the US Department of Energy and the National Science Foundation.
10:45 AM R13.00001 Search for ttbar resonances in semileptonic final states in pp collisions at $\sqrt{s} = 8$ TeV, IRVING SANDOVAL GONZALEZ, Univ of Illinois - Chicago, THE CMS COLLABORATION — We present a search for the production of heavy resonances decaying into top-antitop quark pairs at the CMS Experiment. The data correspond to an integrated luminosity of 19.6 fb$^{-1}$ at $\sqrt{s} = 8$ TeV. We consider all events containing one muon or electron and at least two jets in the final state. We present results from the combination of two dedicated searches, the first optimized for $t\bar{t}$ production at the kinematic production threshold, and the other optimized for $t\bar{t}$ production produced with high Lorentz boosts. We do not observe any excess of events above the expected yield from the standard model processes. We set the following limits at 95% CL on the production of non-SM particles: topcolor $Z'$ bosons with relative widths of 12.2% and 10% are excluded for masses below 2.1 TeV and 2.7 TeV. An upper limit of 1.94 pb and 0.029 pb is set on the production cross section times branching fraction for narrow resonances with masses of 0.5 TeV and 2 TeV. Likewise, limits of 3.71 pb and 0.045 pb are set for wide resonances with masses of 0.5 TeV and 2 TeV. In addition, Kaluza-Klein excitations of a gluon with masses below 2.5 TeV in the Randall-Sundrum model are excluded and an upper limit of 0.101 pb is set for a resonance mass of 2 TeV.

1 On behalf of The CMS collaboration.

10:57 AM R13.00002 Studying Same Sign $W^{\pm}W^{\mp}$ Production at the LHC, ALEXANDER SOOD, University of California - Berkeley, ATLAS COLLABORATION — The production of a pair of W bosons with the same electric charge is a process which has not been observed at the LHC. One of its dominant production mechanisms is through the vector boson scattering (VBS), whose unitarization relies on the electroweak symmetry breaking mechanism and makes VBS of great interest to study. This talk, together with the talk by Lulu Liu, will present a measurement of the inclusive same sign $W^{\pm}W^{\mp}$ cross section, as well as a further study of the production through VBS with the requirement that the two leading $p_T$ jets are separated by at least 2.4 in rapidity ($\Delta y$). Limits are set on the anomalous quartic gauge couplings (aQGC). The analysis is performed using 20 fb$^{-1}$ of data collected by the ATLAS detector at $\sqrt{s} = 8$ TeV. This talk will focus on the background estimations.

11:09 AM R13.00003 Same Sign $W^{\pm}W^{\mp}$ Production and Limits on Anomalous Quartic Gauge Couplings, LULU LIU, University of Michigan, ATLAS COLLABORATION — The production of a pair of W bosons with the same electric charge is a process which has not been observed at the LHC. One of its dominant production mechanisms is through the vector boson scattering (VBS), whose unitarization relies on the electroweak symmetry breaking mechanism and makes VBS of great interest to study. This talk, together with the talk by Alex Sood, will present a measurement of the inclusive same sign $W^{\pm}W^{\mp}$ cross section, as well as a further study of the production through VBS with the requirement that the two leading $p_T$ jets are separated by at least 2.4 in rapidity ($\Delta y$). Limits are set on the anomalous quartic gauge couplings (aQGC). The analysis is performed using 20 fb$^{-1}$ of data collected by the ATLAS detector at $\sqrt{s} = 8$ TeV. This talk will focus on the extraction of the cross section and the limits on aQGC.

11:21 AM R13.00004 $W'$ signatures with odd Higgs particles, ANDREA PETERSON, Univ of Wisconsin, Madison, BOGDAN DOBRESCU, Fermilab — We point out that $W'$ bosons may decay predominantly into Higgs particles associated with their broken gauge symmetry. We demonstrate this in a renormalizable model where the $W'$ and $W$ couplings to fermions differ only by an overall normalization. This “meta-sequential” $W'$ boson decays into a Higgs particle associated with its broken gauge symmetry.

11:33 AM R13.00005 A 2-D Sensitivity Study in Searching for a High Mass $Z'$ Boson at $\sqrt{s} = 8$ TeV with the Dielectron Channel Using the ATLAS Detector, AARON VERMEERSCH, Michigan State University — A possible signature of physics beyond the Standard Model could be the observation of an additional neutral, heavy boson such as the $Z'$. The signal would present itself in the invariant mass spectrum through its decay to dilepton pairs as a resonance on an otherwise irreducible falling background from the Drell-Yan process. Currently at ATLAS, the search for this resonance relies on the invariant mass as the discriminating variable. However, this neglects the potential increase in sensitivity due to the expected angular distributions which stem from the new physics. A sensitivity study was conducted that shows the expected mass limits for two different search scenarios in the high mass region, one using the invariant mass of the dielectron pair and another that is dependent on angular variables, for multiple benchmark $Z'$ models.

11:45 AM R13.00006 Search for $W' \rightarrow tb$ in the hadronic final state in proton-proton collisions at 8 TeV with the ATLAS detector, HO LING LI, The University of Chicago, ATLAS COLLABORATION — We present a model-independent search for a $W'$ boson in the $W' \rightarrow tb \rightarrow q\bar{q}bb$ final state using 20.3 fb$^{-1}$ of 8 TeV data collected by the ATLAS detector from the Large Hadron Collider (LHC) in 2012. This analysis searches for both left- and right-handed chiral $W'$ bosons in the mass range of 1.5 to 3.5 TeV. Reconstructing the hadronically decaying top-quark is done using jet substructure tagging techniques. Limits are set on the ratios of coupling strength $g'$ to the Sequential Standard Model coupling $g_{SM}$.

11:57 AM R13.00007 Search for $Z'$ resonances decaying to top-antitop in dilepton+jets final states in pp collisions at 8 TeV center of mass energy, JIMIN GEORGE, IA IASHIVILI, SUPRIYA JAIN, SUNY-Buffalo, CMS COLLABORATION — We present a model-independent search for heavy resonances decaying to top-antitop pairs using 19.7 fb of data recorded by the CMS detector in pp collisions at 8 TeV center of mass energy. The search is based on events containing two leptons (electron or muon) and at least two jets. No deviation is observed over the expected rate from the standard model processes. We, therefore, set 95% confidence-level upper limits on the production cross section for the heavy resonances decaying to top-antitop in the mass range of 1-3 TeV. Upper mass limits are set for the narrow and wide leptophobic top color $Z'$, as well as for the Kaluza-Klein excitation of a gluon as predicted in theories beyond the standard model.

12:09 PM R13.00008 A Search for $Z' \rightarrow \tau\tau$ using $\sqrt{s} = 8$ TeV pp Collisions at ATLAS, ANDREW LEISTER, Yale University, ATLAS COLLABORATION — Several Standard Model extensions motivated by Grand Unification predict the existence of one or more additional heavy gauge bosons ($Z'$). The $Z' \rightarrow \tau\tau$ analysis at ATLAS uses $\sqrt{s} = 8$ TeV pp collisions from the Large Hadron Collider to search for such $Z'$ bosons, particularly from models that predict enhanced coupling to third generation particles. The $Z'$ signal in the search is derived from the Sequential Standard Model. In each di tau decay channel a search for an excess over the Standard Model background in high-mass di tau events is performed. In cases where observed events are consistent with the Standard Model background, upper limits are set on the production of high mass resonances. In the most recent public result from the fully hadronic decay channel, heavy mass resonances below 1.9 TeV are excluded at a 95% confidence level. This result is expected to improve with the inclusion of the other channels.

1 Presenting on behalf of the ATLAS collaboration.
The n-3He experiment aims to measure the hadronic weak interaction in the reaction $\vec{n} + ^3He \rightarrow \vec{H} + p$. The correlation between the spin of the incident neutron and the momentum direction of the produced proton violates parity and is a clear signature of the weak force in a reaction that is dominated by the strong interaction. n-3He will take place in the Fundamental Neutron Physics Beamline at the Spallation Neutron Source at Oak Ridge National Laboratory upon the completion of the NPDGamma experiment in summer 2014. The objective is to measure the asymmetry to a precision of $10^{-8}$. An overview of the experiment will be given, along with the physics goals, description of the subsystems, and schedule for installation and commissioning.

10:57AM R14.00002 Testing Lorentz invariance using rotating cryogenic sapphire oscillators

STEPHEN PARKER, The University of Western Australia, MORITZ NAGEL, EVGENY KOVALCHUK, Humboldt University of Berlin, PAUL STANWIX, EUGENE IVANOV, JOHN HARTNETT, The University of Western Australia, ACHIM PETERS, Humboldt University of Berlin, MICHAEL TOBAR, The University of Western Australia — A cryogenic sapphire oscillator exploits the remarkable properties of sapphire dielectric at low temperatures to generate a microwave frequency signal with a fractional frequency stability of parts in $10^{-16}$ for integration times on the order of hundreds of seconds. We describe an experimental test of Lorentz invariance in electrodynamics that searches for orientation dependent deviations in the speed of light by comparing the frequencies of two actively rotated orthogonally aligned cryogenic sapphire oscillators. Data has been collected for over one year allowing us to set the most stringent laboratory bound on the speed of light and constrain multiple Lorentz violating parameters of a Standard Model extension framework.

1Partially supported by Australian Research Council grant DP130100205

11:09AM R14.00003 Test of Relativistic Kinetic Energy Equation

BHARAT CHAUDHARY, No Company Provided — Kinetic energy of a body equals the work done on it by a force, constant or variable. Force is the time rate of change of momentum. Momentum is mass times velocity. According to special relativity mass and velocity both are variables. Therefore, the differentiation of their product (momentum) has two terms, both are variables. One term is the product of mass and acceleration. The other is of velocity and the rate of change of mass. They together equal the applied force. Since the force equals the sum of two terms, it also becomes a variable even if it was a constant earlier. Therefore it is a flaw. There are two more flaws in the force equation. They are found by putting the force equal to zero. When this is done, the acceleration doesn’t become zero. This is physically incompatible and is therefore a flaw. The other flaw in the equation is found by integrating the right side terms and evaluating the constant of integration from the initial conditions. Then we get a term containing a logarithm of zero that is undefined, therefore the expression so obtained is meaningless. Since it comes from the relativistic definition of force, therefore we conclude that this definition is wrong. Thus we find that there are three flaws in the relativistic definition of force. They all make the relativistic equation of force wrong.

11:21AM R14.00004 ABSTRACT WITHDRAWN —

11:33AM R14.00005 Stokes’ theorem, gauge symmetry and the time-dependent Aharonov-Bohm effect

JAMES MACDOUGALL, DOUGLAS SINGLETON, California State University, Fresno — Stokes’ theorem is investigated in the context of the time-dependent Aharonov-Bohm effect — the two-slit quantum interference experiment with a time varying solenoid between the slits. The time varying solenoid produces an electric field which leads to an additional phase shift which is found to exactly cancel the time-dependent part of the usual magnetic Aharonov-Bohm phase shift. This electric field arises from a combination of a non-single valued scalar potential and/or a 3-vector potential. The gauge transformation which leads to the scalar and 3-vector potentials for the electric field is non-single valued. This feature is connected with the non-simply connected topology of the Aharonov-Bohm set-up. The non-single valued nature of the gauge transformation function has interesting consequences for the 4-dimensional Stokes’ theorem for the time-dependent Aharonov-Bohm effect. An experimental test of these conclusions is proposed.

11:45AM R14.00006 New precision tests of the Pauli Exclusion Principle for Electrons in the underground laboratory at Gran Sasso

JOHANN MARTON, Stefan Meyer Institute, VIP2 COLLABORATION — One of the fundamental rules of quantum physics is represented by the Pauli Exclusion Principle (PEP). It is evident that this principle is extremely well fulfilled due to many observations. In the past many experiments were performed to search for tiny violations of PEP. The experiment VIP at the Gran Sasso underground laboratory (LNGS) is searching for possible small violations of the PEP for electrons leading to forbidden x-ray transitions in copper atoms. The experimental method, results obtained so far and new developments of a succeeding improved experiment VIP2 at Gran Sasso to further increase the sensitivity by 2 orders of magnitude will be presented.

1Partly supported by FWF project P25529.

11:57AM R14.00007 A New Foundation of Quantum Mechanics

SPYROS EFTHIMIADES, Fordham University — In traditional quantum mechanics the particle wavefunction is considered as a single entity obtained from postulated equations, e.g., from the postulated Schrodinger equation. We set the foundation of the quantum theory on a more fundamental level by determining the physical origin of the wavefunction. Analyzing particle interactions we realize that particles have multiple virtual motions, and that each motion is accompanied by a wave that has constant amplitude. The wavefunction is the superposition of the virtual waves of the particle. As a result, physical quantities are represented by justified expressions, and we derive the Schrodinger, Dirac, etc. equations as the conditions the wavefunction must satisfy at each point in order to fulfill the corresponding total energy equation. In our approach, quantum mechanics is a physically justifiable and clearly founded theory that can also be introduced in simple conceptual terms.
Localization of chiral symmetry breaking in dense QED. Paul Springsteen, University of Texas at El Paso, Efrain Ferrer, Vivian Incera, University of Texas at El Paso Department of Physics, Angel Sanchez, National Autonomous University of Mexico Department of Physics — We investigate the phenomena of magnetic catalysis of chiral symmetry breaking in dense QED. We first calculate the photon polarization operator at finite density in the strong-field limit and use it to find the Debye mass and the electrical susceptibility. The chiral condensate is then calculated beyond ladder approximation, and the critical density for condensate evaporation is found.

12:21 PM 14.00009 Precision Determination of the Newtonian Gravitational Constant G in HUST Group, Jun Luo, Huazhong University of Science and Technology — The Newtonian gravitational constant G holds an important place in physics. Though there have been about 300 published measurement values of G since the first laboratory measurement done by Cavendish over 200 years ago, its measurement precision is among the worst of all the fundamental physics constants. Up to now, even for the seven most precise values of G with their assigned uncertainties within 50 ppm, they are only consistent with each other in the range of about 500 ppm. It seems clear that further investigation and depression of more possible systematic errors are needed greatly for improving the accuracy of the G measurement. In order to find the unknown potential errors in different methods, the time-of-swing method and the angular-acceleration-feedback method are both used to determine the G value in our cave laboratory. In this talk, we will present some updated progress about the G measurement by means of these two different methods.

Session R15 Numerical Relativity with Matter: Methods and Simulations II

10:45 AM 15.00001 Magnetized Neutron Stars With Realistic Equations of State and Neutrino Cooling1. Steven Liebling, Long Island University, David Neilson, Brigham Young University, Matthew Anderson, Indiana University, Luis Lehner, Perimeter Institute, Carlos Palenzuela, CITA — We incorporate realistic, tabulated equations of state into fully relativistic simulations of magnetized neutron stars along with a neutrino leakage scheme which accounts for cooling via neutrino emission. Both these improvements utilize open-source code (GRID) and tables from http://stellarcollapse.org. Our implementation makes use of a novel method for the calculation of the optical depth which simplifies its use with distributed adaptive mesh refinement, such as we have. We present various tests and preliminary results both from single stars and from binary mergers with and without initial magnetization.

1NASA Astrophysics Theory Program grant NNX13AH01G; NSF Grants PHY-0969827 and PHY-1308621.

10:57 AM 15.00002 Electromagnetic Counterparts from Tilted Magnetized Binary Neutron-Stars Mergers1. Marcelo Ponce, Department of Physics, University of Guelph, Carlos Palenzuela, Canadian Institute for Theoretical Astrophysics, Patrick M. Motl, Department of Science, Indiana University Kokomo, Matthew Anderson, Pervasive Technology Institute, Indiana University, Eric W. Hirschmann, Department of Physics and Astronomy, Brigham Young University, Luis Lehner, Perimeter Institute for Theoretical Physics, Steven L. Liebling, Department of Physics, Long Island University, David Neilson, Department of Physics and Astronomy, Brigham Young University — Recent studies have demonstrated that the interaction of magnetospheres in binary neutron star systems can radiate strongly electromagnetically [1,2]. We study here a broader set of configurations accounting for tilted/misaligned dipoles in coalescing binaries and analyze the resulting Poynting flux and its correlation to the dynamics. In particular, the misalignment of the dipoles results in a very dynamic system with magnetic reconnections, shear layers, and current sheets. The electromagnetic radiation displays a distinctive pulsating behaviour tied to the orbital dynamics and stellar dipole orientations and the overall power of this radiation.


1This work was supported by the NSF grants PHY-0969827 (LIU), PHY-0969811 (BYU), NASA’s ATP grant NNX13AH01G, and NSERC through a Discovery Grant.

11:09 AM 15.00003 Beyond 2nd order in the simulations of binary neutron stars in general relativity, David Radice, Caltech, Luciano Rezzolla, Institut fuer Theoretische Physik, Frankfurt, Filippo Galeazzi, Max Planck Institute for Gravitational Physics — The inspiral and merger of binary neutron stars (DNSs) is one of the most promising sources of gravitational waves (GWs) for future ground-based laser detectors such as LIGO, Virgo or KAGRA. GWs carry valuable information concerning the binary parameters as well as the equation of state of neutron stars. Extracting such information, however, requires the use of accurate models of GWs that can only be constructed using numerical-relativity simulations. Even though several high-quality DNSs waveforms have been computed in the past few years, substantial difficulties need to be addressed to be able to cover the parameter space of DNSs and produce reliable GWs templates. In this talk I present some recent progress in the modeling of DNSs in numerical relativity. In particular I will show how, with the use of higher-order numerical schemes, we were able to obtain GWs signals showing, for the first time, higher-than-second-order accuracy in the phase and amplitude evolution. Our results are also in excellent agreement with the predictions of post-Newtonian theory almost up to the contact frequency of the binary.

11:21 AM 15.00004 Magnetar Formation from the Merger of Binary Neutron Stars, Bruno Giacomazzo, University of Trento — I will describe the results of recent fully general relativistic magnetohydrodynamic (GRMHD) simulations of binary neutron star (BNS) mergers performed with the Whisky code. I will describe in particular the role of magnetic fields in the post-merger dynamics, their impact on gravitational waves (GWs), and the possible formation of magnetars. The formation of a rapidly spinning magnetar after the merger could in particular generate electromagnetic signals that, if measured together with GWs emitted during the inspiral, could help to constrain the equation of state of NSs. Moreover BNSs are also thought to be behind the central engine of short gamma-ray bursts (SGRBs) and the formation of a magnetar could explain some of the observed SGRBs. While global GRMHD simulations of BNS mergers are currently unable to produce strong magnetic field amplifications during merger, local high-resolution simulations showed that small-scale turbulence can play a very important role in amplifying the magnetic fields. I will show how such small-scale dynamics can be included in global GRMHD BNS simulations via the implementation of a subgrid-scale model and its effect on the formation of magnetars.
11:33AM R15.00005 Binary neutron stars with realistic spin. WOLFGANG TICHY, Florida Atlantic University, SEBASTIANO BERNUZZI, TIM DIETRICH, BERND BRÜGGMANN, University of Jena — Astrophysical neutron stars are expected to be spinning. We present the first, fully nonlinear general relativistic dynamical evolutions of the last three orbits for constraint satisfying initial data of spinning neutron star binaries, with astrophysically realistic spins aligned and anti-aligned to the orbital angular momentum. The dynamics of the systems are analyzed in terms of gauge-invariant binding energy vs. orbital angular momentum curves. By comparing to a binary black hole configuration we can estimate the different tidal and spin contributions to the binding energy for the first time. First results on the gravitational wave forms are presented. The phase evolution of the gravitational waves during the orbital motion is significantly affected by spin-orbit interactions, leading to delayed or early mergers. Furthermore, a frequency shift in the main emission mode of the hyper massive neutron star is observed. Our results suggest that a detailed modeling of merger waveforms requires the inclusion of spin, even for the moderate magnitudes observed in binary neutron star systems.

11:45AM R15.00006 Evolutions of eccentric binary neutron stars with improved initial data. NATHAN JOHNSON-MCDANIEL, NICLAS MOLDENHAUER, Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, CHARALAMPOS MARKAKIS, School of Mathematics, University of Southampton, BERND BRÜGGMANN, Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, WOLFGANG TICHY, Department of Physics, Florida Atlantic University — We describe the first evolutions of eccentric binary neutron stars using initial data constructed with a new method that solves the Einstein constraints and Euler equation self-consistently, which previously had only been done in the quasicircular case. We show that these data indeed lead to considerable improvement in the initial spurious oscillation of the neutron stars, compared with the superposed data used in previous evolutions. We also consider the convergence of the constraints, the gravitational wave signal (including the tidally induced oscillations), and the properties of the final remnant and ejecta, again comparing the evolutions of the new data with those of the old, superposed data.

11:57AM R15.00007 Binary NS simulations using SpEC. ROLAND HAAS, BELA SZILAGYI, JEFFREY KAPLAN, CHRISTIAN OTT, JONAS LIPPUNER, MARK SCHEEL, KEVIN BARKETT, Cal Inst of Tech (Caltech), CURRAN MÜHLBERGER, Cornell, FRANCOIS FOUCART, CITA, MATTHEW DUEZ, Washington State University — NNSS binaries are expected to be one of the major sources of gravitational radiation detectable by Advanced LIGO. Together with neutrinos, gravitational waves are our only means to learn about the processes deep within a merging pair of NS, shedding light on the as yet poorly understood, equation of state governing matter at nuclear densities and beyond. We report on binary neutron star simulations using the Spectral Einstein Code (SpEC) developed by the Caltech-Cornell-CITA-WSU collaboration. We simulate the inspiral through many orbits, follow the post-merger evolution, and compute the full gravitational wave signal.

12:09PM R15.00008 Exploring the Use of Discontinuous Galerkin Methods for Numerical Relativity. FRANCOIS HEBERT, LAWRENCE KIDDER, SAUL TEUKOLSKY, Cornell University, SXS COLLABORATION — With Advanced LIGO expected to start detecting gravitational wave signals in the next several years, it is important that numerical simulations be able to generate the accurate gravitational wave templates used for both detection and parameter estimation. Generating these accurate gravitational wave templates is particularly challenging for black hole-neutron star mergers or binary-neutron star mergers: the algorithms used in the matter evolution, based on the finite volume method, struggle to reach the desired accuracy. We believe that a different type of algorithm, the discontinuous Galerkin method, would significantly increase the simulation accuracy thanks to its spectral convergence properties for smooth solutions and its robust stability properties for shocks. We present here our initial work implementing and testing a discontinuous Galerkin code on simple problems, leading towards the development of a discontinuous Galerkin-based GR hydro code.

12:21PM R15.00009 Multi-patch methods for magnetohydrodynamic accretion simulations. FATEMEH HOSSEIN NOURI, Washington State Univ, SXS COLLABORATION — Black hole accretion is one of the most important processes in relativistic astrophysics. Numerical simulations must accurately track both disks, polar jets, and near-horizon inflows. However, many standard numerical techniques face challenges evolving some region of the fluid, at least for some range of black hole spin. Cartesian grids with legosphere excision allow outgoing characteristics and are often unstable. Spherical-polar grids suffer extreme Courant time step limitations and coordinate singularities if the poles are evolved. In this talk, we explore two other ways of evolving MHD accretion. One, already in use in numerical relativity for moderate black hole spins, is to remove the black hole interior by a coordinate transformation. The other is to evolve using cubed-sphere multipatches, which allow a horizon-conforming inner boundary without any bad behavior at the poles. We discuss our implementation of this scheme in the SpEC code and report test evolutions of magnetized accretion tori around high-spin black holes.

Monday, April 7, 2014 10:45AM - 12:09PM –
Session R16 GGR: Tests of General Relativity and Gravitation

10:45AM R16.00001 Sensitivity Considerations for a Short-range Test of the Gravitational Inverse-square Law. DAVID SMITH, CRYSTAL CARDENAS, A. CONRAD HARTER, C.D. HOYLE, HOLLY LEOPARDI, Humboldt State University — The gravitational Inverse-Square Law (ISL) has been verified from infinity down to the 0.1 mm regime. Several theoretical scenarios predict possible violations of the ISL at short distances. At HSU we are developing an experiment that will test gravitational interactions below 50 microns. The experiment will be approximately null by using a stepped torsion pendulum and a large attractor plate. Hence, in the approximation that the attractor mass is an infinite sheet of matter, the Newtonian gravitational force is independent of separation distance between the pendulum and attractor. The experiment will measure the torque applied to the pendulum as the attractor mass is oscillated nearby. The size and distance dependence of the torque variation will provide a means to determine any deviations from the ISL at untested scales. The mass distribution of the pendulum and attractor determine the sensitivity of the experiment. This talk will focus on the investigation of the ISL and the experimental sensitivity. Gauss’ Law of Gravitation, the infinite plane approximation, Yukawa potential, and Newtonian vs. Yukawa torque will be discussed.
The Many Worlds of Leo Szilard

10:57AM R16.00002 Tests of the Weak Equivalence Principal Below Fifty Microns

ROBERT D. REASENBERG, JAMES D. PHILLIPS, Harvard-Smithsonian Center for Astrophysics / SAO — We are developing SR-POEM, a payload for detecting a possible violation of the weak equivalence principle (WEP) while on a sounding rocket’s free-fall trajectory. We estimate an uncertainty of \( \sigma(\eta) \leq 10^{-17} \) from a single flight. The experiment consists of calibration maneuvers plus eight 120 s drops of the two test masses (TMs). The instrument orientation will be reversed between successive drops, which reverses the signal but leaves most systematic errors unchanged. Each TM comprises three bars and a Y-shaped connector. The six bars are in a hexagonal housing and calibrated on a plane perpendicular to the symmetry axis (Z axis) of the payload and close to its CM. At a distance of 0.3 m along the Z axis, there is a highly stable plate that holds six of our tracking frequency laser gauges (TFGs), which measure the distances to the bars. The TMs are surrounded by capacitance plates, which allow both measurement and control of TM position and orientation. A central theme of the design is the prevention and correction of systematic error. Temperature stability of the instrument is essential and, during the brief night-time flight, it is achieved passively.

This work was supported in part by NASA grant NNX08AO04G.

11:09AM R16.00003 A Sounding Rocket Payload to Test the Weak Equivalence Principle

ROBERT MOSS, Wentworth Institute of Technology — Galactic rotation curves have proven to be the testing ground for dark matter bounds in galaxies, and comparisons to other alternative gravitational theories such as MOND. The WEP has been extensively studied since the time of Galileo, and is a central feature of General Relativity; its violation at any length scale would bring into question fundamental aspects of the current model of gravitational physics. A variety of scenarios predict possible mechanisms that could result in a violation of the WEP. The Humboldt State University Gravitational Physics Laboratory is using a torsion pendulum with equal masses of different materials (a “composition dipole” configuration) to determine whether the WEP holds below the 50-micron distance scale. The experiment will measure the twist of a torsion pendulum as an attractor mass is oscillated nearby in a parallel-plate configuration, providing a time varying torque on the pendulum. The size and distance dependence of the torque variation will provide means to determine deviations from accepted models of gravity on untested distance scales.

11:21AM R16.00004 Error Budget for SR-POEM, a Test of the Weak Equivalence Principle

JAMES D. PHILLIPS, BIJUNATH R. PATLA, ROBERT D. REASENBERG, Harvard-Smithsonian Center for Astrophysics — SR-POEM is a test of the weak equivalence principle (WEP) using free fall provided by a sounding rocket. The differential motion of two test masses (TMs) will be measured during eight drops of 120 s each to reach the planned accuracy, \( \sigma(\eta) \leq 10^{-17} \). During each drop, the payload is inertially oriented. Payload inversions between each pair of drops are a central tool in the control of systematic error. Another key tool is the rapid measurement enabled by our Tracking Frequency laser Gauge (TFG). This is a unique advantage of SR-POEM over other planned missions. The TFG will measure the length of an SR-POEM resonant cavity to 0.1 pm in 1 s. The rapid measurement allows superior thermal control by inexpensive, passive means. It also allows the TMs to be unconstrained, eliminating both systematic error and noise due to constraints or springs. The sounding rocket reduces mission cost and has a near-vertical trajectory, which reduces Coriolis error. We discuss the errors due to distance measurement, Coriolis and related pseudo-accelerations, gravity, electric fields, magnetic fields, gas, and radiation pressure.

11:33AM R16.00005 Astrophysical Limits on Superluminal Electron and Neutrino Velocities

FLOYD STECKER, NASA Goddard Space Flight Center — The observation of two PeV-scale neutrino events reported by Ice Cube allows one to place constraints on Lorentz invariance violation (LIV) in the neutrino sector. First, I derive an upper limit for the difference between putative superluminal neutrino and electron velocities of \( < 5.6 \times 10^{-19} \) in units where \( c = 1 \). I then derive a new, strong constraint on superluminal electron velocity \( \delta v < 5 \times 10^{-21} \). One then obtains an upper limit on the superluminal neutrino velocity alone of \( \delta v < 5.6 \times 10^{-19} \) many orders of magnitude better than the time-of-flight constraint from the SN1987A neutrino burst. However, if the electrons are subluminal the constraint on \( |\delta v| < 8 \times 10^{-17} \), obtained from the Crab Nebula \( \gamma \)-ray spectrum, places a weaker constraint on superluminal neutrino velocity of \( < 8 \times 10^{-17} \).

11:45AM R16.00006 Theoretical Suggestion of Realistic Experiment on the Earth’s Orbit to Test Quantum Effects in General Relativity

ANDREI LEBED, Department of Physics, University of Arizona — We show theoretically that quantum fluctuations result in the existence of seldom events, where the equivalence between energy and passive gravitational mass is broken for the simplest composite quantum body – a hydrogen atom [1]. We suggest to conduct experiment on the Earth’s orbit, where such seldom events can be observed by measuring electromagnetic radiation, emitted from a tank of pressurized hydrogen molecules or helium atoms placed in a small spacecraft or satellite. It could be the first experiment where quantum effects would be directly observed in general relativity.


This work was supported by the NSF under Grant DMR-1104512.

11:57AM R16.00007 Conformal Gravity Rotation Curve of the Milky Way Galaxy

JAMES O’BRIEN, ROBERT MOSS, Wentworth Institute of Technology — Galactic rotation curves have proven to be the testing ground for dark matter bounds in galaxies, and our own milky way is one of many large spiral galaxies that must follow the same models. Here, we present synthesis mass models of milky way rotation data and apply the fitting procedure of Conformal Gravity. We find that like the other already published 200 plus galactic rotation curves, the Milky Way galaxy follows the same trend observed that a fantastic fit can be achieved without the need for involving dark matter. Specifics of the fitting procedure will be discussed as well as comparisons to other alternative gravitational theories such as MOND.

Monday, April 7, 2014 10:45AM - 12:33PM – Session R17 FHP: Invited Session: The Many Worlds of Leo Szilard

105-106 - Daniel Kleppner, Massachusetts Institute of Technology
We find that for an inverted neutrino mass hierarchy with a hard neutrino spectra, neutrino interactions with He via \( ^4\text{He} \) of California, Berkeley — We discuss a neutrino driven neutron capture mechanism that occurs in the He shell of an early core-collapse supernova. We calculate abundance of neutron capture elements in metal-poor stars. 

\( ∼10^{-15} M \) which is much longer and colder compared to the conventional hot rapid neutron capture process. The process is uniquely sensitive to the neutron capture cross-sections since \( (n, \gamma) \leftrightarrow (\gamma, n) \) equilibrium is not established. We find that variation of neutron capture rates can have a dramatic effect on both the timescale and the final abundance pattern. We also explore the sensitivity of the mechanism on the neutrino emission on a timescale of \( ∼10^8 \) K which is much longer and colder compared to the conventional hot rapid neutron capture process. The process is uniquely sensitive to the neutron capture cross-sections since \( (n, \gamma) \leftrightarrow (\gamma, n) \) equilibrium is not established. We find that variation of neutron capture rates can have a dramatic effect on both the timescale and the final abundance pattern. We also explore the sensitivity of the mechanism on the neutrino emission parameters and oscillations, as well as on explosion energy and progenitor metallicity. We discuss the implications of this process with respect to the observed abundance of neutron capture elements in metal-poor stars.

11:12AM R17.00002 Leo Szilard In Physics and Information, RICHARD GARWIN, IBM — The excellent biography by William Lanoette, “Genius in the Shadows,” tells it the way it was, incredible though it may seem. The 1972 “Collected Works of Leo Szilard: Scientific Papers” Bernard T. Feld and Getruide W. Szilard, Editors, gives the source material both published and unpublished. Szilard’s path-breaking but initially little-noticed 1929 paper, “On the Decrease of Entropy in a Thermodynamic System by the Intervention of Intelligent Beings” spawned much subsequent research. It connected what we now call a bit of information with a quantity \( k \ln 2 \) of entropy, and showed that the process of acquiring, exploiting, and resetting this information in a one-molecule engine must dissipate at least \( kT \ln 2 \) of energy at temperature \( T \). His 1925 paper, “On the Extension of Phenomenological Thermodynamics to Fluctuation Phenomena,” showed that fluctuations were consistent with and predicted from equilibrium thermodynamics and did not depend on atomistic theories. His work on physics and technology, demonstrated an astonishing range of interest, ingenuity, foresight, and practical sense. I illustrate this with several of his fundamental contributions nuclear physics, to the neutron chain reaction and to nuclear reactors, and also to electromagnetic pumping of liquid metals.


Monday, April 7, 2014 1:30PM - 3:18PM –

Session S2 DPF: Invited Session: Searches for New Physics at the LHC Chatham Ballroom A - Yuri Gershtein, Rutgers University

1:30PM S2.00001 Exotics (non-SUSY) physics searches at the LHC\(^1\), HARINDER BAWA, California State University Fresno — The considerable center-of-mass energy and luminosity provided by the Large Hadron Collider (LHC) ensures a discovery reach for new particles which extends well into the multi-TeV region. ATLAS and CMS Collaborations at LHC have carried out a wide range of searches for new phenomena with many different final states. In this talk, I report on recent Exotics(non-SUSY) physics searches with 8 TeV data from ATLAS and CMS Collaborations. Among the topics covered are heavy resonances decaying into pairs of jets, leptons, lepton and jets, as well as dibosons. Dark matter searches were carried out in events with large missing transverse missing momentum and a single jet, photon or W/Z boson. Many of the above final states have also been interpreted in the context of models with large or warped extra dimensions.

2:06PM S2.00002 SUSY Results from the LHC, DARYL HARE, Fermilab — No abstract available.

2:42PM S2.00003 New Physics Where do we go from here, MARIANGELA LISANTI, Princeton University — No abstract available.

Monday, April 7, 2014 1:30PM - 3:18PM –

Session S3 DNP: Invited Session: Electroweak Interactions, Neutrinos and Neutrons Chatham Ballroom B - Ani Aprahamian, University of Notre Dame

1:30PM S3.00001 Neutrino Driven Nucleosynthesis in the Early Galaxy, PROJJWAL BANERJEE, University of California, Berkeley — We discuss a neutrino driven neutron capture mechanism that occurs in the He shell of an early core-collapse supernova. We calculate the nucleosynthesis, both before and after the passage of shock, in recent pre-supernova models of \( 11 - 15M_\odot \) stars with an initial metallicity of \( [Z] < -3 \). We find that for an inverted neutrino mass hierarchy with a hard neutrino spectra, neutrino interactions with He via \( ^4\text{He}(\nu_e, e^-n)^7\text{He} \) produces free neutrons on a timescale of \( \sim 5 - 6 \) s, which are captured by Fe seeds present in the He shell to produce isotopes with \( A > 200 \). This process occurs on a timescale of \( \sim 100 - 300 \) s at a temperature of \( \sim 10^8 \) K which is much longer and colder compared to the conventional hot rapid neutron capture process. The process is uniquely sensitive to the neutron capture cross-sections since \( (n, \gamma) \leftrightarrow (\gamma, n) \) equilibrium is not established. We find that variation of neutron capture rates can have a dramatic effect on both the timescale and the final abundance pattern. We also explore the sensitivity of the mechanism on the neutrino emission parameters and oscillations, as well as on explosion energy and progenitor metallicity. We discuss the implications of this process with respect to the observed abundance of neutron capture elements in metal-poor stars.

\(^1\)Results from ATLAS & CMS Collaborations at LHC, CERN
2:06PM S3.00002 Neutron Trapping using a Magneto-Gravitational Trap, CHEN-YU LIU, Center for Exploration of Energy and Matter, Indiana University. Eighty years after Chadwick discovered the neutron, physicists today still cannot agree on how long the neutron lives. Measurements of the neutron lifetime have achieved the 0.1% level of precision (∼1 s). However, results from several recent experiments are up to 7 s lower than the (pre-2010) particle data group (PDG) value. Experiments using the trap technique yield lifetime results lower than those using the beam technique. The PDG urges the community to resolve this discrepancy, now 6.5 sigma. Measuring the absolute neutron lifetime is difficult because of several limitations: the low energy of the neutron decay products, the inability to track slow neutrons, and the fact that the neutron lifetime is long (880.1 ± 1.1 s). Slow neutrons are susceptible to many loss mechanisms other than beta-decay, such as upscattering and absorption on material surfaces. Often, these interactions act on time scales comparable to the neutron beta-decay, making the extraction of the beta-decay lifetime particularly challenging. We will revisit this measurement by trapping ultracold neutrons (UCN) in a hybrid magnetic-gravitational trap. The trap consists of a Halbach array of permanent magnets, which can levitate UCN up to 50 nT. These neutrons are also confined vertically up to 0.5 m by gravity. Such a trap minimizes the chance of neutron interactions with material walls. In addition, the open-top geometry allows room to implement novel schemes to detect neutrons and decay particles in-situ. The UCN trap experiment aims to reduce the uncertainty of the neutron lifetime measurement to below 1 second. In this talk, I will report results of our first attempt to trap UCN in 2013 and discuss plans to quantify systematic effects.

2:42PM S3.00003 The beta-decay of \( ^{6}\text{He} \): a sensitive window to search for physics beyond the standard model, OSCAR NAVLIAT-CUNCIC, National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy - Michigan State University. The simplicity of the Gamow-Teller beta-decay of the \( ^{6}\text{He} \) nucleus has attracted considerable experimental and theoretical attention in the past few years. Precision correlation measurements in this allowed transition have motivated the production of high intensity and high purity sources and beams at several facilities. The main purpose of such measurements is to search for new physics contributing to the weak interaction that would manifest itself through phenomenological tensor couplings. New measurement techniques, including the detection of recoiling ions from decays in ion and atom traps, have been developed in order to make the most efficient use of the available intensities and to reduce instrumental systematic effects. This talk will first present the result of a measurement of the beta-neutrino angular correlation in the decay of \( ^{6}\text{He} \) which has been carried out by trapping ions in a Paul trap. The talk will then describe current efforts of second generation experiments aiming at new levels of sensitivity in the search for phenomenological exotic tensor couplings in \( ^{6}\text{He} \) decay.

3. Work supported in part by the U.S. National Science Foundation under grant number PHY-11-02511.

Monday, April 7, 2014 1:30PM - 3:18PM –
Session S4 DAP: Invited Session: Cosmological Constraints from Gamma-Ray Data

1:30PM S4.00001 DAP Young Star: Intensity and Origin of the Extragalactic Gamma-ray Background, KEITH BECHTOL, KICP / University of Chicago. The gamma-ray sky can be decomposed into individually detected sources, diffuse emission attributed to the interactions of cosmic rays with gas and radiation fields in our Galaxy, and a residual all-sky emission component commonly called the isotropic diffuse gamma-ray background (IGRB). The IGRB comprises all extragalactic emissions too faint or too diffuse to be resolved in a given survey, as well as any residual Galactic foregrounds that are indistinguishable from isotropic. The sum of the IGRB and individually resolved extragalactic sources represents our best estimate of the total extragalactic gamma-ray background. The first IGRB measurement with the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope used 10 months of sky-survey data and considered an energy range between 200 MeV and 100 GeV. Improvements in event selection and characterization of particle backgrounds, better understanding of the diffuse Galactic emission, updated emission models for the Earth atmosphere, Sun, and Moon, as well as a longer data accumulation of 50 months, allow for a refinement and extension of the IGRB measurement with the LAT, now covering the energy range from 100 MeV to 820 GeV. We discuss the possible presence of a high-energy cutoff (>100 GeV) in the IGRB, as well as systematic uncertainties that impact the shape and normalization of the measured spectrum. Finally, we review the current census of extragalactic source populations and truly diffuse processes contributing to the extragalactic gamma-ray background.

2:06PM S4.00002 Using Very High Energy Photons from Blazars for Cosmological Insight, AMY FURNISS, Stanford University. Gamma-ray blazars are among the most extreme astrophysical sources, harboring energetic phenomena far beyond that attainable by terrestrial accelerators. These galaxies are understood to be active galactic nuclei that are powered by accretion onto supermassive black holes and have relativistic jets pointed along the Earth line of sight. The very high energy photons emitted by these extragalactic sources are detectable with ground based imaging atmospheric Cherenkov telescopes such as VERITAS, MAGIC and HESS. As these photons propagate extragalactic distances, the interaction with the diffuse starlight that pervades the entire Universe results in a distance and energy dependent gamma-ray opacity, offering a unique method for probing photon densities on cosmological scales. These galaxies have also been postulated to be potential sources of ultra-high-energy cosmic rays, a theory which can be examined through the deep gamma-ray observations of sources which probe moderate gamma-ray opacities. If confirmed as cosmic ray progenitors, these galaxies would provide an opportunity to probe the intergalactic magnetic field, as the charged particles would be deflected from the line of sight in a field-dependent manner.

2:42PM S4.00003 Cascade gamma rays as a probe of the high-energy universe: general constraints, hints, and implications, KOHTA MURASE, Inst for Advanced Study. Very-high-energy (VHE) and ultra-high-energy (UHE) gamma rays from extragalactic sources experience electromagnetic cascades during their propagation in intergalactic space. Recent observations by Fermi and Cherenkov telescopes allow us to get more insight into VHE and UHE gamma-ray emitters. The latest Fermi data on the diffuse gamma-ray background have provided us with powerful constraints on potential cosmic-ray sources and annihilating/decaying dark matter, as well as a possible hint of the cascades. The relevance of the cascades is also motivated by some extreme blazars seen in the VHE range, and understanding such VHE gamma-ray sources is relevant to constrain intergalactic magnetic fields in voids and identify extragalactic cosmic-ray sources.
1:30PM S6.00001 Single-neutron excitations in $^{96}$Mo from the $^{95}$Mo(d,p) reaction$^1$. SHUYA OTA, Japan Atomic Energy Agency / Rutgers, J.A. CIZEWSKI, A. RATKIEWICZ, S. BURCHER, B. MANNING, S.L. RICE, C. SHAND, Rutgers, J.T. BURKE, R.J. CASPERSON, J.E. ESCHER, N.D. SCIELZO, I. THOMPSON, LLNL, M. MCCLESEKY, Texas A&M, W.A. PETERS, ORAU, R.A.E. AUSTIN, St. Mary's, C.W. BEAUSANG, R.O. HUGHES, T.J. ROSS, Richmond — Uncertainties in neutron capture cross sections can affect r-process nucleo-synthesis at late times. Neutron transfer reactions are important in determining direct neutron capture cross sections and may be a promising surrogate for neutron capture when the desired reaction involves short-lived nuclei. As part of the effort to validate (d,p)$^+$ as a surrogate for neutron capture, the $^{95}$Mo(d,p) reaction was studied at a cyclotron at Texas A&M University with a 12.5-MeV deuteron beam. The reaction protons were measured at forward angles of 30-60° with the STARS (Silicon Telescope Array for Reaction Studies) array of three segmented Micron 92 silicon detectors to populate discrete states below 5 MeV in excitation. This is the first study of the $^{95}$Mo(d,p) reaction. Angular distributions of protons populating low-spin discrete excitations and a comparison with distorted-wave calculations will be presented. $^1$This work is supported in part by the JSPS Research Fellowship and the U.S. Department of Energy (DE-FG52-08NA28552 (Rutgers, ORAU), DE-AC52-07NA27344 (LLNL), DE-FG02-05ER14379 and DE-FG52-06NA20260 (Richmond)) and the National Science Foundation.

1:42PM S6.00002 Investigation of the structure of neutron-deficient Cd isotopes, ANNA SIMON, P. HUMBY, C.W. BEAUSANG, University of Richmond, J.T. BURKE, R.J. CASPERSON, Lawrence Livermore National Laboratory, M. MCCLESEKY, A. SAASTAMOINEN, Texas A&M University, J.M. ALLMOND, Oak Ridge National Laboratory, R. CHYZH, M. DAG, Texas A&M University, J. KOGLIN, Lawrence Livermore National Laboratory, S. OTA, Rutgers University, T.J. ROSS, University of Kentucky — The STARLITER setup at Texas A&M University consists of an array of six Compton suppressed HPGe clothor detectors coupled with a segmented Si-E-D charged particle telescope. The combination allows for coincident γ-ray and particle spectroscopy and provides a powerful tool for precise determination of the nuclear level structure. A recent experiment conducted using STARLITER aimed at the investigation of structures of neutron-deficient Cd isotopes (A = 104, 105, 106) using an enriched $^{100}$Cd target and 35 MeV proton beam supplied by the K-150 Cyclotron at TAMU. Low mass cadmium isotopes are a great environment for analysis of the evolution from vibrational to rotational sequences in A=100-110 region and provide insight into the structure phenomena around Z=50 shell closure. Here, the first results of the experiment will be presented. This work was partly supported by the US Department of Energy Grants No. DE-FG52-06NA26206 and No. DE-FG02-05ER14379.

1:54PM S6.00003 Investigation of low/medium spin excited states in $^{150-154}$Sm via the (p,d) and (p,t) reactions$^1$. P. HUMBY, University of Richmond, University of Surrey, A. SIMON, C. BEAUSANG, K. GELL, T. TARLOW, G. VYAS, University of Richmond, T.J. ROSS, University of Kentucky, R.O. HUGHES, J.T. BURKE, R.J. CASPERSON, J. KOGLIN, Lawrence Livermore National Laboratory, S. OTA, Rutgers University, T.J. ROSS, University of Kentucky — Low-medium spin excited states of $^{151,153}$Sm and $^{150,152}$Sm were studied via the (p,d) and (p,t) reactions, respectively, utilizing the STARLITER arrays at the Cyclotron Institute of Texas A&M University. In the experiment $^{152}$Sm and $^{154}$Sm targets were bombarded with 25 MeV protons and the outgoing light charged particles (p, d and t) in the exit channels were detected using the STARS $\Delta E-E$ silicon telescope, thus allowing particle identification and a measurement of the nuclear excitation energy. Six BGO shielded HPGe detectors were used to observe the emitted gamma rays in coincidence with the particles. A post-run measurement of gamma rays emitted from the activated target allowed an improved measurement of the half life of the 96 minute $J^\pi = 8^+$ isomer of $^{152}$Eu. Preliminary results are presented. $^1$This work was partly supported by the US Department of Energy under Grants No. DE-FG52-06NA26206 and No. DE-FG02-05ER14379.

2:06PM S6.00004 ABSTRACT WITHDRAWN

2:18PM S6.00005 Progress in Electromagnetic Alteration of Nuclear Decay Properties, R.J. CASPERSON, R.O. HUGHES, J.T. BURKE, N.D. SCIELZO, R. SOULFI, Lawrence Livermore National Laboratory — Significant alteration of nuclear decay properties would have important consequences, ranging from novel approaches to nuclear batteries and gamma-ray lasers, to improved viability for physics experiments with short-lived targets. Quantum systems that decay by photon emission must couple to the electromagnetic modes of the local environment, and by modifying these modes, one can manipulate the rate of spontaneous emission. The nuclear isomer $^{235}$mU is low-energy, long-lived, and is easily populated through $^{239}$Pu α-decay, which makes it an excellent benchmark for this effect. The decay rate of this isomer in a variety of environments is currently under investigation. Implications of this work will be discussed, and first results will be presented. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

2:30PM S6.00006 Measurement of the $\alpha$/SF branching ratio of $^{252}$Cf with the NIFFTE fission TPC, LUCAS SNYDER, Lawrence Livermore Natl Lab, NIFFTE COLLABORATION — Neutron-induced fission cross sections are important in the simulation and modeling nuclear fuel cycles. The Neutron Induced Fission Fragment Tracking Experiment (NIFFTE) collaboration is developing a fission Time Projection Chamber (TPC) to measure neutron-induced fission cross sections with total uncertainty of better than 1%. To achieve such precision, the systematic uncertainties of the previously used measurement techniques must be addressed. The fission TPC will do this, in part, by providing detailed 3-dimensional images of fission fragments and other charged-particles produced in a neutron beam environment. Throughout the fission TPC’s development phase the α-decay and spontaneous fission of $^{252}$Cf has been used to benchmark its performance. Recently the first $^{252}$Cf data were collected using the fully instrumented fission TPC, which has nearly 6000 individual channels and provides 4π coverage. A preliminary analysis of the $\alpha$/SF branching ratio will be presented.

2:42PM S6.00007 Fusion, fission, and quasi-fission using TDHF$^1$, SAIT UMAR, VOLKER OBERACKER, Vanderbilt University — We study fusion, fission, and quasi-fission reactions using the time-dependent Hartee-Fock (TDHF) approach together with the density-constrained TDHF [1] method for fusion. The only input is the Skyrme NN interaction, there are no adjustable parameters. We discuss the identification of quasi-fission in 40Ca+238U: the scission dynamics in symmetric fission of 264Fm, as well as calculating heavy-ion interaction potentials $V(R)$, mass parameters $\Delta (R)$, and total fusion cross sections from light to heavy systems. Some of the effects naturally included in these calculations are: neck formation, mass exchange, internal excitations, deformation effects, as well as nuclear alignment for deformed systems.

$^1$Supported by DOE grant DE-FG02-96ER40975
2:54PM S6.00008 Auxiliary-field quantum Monte Carlo simulations of neutron matter in chiral effective field theory1, JEREMY HOLT, AUREL BULGAC, SERGEI MOROZ, Univ of Washington, KENNETH ROCHE, Univ of Washington and Pacific Northwest National Laboratory, GABRIEL WLAZLOWSKI, Warsaw University of Technology and Univ of Washington — We report on recent variational calculations of the neutron matter equation of state using chiral nuclear interactions. The ground-state wavefunction of neutron matter, containing nonperturbative many-body correlations and nucleon pairing, is obtained from auxiliary-field quantum Monte Carlo simulations of up to 200 neutrons interacting on a a 103 discretized lattice with spacing 1.5 fm, consistent with a momentum-space cutoff of 414 MeV. The evolution Hamiltonian is chosen to best reproduce broad features of chiral nuclear forces while at the same time avoiding the Fermion sign problem, and to account for the presence of nuclear three-body forces it is constructed as a function of the nucleon density. Differences between this evolution Hamiltonian and the full chiral nuclear interaction are then treated perturbatively. Our results for the equation of state are in good agreement with previous auxiliary-field quantum Monte Carlo simulations which employed only chiral two-body forces at next-to-next-to-leading order (N2LO). In addition we include the effects of three-body forces at N2LO, which provide important repulsion at densities higher than 0.02 fm−3, as well as two-body forces at N3LO.

Monday, April 7, 2014 1:30PM - 2:42PM –
Session S7 Instrumentation II

2:18PM S7.00005 The fissionTPC, MIKE HEFFNER, Lawrence Livermore Natl Lab, NIFFTE COLLABORATION — A new instrument to study fission, called the fissionTPC, has been constructed to make high accuracy measurements of neutron induced fission cross-sections of the major actinides. Most of the cross sections have been measured over the last 60 years, although improvements in the accuracy of the data appear unlikely with the current technology. A potential breakthrough is the deployment of the Time Projection Chamber (TPC) which was developed within the particle physics community. The NIFFTE collaboration, a group of 7 universities and 4 national laboratories, has undertaken the task of building the first TPC for this purpose. In this talk I will present the fission TPC design, challenges that had to be addressed, and the performance of the detector.

2:06PM S7.00004 MOVED TO L1.029 –

2:00PM S7.00001 Development of fast-release solid catchers for rare isotopes1, JERRY NOLEN, JOHN GREENE, Physics Div, Argonne Natl Lab, JEONG-SEOG SONG, RISP, Institute for Basic Science, Daejeon, S Korea, JEFFREY ELAM, ANIL MANE, Energy Systems Div, Argonne Natl Lab, UMA SAMPATHKUMARAN, RAYMOND WINTER, DAVID HESS, MOHAMMAD MUSFIQ, Innsosec, LLC, Torrance, CA, DANIEL STRACENER, Physics Div, Oak Ridge Natl Lab — Porous solid catchers of rare isotopes produced at high energies via in-flight reactions can play an important role in high power heavy ion accelerator facilities such as RIKEN, FRIB, and RISP. Such catchers can be complementary to helium gas catchers especially for parasitic harvesting of rare isotopes in the in-flight separators at such facilities. Materials for solid catchers are being developed by Innsosec, LLC, under the DOE ONP SBIR program. The role of the catchers at high energy heavy ion facilities is to stop and quickly release rare isotopes for research with these isotopes either with stopped-beam instruments or as reaccelerated beams. Solid catchers can operate effectively with high intensity secondary beams, e.g. >3×1010 atoms/s with release times as short as 10-100 milliseconds. A new method for characterizing the release curves of such catchers is being developed at Argonne under this SBIR program. The method will utilize a very efficient and sensitive commercial residual gas analyzer for rapid measurements following implantation of stable isotopes delivered as energetic heavy ion beams.

Monday, April 7, 2014 1:30PM - 2:42PM –
Session S8 DAP: Radio in Ice: UHECR Cosmic-rays and Neutrinos

2:30PM S8.00006 The GA PEACh: A Portable Electrostatic Accelerator1, PATRICK MCCLANAHAN, ASHLYN BURCH, QUINTORIOUS BIVINS, MEGAN GARRETT, ZACHARY JORDAN, RHETT ROBERTS, BENJAMIN THOMAS, SHARON CARECCIA, RONNIE JOHNSON, RALPH FRANCE III, Georgia College & State University, K.C. MCGILL, JR., MARK SPRAKER, University of North Georgia — In collaboration with the University of North Georgia, we are constructing a portable electrostatic ion accelerator at Georgia College. It will use a model 2JA066280 R.F. ion source from National Electrostatics Corporation to produce ions from gaseous elements and a model AU-100N1 100 kV power supply to produce the accelerating voltage. The linear accelerator will be less than 2 meters in length. The beam energy will be roughly determined by the acceleration voltage. Low energy proton-induced fusion reactions are envisioned for both pure and applied physics research. One potential application is to use the 17 MeV γ-ray from the 7Li(p, γ)8Be reaction to help calibrate γ-ray detectors at the Hi8S facility.

1Supported by the Georgia College Faculty Research Grant Program.

1Research supported through the U.S. DOE Office of Nuclear Physics under the SBIR Program

1Supported under US DOE Grant No. DE-FG02-97ER-41014.
1:30PM S8.00001 The Askaryan Radio Array: Status and Performance , RYAN MAUNU, KARA HOFFMAN, MIKE RICHMAN, University of Maryland, ASKARYAN RADIO ARRAY COLLABORATION — Ultra high energy neutrinos could be most efficiently detected in dense, radio frequency transparent media via the Askaryan effect. The Askaryan Radio Array is a new ultra high energy neutrino detector which will encompass a fiducial area of 100 square kilometers of the deep radio transparent ice near the South Pole. A “Testbed” and the first three clusters of antennae (out of 37 planned) have been installed to date. The primary science goal is the discovery of the cosmogenic neutrinos and measurement of the flux. We report on the science, design, and performance of this instrument, along with the prospects for completion of the detector construction.

1:42PM S8.00002 ARA testbed template based UHE neutrino search , STEVEN PROHIRA, University of Kansas, ARA COLLABORATION — The Askaryan Radio Array (ARA) is an in-ice Antarctic neutrino detector deployed near the South Pole. ARA is designed to detect ultra high energy (UHE) neutrinos in the range of 0.1-10 EeV. Data from the ARA testbed, deployed in the 2010-2011 season, is used for a template based neutrino search.

1:54PM S8.00003 A cut-based search for ultra-high energy neutrinos with the ARA TestBed , EUGENE HONG, AMY CONNOLLY, CARL PFENDNER, The Ohio State University, ASKARYAN RADIO ARRAY COLLABORATION — Cosmic ray flux cut off above primary energies of 10^{19.5} eV lead us to expect an UHE neutrino flux due to the GZK effect. Askaryan Radio Array (ARA) is an ultra-high energy (UHE) cosmic neutrino detector located at the South Pole that uses the radio Cherenkov technique by deploying radio frequency antennas at a depth of 200m in the Antarctic ice. While there are three complementary ARA neutrino searches in progress, I present the result of the first neutrino search with 2011-2012 ARA TestBed data using a cut-based analysis. For the analysis, I use a Monte Carlo (MC) simulation named AraSim that is calibrated against TestBed calibration pulser data and thermal noise data. We generate custom radio Cherenkov signals in the ice in the time domain for each event with a fully parameterized model. Using timing differences measured at antennas within a single station, we use interferometric techniques to reject thermal noise and continuous wave (CW) backgrounds, and reconstructed directions to search for neutrino candidates in the ice. I will present the UHE neutrino flux constraints from all ARA TestBed analyses.

2:06PM S8.00004 Time Domain Analysis of ARIANNA Data Acquisition: Distinguishing Askaryan Radiation from Thermal Backgrounds , JORDAN HANSON, University of Kansas, ARIANNA COLLABORATION — The Antarctica Ross Ice Shelf Antenna Neutrino Array (ARIANNA) is a high energy astrophysical neutrino detector, currently under construction near McMurdo Station, Antarctica. The ARIANNA detector design is optimized for detection of Askaryan radio frequency pulses, created in the ice shelf above the Antarctic ocean that originate from cosmogenic GZK neutrino interactions. A formal analysis of the electromagnetic properties of the ARIANNA detection chain in the time domain is presented, and combined with a theoretical understanding of the Askaryan signal. This combination produces signal templates, used to distinguish thermal backgrounds from true signal in the current ARIANNA data. The results of this data analysis are also presented.

2:18PM S8.00005 The ExaVolt Antenna , BRIAN DAILEY, Ohio State Univ - Columbus, EVA COLLABORATION — There are strong motivations for a flux of ultra-high energy (UHE) neutrinos that is observable on earth, yet they remain undetected. The proposed ExaVolt Antenna (EVA) uses a novel approach to increase the expected rate of neutrinos in a balloon-borne experiment such as ANITA by 100-fold by turning a 100m-diameter, long-duration, super pressure NASA balloon into an antenna reflector with receivers deployed in the interior of the balloon. EVA would be the world’s largest airborne telescope with ~1000 m^2 of collection area. I will present preliminary results from a 1:20 scale EVA prototype test conducted in early 2014 in a hangar at NASA's Wallops Flight Facility. I will conclude with the expected sensitivity of the full EVA experiment to UHE neutrino fluxes.

2:30PM S8.00006 Radio Frequency Attenuation Length Estimates In Ice from Antarctic and Greenlandic Radar Depth Sounding Data , MARK STOCKHAM, University of Kansas, ANITA COLLABORATION — The balloon-borne Antarctic Impulsive Transient Antenna (ANITA) experiment is designed to detect in-ice neutrino collisions in Antarctica. These collisions produce radio waves that propagate upward to the suite of 32 horn antennas that constitute ANITA. The primary virtue of ANITA is the ability to simultaneously observe 1 million cubic kilometers of ice from its 38 kilometer altitude vantage point. The radio frequency signal strength observed at the balloon, however, depends on the radio frequency attenuation length of the ice through which the neutrino-generated signal must travel. Attenuation length is a location-specific ice property and varies mainly as a function of temperature and chemistry. The Center for Remote Sensing of Ice Sheets (CReSIS) project has data from many locations in Antarctica and Greenland produced by radar depth sounding. Using methods developed by analyzing the continuum signal in radar depth sounding data from Greenland, attenuation length estimates are compared to estimates derived from ice core data.

2:42PM S8.00007 Optimization of energy reconstruction for ANITA III , VIATCHESLAV BUGAEV, BRIAN RAUCH, ROBERT BINNS, MARTIN ISRAEL, Department of Physics and McDonnell Center for the Space Sciences, Washington University in St. Louis, KONSTANTIN BELOV, DAVID URDANETA, JOE LAM, Department of Physics and Astronomy, UCLA, ANDREW ROMERO-WOLF, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, STEPHANIE WISSEL, Department of Physics and Astronomy, UCLA, ANITA COLLABORATION — The third flight of the high-altitude balloon-borne ANtarctic Impulsive Transient Antenna (ANITA III) planned for December 2014 will be optimized for the measurement of impulsive radio signals from the charged component of extensive air showers initiated by Ultra-High Energy Cosmic Rays (UHE CR) in the frequency range ~ 80 – ~ 1200 MHz (RF), in addition to detection of radio impulses initiated by the high-energy neutrinos, which was the objective of the first two ANITA flights. Based on an extensive set of Monte Carlo simulations of radio emissions from CR with the ZHAireS simulation package, we propose a strategy of utilizing reconstructed RF spectra from individual showers optimized for the energy reconstruction of primary CR particles. The optimization, in particular, takes advantage of an extended sensitive frequency range of ANITA III due to adding a drop-down antenna shifting the lower limit from ~ 180 MHz to ~ 80 MHz. An idealized model of the detector is used in our study, in which RF spectra can be reconstructed to an arbitrary precision.

2:54PM S8.00008 Ice surface roughness modeling for effect on radio signals from UHE particle showers , JESSICA STOCKHAM, University of Kansas, ANITA COLLABORATION — For radio antenna detectors located in or above the Antarctic ice sheet, the reconstruction of both ultra-high energy (UHE) neutrino and cosmic ray air shower events requires understanding the transmission and reflection properties of the air-ice interface. To this end, surface and volume scattering from granular materials in the microwave frequency range are measured and stereoscopic images of the ice surface, obtained by the Antarctic Geophysics Along the Vostok Expedition (AGAVE), are used to determine the 3D surface structure. This data is implemented to determine an appropriate model for use in simulation and data analysis of the shower events.

1 ANtarctic Impulsive Transient Antenna
1:30PM S9.00001 Uniformity of CMB as a non-inflationary geometrical effect. BRANISLAV VLAHOVIC, COSMIN ILIE, MAXIM EINGORN, North Carolina Central University — The conventional LambdaCDM cosmological model supplemented by the inflation concept explains the Universe evolution well. However, there are still a few concerns: New Planck data impose a non-trivial constraint on the shape of the inflation potential, which excludes many inflationary models; the dark matter is not detected directly; and the dark energy is not described theoretically on a satisfactory level. Within the FLRW formalism we consider a model of the closed Universe (with the spherical spatial topology), filled with the additional perfect fluid with the constant parameter -1/3 in the linear equation of state (which may be called quintessence). We compare this model with the standard LambdaCDM and answer the following question: can this additional fluid lead to light traveling between the antipodal points during the current age of the Universe? This possibility could strongly affect the inflation scenario which may completely lose its necessity. This work is supported by NSF CREST (HRD-0833184) and NASA (NNX09AV07A).

1:42PM S9.00002 Constraining light WIMPs and neutrinos with BBN and the CMB. KENNETH NOLLETT, Ohio University, GARY STEIGMAN, The Ohio State University — Cosmology constrains the properties of light (< 10 MeV, roughly) particle species mainly through their effects on the expansion rate of the universe at early times. The sensitivity of cosmic microwave background (CMB) observations to the expansion rate up to recombination is now comparable to that of big bang nucleosynthesis (BBN) during the first few minutes of the universe. While CMB observations do not currently favor neutrino-like particles beyond the standard model, the signal could be hidden if "light WIMPs" with MeV-scale masses were in thermal equilibrium in the early universe. Light WIMPs affect BBN through modified expansion rates and heating of photons or neutrinos, so light-element observations break the CMB degeneracy between neutrinos and light WIMPs. We describe joint analyses of BBN and CMB data that constrain simultaneously light WIMPs and extra neutrinos, finding that one extra neutrino species is allowed, the standard-model expansion rate is disfavored, and any WIMP mass must be greater than an MeV.

1:54PM S9.00003 Rees-Sciama signatures from evolving dark matter halos in the cosmic microwave background. LIANG DAI, LIN YANG, MARC KAMIONKOWSKI, JOSEPH SILK, Johns Hopkins Univ — Photons in the cosmic microwave background (CMB) radiation receive an extra blueshift in their energies as they traverse slowly-growing dark matter halos. This Rees-Sciama effect arises from the time-dependent gravitational potentials generated by the subsequent accretion of dark matter flows onto collapsed halo cores. Studies of the Rees-Sciama contributions to the stochastic anisotropies in the CMB from large scale linear or quasi-linear perturbations have been previously conducted, but in this work we focus on non-perturbative, collapsed halos. We calculate the magnitude of this effect for a spherical symmetric halo model of self-similarity, and demonstrate a projected profile of this signature on the sky as a function of the impact parameter of the line of sight. Its typical angular size is larger than that of the halo's virialized core, which provides a possible avenue to separate Rees-Sciama signatures from scattering signatures of Sunyaev-Zeldovich effects. We argue that this effect can be potentially utilized not only to probe the dynamics of dark matter halos, but also to measure cosmological parameters such as $H(z)$ and $\Omega_m(z)$.

2:06PM S9.00004 Cosmology with CMB measurements from ACTPol: current status and future constraints. FRANCESCO DE BERNARDIS, Cornell University, ACTPOL COLLABORATION — Measurements of the polarization of the Cosmic Microwave Background (CMB) contain important information complementary to the temperature anisotropies. The ACTPol polarization sensitive receiver for the Atacama Cosmology Telescope (ACT) is measuring CMB polarization from arcminute to degree scales. These data will improve constraints on cosmological parameters, in particular on neutrino mass, dark energy and inflationary models. One of the unique advantages of ACTPol is its ability to overlap with several large scale structure surveys, allowing cross-correlation studies that will achieve even stronger constraints on the cosmological parameters. Additional science is enabled by the combination of high sensitivity and arcminute resolution, such as surveys of galaxy clusters and new probes of dark energy via the thermal and kinematic Sunyaev-Zeldovich (SZ) effects. Beyond ACTPol is the stage III Advanced ACTPol project, which offers greater sensitivity and frequency coverage than ACTPol. I will discuss ACTPol constraints and projections achievable with the Advanced ACTPol experiment. I will focus in particular on neutrino mass and on dark energy constraints from measurements of galaxy clusters peculiar velocities made by combining SZ effect measurements with galaxy surveys data.

2:18PM S9.00005 ACTPol: Status and preliminary CMB polarization results from the Atacama Cosmology Telescope. BRIAN KOOPMAN, Cornell University, ACTPOL COLLABORATION — The Atacama Cosmology Telescope Polarimeter (ACTPol) is a polarization sensitive upgrade for the Atacama Cosmology Telescope, located at an elevation of 5190 m on Cerro Toco in Chile. In summer 2013, ACTPol achieved first light with one third of the final detector configuration. The remaining two thirds of the detector array will be installed during spring 2014, enabling full sensitivity, high resolution, observations at both 90 GHz and 150 GHz. Using approximately 3,000 transition-edge sensor bolometers, ACTPol will enable measurements of small angular scale polarization anisotropies in the Cosmic Microwave Background (CMB). I will present a status update for the ACTPol receiver and some preliminary results. ACTPol measurements will allow us to probe the spectral index of inflation as well as to constrain early dark energy and the sum of neutrino masses.

2:30PM S9.00006 SPTPol Measurement of E and B-mode CMB Polarization. TYLER NATOLI, Univ of Chicago, SPTPOL COLLABORATION — The South Pole Telescope Polarimeter (SPTpol) began observations of the cosmic microwave background (CMB) in February 2012. The instrument features dual polarization transition edge sensor bolometers in two bands, 588 pixels (1176 bolometers) at 150 GHz and 180 pixels (360 bolometers) at 95 GHz. During the first year of observations SPTpol covered a 100 square degree patch of sky, which led to the first detection of B modes produced by gravitational waves. This field has now been mapped in polarization to a depth of 9 $\mu$K-arcmin at 150 GHz and 19 $\mu$K-arcmin at 95 GHz. Measurements of CMB polarization anisotropy will provide information that cannot be obtained with temperature measurements alone. Measuring even parity modes, E modes, will lead to tighter parameter constraints and tests of the cosmological implications. Here we will present the SPTpol E and B mode measurements and constraints on neutrinos and dark energy.

2:42PM S9.00007 The E and B Experiment: EBEX. KYLE HELSON, Brown University, THE EBEX COLLABORATION — We report on the status of the E and B Experiment (EBEX) a balloon-borne polarimeter designed to measure the polarization of the cosmic microwave background radiation. The instrument employs a 1.5 meter Gregorian Mizuguchi-Dragone telescope providing 5 arc-minute resolution at three bands centered on 150, 250, and 410 GHz. A continuously rotating achromatic half wave plate, mounted on a superconducting magnetic bearing, and a polarizing grid give EBEX polarimetric capabilities. Radiation is detected with a kilo-pixel array of transition edge sensor (TES) bolometers that are cooled to 0.25 K. The detectors are readout using SQUID current amplifiers and a digital frequency-domain multiplexing system in which 16 detectors are readout simultaneously with two wires. EBEX is the first instrument to implement TESs and such readout system on board a balloon-borne platform. EBEX was launched from the Antarctic in December 2012 on an 11-day long-duration balloon flight. This presentation will provide an overview of the instrument and discuss the flight and status of the data analysis.
In this talk, I will outline the new structure of the course and detail the effect of the changes on student comprehension, retention, and engagement. The goal of the course is to improve the ability of students to evaluate form and function by enhancing their understanding of general scientific principles. In the beginning, with 60 students in an introductory physics class to the 3000 now attending (January 2014) the around 60 courses offered in almost all areas of environmental engineering and training, inc. — Successful undergraduate physics majors will usually rank in the top 2% of their college class. Such students finishing high school probably have never had a teacher that has a physics degree or a teacher that is as bright as them. Thus they have not considered physics as a field of further study. In a high school that is graduating 200 students I have usually found 2 or 3 such students with no firm college plans. We will discuss when, where and how to recruit these excellent students to your program. Efforts that were tried and do not work will be mentioned. The successful approach working on this kind of projects and our projections for the future.

1Partial travel support from Escuela de Verano

1:54PM S9.00003 Ideas for Use of an IPad in Introductory Physics Education1, TARLOK S. AURORA, University of the Sciences — Mobile devices such as an IPad, tablet computers and smartphones offer an opportunity to collect information to facilitate physics teaching and learning. The data collected with built-in sensors, such as a video camera, may be analyzed on the mobile device itself or on a desktop computer. In this work, first, the circular motion of a steel ball rolling in a cereal bowl was analyzed to show that it consisted of two simple harmonic motions, in perpendicular directions. Secondly, motion of two balls - one dropped vertically down, and the other one launched as a projectile - was analyzed. Data was analyzed with Logger Pro software, and value of g was determined graphically. Details of the work, its limitations and additional examples will be described. The material so far presented illustrates the potential of using mobile devices in introductory physics classes.

1The author is thankful to USciences for the IPad; and Rich Cosgriff, Phyllis Blumberg and Elia Eschenazi for useful discussions.
Maryland

Numerical simulations of singularities have been done and the extent to which the above conjecture has been verified by the simulations.

Inside black holes are two types of singularities: one that is spacelike, local, and oscillatory, and the other that is null and weak. This talk will review what the precise nature of these singularities. More information can be found using analytic approximations and numerical simulations. It is conjectured that

KLE, Oakland University — The singularity theorems of general relativity tell us that spacetime singularities form in gravitational collapse, but tell us very little about the nature of these singularities. More information can be found using analytic approximations and numerical simulations. It is conjectured that

ASHTEKAR, IGC and Physics Department, The Pennsylvania State University — The Belinski, Khalatnikov and Lifshitz conjecture says that as one approaches

Equations

Shoemaker, Georgia Institute of Technology

This work was supported by the NSF grant PHY-1205388 and the Eberly research funds of Penn state.

This research has been supported by the NSF under grant PHY 1306441.

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2:30PM S10.00006 Novel approaches for inspiring students and electrifying the public

SUZY LIDSTROM, Physica Scripta, Royal Swedish Academy of Sciences, Stockholm, ALEX READ, University of Oslo, STEPHEN PARKE, Fermilab, ROLAND ALLEN, Texas A&M University, STEVEN GOLDFARB, CERN, SASCHA MEHLHAUSE, Niels Bohr Institute, TORD EKELÖF, Uppsala University, ALAN WALKER, Edinburgh University — We will briefly summarize a wide variety of innovative approaches for inspiring students and stimulating broad public interest in fundamental physics research, as exemplified by recent activities related to the Higgs boson discovery and Higgs-Englert Nobel Prize on behalf of the Swedish Academy, CERN, Fermilab, and the Niels Bohr Institute. Personal interactions with the scientists themselves can be particularly electrifying, and these were encouraged by the wearing of “Higgs Boson? Ask Me!” badges, which will be made available to those attending this talk. At CERN, activities include Virtual Visits, (Google) Hangout with CERN, initiatives to grab attention (LEGO models, music videos, art programs, pins, etc.), substantive communication (lab visits and events, museum exhibits, traveling exhibits, local visits, Masterclasses, etc.), and educational activities (summer student programs, semester abroad programs, internships, graduate programs, etc.). For serious students and their teachers, or scientists in other areas, tutorial articles are appropriate. These are most effective if they also incorporate innovative approaches — for example, attractive figures that immediately illustrate the concepts, analogies that will resonate with the reader, and a broadening of perspective.

1Physica Scripta, Royal Swedish Academy of Sciences

2:42PM S10.00007 RiSA: A Science Festival for the Bilingual and Bicultural Rio Grande Valley

JOEY SHAPIRO KEY, CRISTINA TORRES, ROBERT STONE, University of Texas at Brownsville — The Rio Grande Science and Arts (RiSA) Festival organized by the Center for Gravitational Wave Astronomy (CGWA) at the University of Texas at Brownsville (UTB) will use a wide variety of artforms to bring physics and science topics to the bilingual and bicultural population of the Rio Grande Valley of South Texas. The science and art faculty at UTB will partner with art and education professionals to create an annual community event celebrating science though art. Music, dance, poetry, and visual arts will headline the festival activities. Festival events and products will be produced in both English and Spanish to attract and inform the bilingual local community. The RiSA Festival is supported by the Science Festival Alliance and the Sloan Foundation.

1Supported by the Science Festival Alliance and the Sloan Foundation

2:54PM S10.00008 Federal STEM Educator Professional Development Programs: a discussion of funding, approaches, and implementation

ALINE MCNAULL, American Institute of Physics — Effective professional development is vital to training the next generation of quality science, technology, engineering, and math (STEM) teachers. I will discuss approaches used to improve educator professional development under the Higher Education Act and Elementary and Secondary Education Acts. I will examine how federal funding is currently being allocated and summarize some of the programs that are being implemented whose aim is to improve content knowledge and provide disciplinary specific pedagogy in professional development. The recent proposed reorganization of STEM education programs in the FY 2014 budget sparked significant debate among policy-makers; however the issue of quality K-12 instruction has remained important to the physics societies. I will provide an update on these discussions and on the status of federal STEM teacher training programs in the FY 2015 budget proposal.

Monday, April 7, 2014 1:30PM - 3:18PM —

Session S11 GGR: Invited Session: Singularities in General Relativity

Oglethorpe Auditorium - Dierdre Shoemaker, Georgia Institute of Technology

1:30PM S11.00001 On the Nature of Singularities in Cosmological Solutions of Einstein’s Equations

JAMES ISENBERG, University of Oregon — The Hawking-Penrose theorems tell us that cosmological solutions of Einstein’s equations are generally singular, in the sense of the incompleteness of causal geodesics (the paths of physical observers). These singularities might be marked by the blowup of curvature and therefore crushing tidal forces, or by the breakdown of physical determinism. Penrose has conjectured (in his “Strong Cosmic Censorship Conjecture”) that it is generically unbounded curvature that causes singularities, rather than causal breakdown. The verification that BKL behavior (marked by the domination of time derivatives over space derivatives) is generically present in a family of solutions has proven to be a useful tool for studying Strong Cosmic Censorship in that family. We discuss what is known about BKL behavior and Strong Cosmic Censorship in families of solutions defined by varying degrees of isometry, and discuss new results which we believe will extend this knowledge and provide new support for Strong Cosmic Censorship.

1This research has been supported by the NSF under grant PHY 1306441.

2:06PM S11.00002 Dynamics near Space-like Singularities and Quantum Bounces

ABHAY ASHTEKAR, IGC and Physics Department, The Pennsylvania State University — The Belinski-Khalatnikov and Lifshitz conjecture says that as one approaches space-like singularities in general relativity, “time derivatives dominate over spatial derivatives” so that the dynamics at any spatial point is well captured by an ordinary differential equation. This talk will review results from a formulation of this conjecture motivated by Hamiltonian “connection dynamics” both in classical general relativity and loop quantum cosmology.

1This work was supported by the NSF grant PHY-1205388 and the Eberly research funds of Penn state.

2:42PM S11.00003 Numerical Investigations of Singularities in General Relativity

DAVID GARFIN-KLE, Oakland University — The singularity theorems of general relativity tell us that spacetime singularities form in gravitational collapse, but tell us very little about the precise nature of these singularities. More information can be found using analytic approximations and numerical simulations. It is conjectured that inside black holes are two types of singularities: one that is spacelike, local, and oscillatory, and the other that is null and weak. This talk will review what numerical simulations of singularities have been done and the extent to which the above conjecture has been verified by the simulations.

Monday, April 7, 2014 1:30PM - 2:42PM —

Session S12 DPF: Flavor Physics: Charged Leptons and Updates

100 - Nicholas Hadley, University of Maryland
1:30PM S12.00001 Analyzing KOTO Data With Correlation Coefficients\textsuperscript{1}. DUNCAN MCFARLAND, JOSEPH COMFORT, Arizona State University — The KOTO experiment is underway at the J-PARC laboratory to measure the branching ratio for the $K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$ decay. The ratio provides a direct measure of Standard Model parameter that is responsible for CP violation, and the SM prediction of $2.4 \times 10^{-11}$ has small uncertainties. Two-photon events will be detected in a large array of 2716 CsI crystals, surrounded by veto detectors to suppress backgrounds. The raw signals are filtered to produce Gaussian-shaped peaks and digitized to provide both energy and time information. Sensitivity to very small signals is needed. We have developed a method that leverages the nearly constant peak shape to distinguish real signals from noise with high reliability. Its use and performance will be applied to the analysis of early data from a 2013 run.

\textsuperscript{1}Supported by DOE grant DE-SC0006497


1:42PM S12.00002 Searching for Heavy Photons with TREK. PETER MONAGHAN, Hampton University — Experiment TREK/E36 at J-PARC to test lepton flavor universality and to search for new particles is expected to run in 2015. The possibility of a massive dark photon opens up new avenues of physics beyond the standard model. The motivation for the existence of photon-like gauge bosons can be seen in the observed positron excess in the universe, occurring via dark matter annihilation; through the muon anomalous magnetic moment, where theory and experiment disagree; through the proton radius puzzle, where the discrepancy between measurements of electronic and muonic hydrogen could be reconciled with a neutral gauge boson with selective coupling. This talk explores the opportunity to search for a neutral gauge boson in rare kaon decay channels. An in-depth look at such a search with experiment E36 at the J-PARC facility in Japan will be presented.

1:54PM S12.00003 Producing a Precision Magnetic Field in the Muon $g - 2$ Experiment at Fermilab. BRENDAN KIBURG, Fermilab — A new effort to measure the muon's anomalous magnetic moment is currently underway at Fermilab. The 3σ discrepancy between theoretical calculations of the muon's anomalous magnetic moment and the Brookhaven E821 measurement motivates this experiment. The main systematic uncertainties are related to the detection of the decay positron produced in muon decay, and the production and measurement of the precision magnetic field in the muon storage ring. To reach the precision goal of 140 ppb, the muon $g - 2$ experiment will implement several upgrades to the E821 approach and collect 20 times as many muons. This talk will give a brief overview of the experimental status. The upgrades associated with the production and measurement of the highly uniform magnetic field will be described.

2:06PM S12.00004 A SQUID-based $^3$He Co-magnetometer Readout for the SNS nEDM Experiment. YOUNG JIN KIM, STEVEN CLAYTON, Los Alamos National Laboratory — A discovery of a permanent electric dipole moment (EDM) of the neutron would provide one of the most important low energy tests of the discrete symmetries beyond the Standard Model of particle physics. A new experimental neutron EDM search, to be conducted at the Spallation Neutron Source (SNS) at ORNL, has been proposed to improve the present experimental limit of $10^{-30}$ e·cm by two orders of magnitude. The experiment is based on the magnetic-resonance technique in which polarized neutrons precess at the Larmor frequency when placed in a static magnetic field; a non-zero EDM would be evident as a difference in precession frequency when a strong electric field is applied parallel vs. anti-parallel to the magnetic field. In addition to its role as neutron spin-analyzer via the spin-dependent n+ + n nuclear capture process, polarized helium-3 (which has negligible EDM) will serve as co-magnetometer to correct for drifts in the magnetic field. The helium-3 magnetization signal will be read out by superconducting gradiometers coupled to SQUIDs. We describe a proposed SQUID system suitable for the complex neutron EDM apparatus, and demonstrate that the field noise in the SQUID system, tested in an environment similar to the EDM apparatus, meets the nEDM requirement.

2:18PM S12.00005 Study of b baryons using D0 Run II data. JOSE ANDRES GARCIA, CINVESTAV, D0 COLLABORATION — We present a search for $b$ baryons decaying into $J/\psi$ final states using the full D0 Run II dataset, corresponding to an integrated luminosity of 10.4 fb$^{-1}$ of proton-antiproton collisions. The search includes the channels $\Xi^+_b \rightarrow J/\psi \Xi^-$ and $\Omega_b \rightarrow J/\psi \Omega^-$. We extract the lifetimes of these states using the resulting signals, and compare to predictions from theory, and to existing results from CDF.

2:30PM S12.00006 Further Investigation for Exotic Strucutres in the $J/\psi \phi$ Mass Spectrum from Exclusive B decays\textsuperscript{1}. SULEYMAN DURGUT, USCMS, USCMS COLLABORATION — Heavy quarkonium spectroscopy provides insight into strong interactions that are not precisely predictable by QCD theory. The structure $Y(4140)$ observed at CDF, D0 and CMS cannot be explained by classical

\textsuperscript{1}University of Iowa

Monday, April 7, 2014 1:30PM - 3:06PM –
Session S13 DPF GPMFC: Higgs Boson: Theory and Experiment

1:30PM S13.00001 ABSTRACT WITHDRAWN –

1:42PM S13.00002 Measurement of the properties of a Higgs boson in the four-lepton final state. IAN ANDERSON, Johns Hopkins University, CMS COLLABORATION — The properties of a Higgs boson candidate are measured in the $H \rightarrow ZZ \rightarrow 4l$ decay channel, with $\ell = e, \mu$, using data from pp collisions corresponding to an integrated luminosity of 5.1 fb$^{-1}$ at center-of-mass energy of $\sqrt{s} = 7$ TeV and 19.7 fb$^{-1}$ at $\sqrt{s} = 8$ TeV, recorded with the CMS detector at the LHC. The mass, width, production cross section and the production mechanism fractions of the new boson are measured. Several hypotheses of spin-0, spin-1, and spin-2 are tested. A fit for the anomalous couplings of a spin-0 hypothesis is performed. All properties of the Higgs boson candidate are found to be consistent with the Standard Model.

1:54PM S13.00003 Measurement of the Spin and Parity of the Higgs Boson with $H \rightarrow ZZ^* \rightarrow 4l$ Decay Channel Using the ATLAS Detector. NAN LU, University of Michigan, ATLAS COLLABORATION — Measurement of the spin and parity properties of the Higgs boson by the ZZ* decay channel with the ATLAS experiment will be presented. A spin-parity discriminator, boosted decision tree (BDT), is developed to distinguish between different spin-parity states. In addition, a second BDT discriminant is developed to separate Higgs signal and the background from the SM ZZ events. The determination of the spin-parity is obtained by fitting data with 2-dimensional PDF (the probability density function) based on these two BDT outputs. Sensitive discriminate variables are selected for BDT training, and BDT outputs. The spin and parity of the Higgs boson is found to be consistent with the SM predictions.
2:06PM S13.00004 Spin and Parity of the Higgs Boson in the $H \to b\bar{b}$ Decay Channel at D0.
EMILY JOHNSON, Michigan State University, D0 COLLABORATION — We present constraints on the 125 GeV boson spin $J$ and parity $P$ in the $H \to bb$ decay channel in up to 9.7 fb$^{-1}$ of data collected by the D0 detector. We compare the standard model (SM) prediction of $J^P = 0^+$ with two alternative hypotheses, $J^P = 0^+$ and $J^P = 2^+$, in the $ZH \to \ell\nu\bar{b}b$, $WH \to \ell\nu\bar{b}b$, and $ZH \to \nu\nu\bar{b}b$ final states. To distinguish different Higgs boson $J^P$ states we use the invariant mass of the $VH$ system, which is sensitive to the different kinematics of the $J^P$ states. We use a likelihood ratio to quantify the level of preference in data for the $J^P = 0^+$ SM prediction. This presentation will describe the methodology and present the latest results.

2:18PM S13.00005 ABSTRACT WITHDRAWN —

2:30PM S13.00006 Search for the Standard Model Higgs Boson Decaying to $\mu^+\mu^-$ in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the CMS Detector.
JUSTIN HUGON, University of Florida, CMS COLLABORATION — A search for the standard model Higgs boson in the rare $\mu^+\mu^-$ decay channel is presented. The data samples, recorded by the CMS experiment at the LHC, correspond to integrated luminosities of 5.0 ± 0.1 fb$^{-1}$ at 7 TeV center-of-mass energy and of 19.7 ± 0.5 fb$^{-1}$ at 8 TeV. To enhance the Higgs signal over the dominant Drell-Yan background, the events are categorized by topologies corresponding to different production processes. Upper limits on the production rate, with respect to the Standard Model prediction, are reported at the 95% confidence level for Higgs boson masses in the range from 120 to 150 GeV/c$^2$.

2:42PM S13.00007 Probing CP Violation in $h \to \gamma\gamma$ with Converted Photons$^1$.
FADY BISHARA, University of Cincinnati/Fermilab, YUVAL GROSSMAN, Cornell University, RONI HARNIK, Fermilab, DEAN ROBINSON, University of California Berkeley/LBL, JING SHU, KitP China, JURE ZUPAN, University of Cincinnati — We study Higgs diphoton decays where both photons convert to electron-positron pairs in the field of a nucleus in a silicon tracker. The kinematic distribution of the two electron-positron pairs may be used to probe the CP violating (CPV) coupling of the Higgs to photons, that may be produced by new physics. Further, interference terms in the differential rate are linearly proportional to the CPV coupling of Higgs to two photons but vanish in the integrated rate which is only quadratically sensitive. We derive compact expressions for the fully differential rate which we use to generate Monte Carlo (MC) events with a dedicated code. We then apply experimental cuts to the MC events to enhance the CPV signal. We show that there exist regions of phase space on which sensitivity to CPV is of order unity.

$^1$FB is supported in part by the Fermilab Fellowship in Theoretical Physics.

2:54PM S13.00008 Search for the standard model Higgs boson in the $Z(l\bar{l})H(b\bar{b})$ channel using jet substructure.
INGA BUCINSKAITE, Univ of Illinois - Chicago, CMS COLLABORATION — A search for the standard model Higgs boson decaying to $bb$ produced in association with a $Z$ boson decaying to $e^+e^-$ or $\mu^+\mu^-$ is presented. The search is performed with a data sample corresponding to an integrated luminosity of 19.7 fb$^{-1}$ at $\sqrt{s} = 8$ TeV, recorded by the CMS experiment at the LHC. Two techniques for reconstructing the Higgs candidate are discussed: the standard method using two jets reconstructed with the anti-$k_T$ algorithm, and a second technique using jet substructure that was developed for highly boosted massive particles.

Monday, April 7, 2014 1:30PM - 3:18PM —
Session S14 DPB DPF: Topics in Accelerators and Beams

1:30PM S14.00001 High field muon ionization cooling channel for micron scale emittance.
HISHAM SAYED, ROBERT PALMER, Brookhaven National Laboratory — A muon collider with center of mass energy of 1.5 TeV can achieve luminosity of $10^{34} \text{cm}^{-2} \text{sec}^{-1}$ provided that the muon beam normalized transverse emittance be of the order of 25 microns. We present a complete final ionization cooling channel that can achieve such low transverse emittance requirements. The cooling is performed using liquid Hydrogen absorbers embedded in 40 T solenoids. A full simulation of the channel will be discussed including the re-accelerating and matching between stages. Additional studies of the space charge effects and absorber heating will be also covered.

1:42PM S14.00002 A complete six-dimensional beam cooling scheme for a Muon Collider.
DIKTYS STRATAKIS, SCOTT BERG, ROBERT PALMER, Brookhaven National Laboratory — A high luminosity muon collider requires a significant reduction of the six-dimensional emittance prior acceleration. Obtaining the desired emittances requires transporting the muon beam through long section of a beam channel containing rf cavities, absorbers, and focusing solenoids. Here we propose new scheme to improve the performance of the channel, consequently increasing the number of transmitted muons and the lattice cooling efficiency. The key idea of our scheme is to tune progressively the main lattice parameters, such as the cell dimensions, rf frequency, and coil strengths, while always keeping the beam emittance significantly above the equilibrium value. We use the aid of this novel approach we present for the first time a complete cooling scheme for a Muon Collider, and demonstrate a notable 6D emittance decrease by five order of magnitude. We review key parameters such as the required fields, frequencies and gradients for a complete muon cooling scenario.

1:54PM S14.00003 Construction and Physics program for MICE next step IV.
BEN FREEMIRE, Illinois Institute of Technology, Chicago, MICE COLLABORATION$^1$ — The International Muon Ionisation Cooling Experiment is progressing towards full demonstration of the feasibility of this cooling technology decisive for neutrino physics and muon colliders. Its next step IV should provide the first precise measurements of emittances and first evidence of cooling. Spectrometer solenoids, muon trackers and absober-FC (focus coil) modules are being assembled to make this possible in 2015. The physics programme of ionisation cooling Step IV measurements will be described in detail, with Li-H and a few other promising absorber materials of different shapes. So will the progress of the hardware. The longer term final step V and step VI complete demonstration measurements being simultaneously prepared (re-accelerating RFCC modules, RF cavities inside their own focusing CC (“coupling” coils) will also be outlined.

$^1$Muon Ionisation Cooling Experiment
2:06PM S14.00004 Non-Scaling FFAG lattice for the eRHIC, DEJAN TRBOJEVIC, STEVEN BROOKS, FRANCOIS MEOT, SCOTT BERG, WUZHENG MENG, NICHOLAOS TSOPHAS, BRETTE PARKER, VADIM PTISTYN, PETER THIEBERGER, VLADIMIR LITVINENKO, THOMAS ROSE, MICHIKO MINTY, Brookhaven Nation Laboratory — The future electron ion collider eRHIC the “QCD test facility” will continue extraordinary results of the present Relativistic Heavy Ion Collider RHIC. There will be collisions between polarized electrons with heavy ions and with polarized protons/He\(^1\) using existing superconducting RHIC accelerator and with electrons accelerated inside of the existing tunnel. Electron acceleration will be with the Electron Recovery Linac (ERL) with a combination of Non-Scaling Fixed Field Alternating Gradient arcs. Two NS-FFAG allow electrons to pass through the same structure with an energy range between 1.334 and 21.1 GeV. After collisions the beam is brought back by the NS-FFAG’s and decelerated to the initial energy and directed to the dump.

2:18PM S14.00005 Radiation Heating Analysis for Superconducting Undulator, LAURA BOON, Purdue Univ, KATHERINE HARKAY, YURY IVANYUSHENKOV, YUKO SHIROYANAGI, Argonne National Laboratory — In January 2013 the Advanced Photon Source commissioned a Superconducting Undulator (SCU). The superconducting magnet is thermally isolated from the beam vacuum chamber, which absorbs the beam-induced heating [Y. Ivanyushenkov et al, IEEE T. Appl. Supercon. 22 (3) (2012) DOI: 10.1088/1742-6596/425/3/032007]. The cryo-coolers cooling the vacuum chamber can handle 40 W of heating. Throughout the SCU design process calculations were made to determine the radiation heating from an on-axis and off-axis electron beam. Simulation results show that when the electron beam is vertically off-axis radiation heating increases from the on-axis heating of less than 1 W. During user operation beam-position-limiting detectors (BPLD) are used to limit beam motion and keep the radiation heating below 25 W. During machine studies when the BPLD is not armed other measures must be taken to protect the SCU. Presented in this talk will be the comparison between analytical calculations and measured temperature rise on the installed SCU. The measured temperatures have been converted to a power using a finite element model.

2:30PM S14.00006 Beam Position Monitoring in the CSU Accelerator Facility, JOSHUA EINSTEIN, MAX VANKEUREN, STEPHEN WATRAS, Colorado State Univ — A Beam Position Monitoring (BPM) system is an integral part of an accelerator beamline, and modern accelerators can take advantage of newer technologies and designs when creating a BPM system. The Colorado State University (CSU) Accelerator Facility will include four stripele detectors mounted around the beamline, a low-noise analog front-end, and digitization and interface circuitry. The design will support a sampling rate greater than 10 Hz and sub-100 μm accuracy.

2:42PM S14.00007 High Repetition Rate Crab Cavity Prototype for an Electron-Ion Collider, ALEJANDRO CASTILLA, JEAN DELAYEN, Old Dominion University/ Jefferson Lab — A 750 MHz superconducting rf dipole cavity has been studied as part of the crab crossing correction system for a large crossing angle (50 mrad) and high current electron-ion collider (0.5/3 A per bunch). The crab cavity prototype for Jefferson Lab’s Medium Energy Electron-Ion Collider (MEIC) has been built at Niowave, Inc. In this talk we will present the principal rf properties of the design such as a broad separation of the Higher Order Modes (HOM) with respect to the operating (fundamental) mode, high quality factor, balanced surface electric and magnetic fields and low multipacting barriers, along with the results and experimental analysis of the cavity performance at 4 K and 2 K during tests realized at the Jefferson Lab facilities.

2:54PM S14.00008 Superconducting Spoke Cavities for High-Velocity Applications, CHRISTOPHER HOPPER, JEAN DELAYEN, Old Dominion University — Low frequency, compact half-wave cavities, including spoke cavities, are typically designed for the low energy section of particle accelerators. The advantages these structures offer can also prove beneficial for the high-velocity section of accelerators designed for certain applications. In this talk, the basic electromagnetic design considerations and proposed applications will be presented.

3:06PM S14.00009 Design of a New Acceleration System for High-Current Pulsed Proton Beams from an ECR Source, ANDREW L. COOPER, IVAN POGREBNYAK, JASON T. SURBROOK, KEEGAN J. KELLY, University of North Carolina at Chapel Hill and TUNL, BRET P. CARLIN, Duke University and Triangle Universities Nuclear Laboratory (TUNL), ARTHUR E. CHAMPAGNE, THOMAS B. CLEGG, University of North Carolina at Chapel Hill and TUNL — A primary objective for accelerators at TUNL’s Laboratory for Experimental Nuclear Astrophysics (LENA) is to maximize target beam intensity to ensure a high rate of nuclear events during each experiment. Average proton target currents of several mA are needed from LENA’s electron cyclotron resonance (ECR) ion source because nuclear cross sections decrease substantially at energies of interest <200 keV. We seek to suppress undesired continuous environmental background by pulsing the beam and detecting events only during beam pulses. To improve beam intensity and transport, we installed a more powerful, stable microwave system for the ECR plasma, and will install a new acceleration system. This system will: reduce defocusing effects of the beam’s internal space charge; provide better vacuum with a high gas conductance accelerating column; suppress bremsstrahlung X-rays produced when backstreaming electrons strike internal acceleration tube structures; and provide better heat dissipation by using deionized water to provide the current drain needed to establish the accelerating tube’s voltage gradient. Details of beam optical modeling calculations, proposed accelerating tube design, and initial beam pulsing tests will be described.

Monday, April 7, 2014 1:30PM - 3:18PM — Session S15 Gravitational Waveform Modeling 103-

1:30PM S15.00001 Applying Late-Merger IRS Multi-Mode Templates to Parameter Estimation, BERNARD KELLY, University of Maryland, Baltimore County & NASA GSFC, JOHN BAKER, NASA GSFC — The IRS picture [Baker et al. PRD 78:044046 (2008); Kelly et al. 84:084009 (2011)] visualises black-hole-binary late-inspiral/merger/ringdown gravitational waveforms as being generated by a single “implicit rotating source,” with the most important waveform angular modes being locked in phase through merger into ringdown. This led to the development of late-merger/ringdown waveform templates for the dominant modes of the binary for nonspinning black holes, and for holes with aligned (non-precessing) spins. We report on the current status of the original IRS model as used in multi-mode templates. We consider its performance for the most important } |m| = ℓ modes. We also consider the inconvenient behavior of } |m| < ℓ waveform modes, focusing on their physicality, how they may be treated in the IRS picture, and implications for other approaches to constructing template banks that reach beyond the dominant quadrupole radiation for black-hole binary mergers.
1:42PM S15.00002 Extending empirical models for binary black hole merger-ringdown waveforms to include late inspiral, JOHN BAKER, NASA-Goddard Space Flight Center, BERNARD KELLY, CRESST/UMBC and GSFC — Analytic and empirical models for gravitational merger waveforms are a valuable tool for efficiently encoding the information from expensive numerical relativity simulations. Such models can be applied as a practical intermediary for gravitational-wave data analysis studies and may provide interesting heuristics for interpretation of waveform phenomenology. In the Implicit Rotating Source description of waveforms, we exploit the simple structure of computed spherical harmonic components for near-circular mergers, to represent the waveforms through the secular development of a circularly polarized waveform. We have previously presented waveform models for the most powerful merger-ringdown portions of these waveforms following an approach which first describes rotational frequency as a function of time, then treats amplitude in terms of the phasing behavior. A parametric representation of time and frequency allows useful extension of the waveforms back through the late inspiral. We present results showing precise fits for numerical relativity ($\ell = 2, m = 2$) waveform phasing with the extended model.

1:54PM S15.00003 Effective-one-body modeling of generic black-hole binaries, ANDREA TARACCHINI, University of Maryland — We report on the current status of the effective-one-body description of gravitational-wave emission from black-hole binaries. An ongoing effort at the interface between analytical and numerical relativity aims at the construction of an accurate model that could be used for detection and parameter estimation with advanced ground-based detectors. We will show how the effective-one-body model has been extended to generic mass ratios and spin magnitudes in nonprecessing systems by calibrating it to a large catalog of numerical-relativity waveforms. We will also discuss how to build precessing waveforms starting from such accurate nonprecessing model, and show comparisons with numerical relativity.

2:06PM S15.00004 Spin Precession: Breaking the degeneracy between Neutron Stars and Black Holes¹, KATERINA CHATZIOANNOU, NEIL CORNISH, ANTOINE KLEIN, NICOLAS YUNES, Montana State Univ — Gravitational waves from spin-precessing compact binaries carry a lot of information about the system that emitted them. However, our ability to extract the system's parameters, is related to the accuracy of the models we use when analyzing the data. More specifically, models that do not capture the information that comes from the precession of the orbital plane due to spin-orbit coupling lead to degeneracies between neutron stars and black holes. In this talk I will describe how one includes such precessional effects in the models, this degeneracy breaks, allowing us to distinguish between standard neutron stars and alternative possibilities, such as black holes or exotic neutron stars with large masses and spins.

¹We acknowledge support from NSF Grant No. PHY-1114374 and NASA Grant No. NNX11AI49G, under 00001944.

2:18PM S15.00005 Surrogate models for EOB gravitational waveforms, SCOTT FIELD, Univ of Maryland-College Park, CHAD GALLEY, Caltech, JAN HESTHAVEN, Ecole Polytechnique Federale de Lausanne, JASON KAYE, Brown University, MANUEL TIGLIO, Univ of Maryland-College Park — Parameterized gravitational waves models specified through ordinary differential equations often carry large evaluation costs. These costs constitute a major bottleneck for many important applications such as Bayesian parameter estimation which can require thousands or millions of model evaluations. In these multi-query contexts the cost per model evaluation dominates the overall simulation time. I will describe how surrogate models can be used to quickly evaluate an underlying parameterized waveform model. Surrogate models are built by accumulating model evaluations at a representative few parameter values and tying together these samples. This offline building stage needs to be performed only once, while its subsequent online use is computationally inexpensive to evaluate. I will show how surrogates can be used to speed up the generation of effective one body waveforms by many orders of magnitude without sacrificing accuracy.

2:30PM S15.00006 Surrogate models for numerical relativity waveforms, CHAD GALLEY, JONATHAN BLACKMAN, California Institute of Technology, SCOTT FIELD, University of Maryland, MARK SCHEEL, BELA SZILAGYI, California Institute of Technology, MANUEL TIGLIO, University of Maryland — Simulating binary black hole coalescences involves solving Einstein's equations with large-scale computing resources that can take months to complete for a single numerical solution. This engenders a computationally intractable problem for multiple-query applications related to parameter space exploration, data analysis for gravitational wave detectors like LIGO, and semi-analytical waveform fits. Recently, reduced order modeling techniques were used to build surrogate models that substitute having to solve the original ordinary/partial differential equations which generate the waveform itself. Whereas the original waveform computation can carry large evaluation costs, the surrogate can be evaluated very quickly and often without loss of accuracy. I discuss a surrogate model for numerical relativity waveforms of non-spinning binary black hole coalescences. This surrogate can be used to generate numerical relativity waveforms with about 15 cycles for mass ratios in the range of 1 to 10 in the matter of milli-seconds as opposed to months compared to the Spectral Einstein Code. The results of this work represent a significant advance in using numerical relativity waveforms for multiple-query applications.

2:42PM S15.00007 Self–force gravitational waveforms for extreme and intermediate mass ratio inspirals: importance of spin–orbit coupling, GAURAV KHANNA, University of Massachusetts Dartmouth, LIOR M. BURKO, Alabama A&M University — We consider the importance of spin–orbit coupling for gravitational-wave dephasing for an extreme or intermediate mass ratio system moving along a quasi-circular Schwarzschild orbit. For the first-order self force we use the fully relativistic force in the Lorenz gauge for eternally circular geodesics. The second-order self force is modeled with its 3.5 post–Newtonian counterpart, and spin–orbit coupling is calculated with the Papapetrou equations. We evolve the system using the osculating orbits method, and obtain the gravitational waveforms, whose phase includes all the terms — within our approximation (and using the self force along circular geodesics) — that are independent of the system’s mass ratio. We find the partial dephasing due to the following terms, all of which contribute at the same order in the mass ratio (i.e., at order unity): the first-order conservative self force, the second-order dissipative self force, and spin–orbit coupling. We discuss the relative importance of each of these effects.

2:54PM S15.00008 Self-forced evolutions for comparable and intermediate mass ratio coalescences, ELIU HUERTA¹, West Virginia University, PRAYUSH KUMAR, Syracuse University, JONATHAN GAIR, University of Cambridge, SEAN MCWILLIAMS, West Virginia University — The quest for intermediate mass black holes (IMBHs) has been revived by the recent detection of hyper-luminous X-ray sources. To confirm that these sources host IMBHs, we require a robust measurement of the mass of the central object. Advanced gravitational wave detectors may detect from 1–30 events per year that involve the coalescence of stellar mass black holes with IMBHs in globular clusters. Furthermore, it is expected that neutron star-black hole mergers will have electromagnetic counterparts, whose detection will provide important information about the astrophysical properties of their progenitors. Detecting these events and learning about the stellar dynamics of their environments require accurate waveform models. After discussing the inadequacy of post-Newtonian calculations and black hole perturbation theory to capture the true dynamics of these sources, we introduce a waveform model that includes the inspiral, merger and ringdown phases to describe neutron star-black hole mergers, and explore the information that could be extracted from these events using a four detector network in the context of second and third generation gravitational wave detectors.

¹We introduce a self-forced evolution waveform model that includes the inspiral, merger and ringdown phases to describe neutron star-black hole mergers, and explore the information that could be extracted from these events using a four detector network.
3:06PM S15.00009 Post-newtonian approach for spin effects in compact objects binaries. SYLVAIN MARSAT, University of Maryland College Park — The upcoming new generation of ground-based detectors such as LIGO and VIRGO is likely to allow for the first direct detections of gravitational waves, opening a new window on the universe and on extreme events in the regime of strong-field gravity. Compact object mergers are the most promising sources for these detectors, as for the future space-based experiments. The faintness of the signal has driven a lot of effort to model it as accurately as possible, which is done using a combination of analytical and numerical methods. In this talk, we will address the question of the analytical modelling of spin-orbit effects in the inspiral of compact binaries, within the post-Newtonian approach. From astrophysical observations, black holes spins are expected to be generically close to maximal, and they play an important role by causing orbital plane precession modulating the signal. After a presentation of the formalism, we will report results recently obtained for the spin-orbit dynamics at higher order, as well as the new corresponding contributions to the emitted flux and phasing of the binary, and discuss briefly their importance.

Monday, April 7, 2014 1:30PM - 3:18PM
Session S17 DPB: Invited Session: Division of Physics of Beams Award Session 105-106 - Stan Shriver, Michigan State University


2:06PM S17.00002 Robert R. Wilson Prize: The Quest for Bright, Coherent X-Rays: A Personal Story1. KWANG JE KIM, Argonne Natl Lab — Stories associated with the advances in x-ray source techniques during the last several decades will be told from a personal viewpoint. I will start from the “third-generation” x-ray sources based on storage-ring-based undulators and a struggle to find a proper way to quantify the radiation strength. I will then discuss how the initially incoherent undulator radiation evolves into an intense quasi-coherent radiation via free-electron laser (FEL) interaction. This so-called self-amplified spontaneous emission (SASE) in the x-ray region could be realized with the advent of laser-induced electron guns and forms the basis of the linac-driven “fourth generation” x-ray facilities. An x-ray FEL oscillator (XFELO) will also be feasible if Bragg reflectors, such as diamond crystals, are used as cavity mirrors. An XFELO driven by a CW superconducting linac would be a “real x-ray laser,” producing a steady stream of fully coherent, spectrally pure x-ray pulses. An XFELO can be mode-locked, thus producing x-ray spectral comb, if the cavity length can be fixed to a fraction of the x-ray wavelength by referencing to a narrow nuclear resonance. A mode-locked XFELO will enable x-ray quantum optics experiments, such as matter-wave interferometry, for fundamental physics. Alongside these main themes, stories for novel and “cute” schemes, such as a crossed undulator for polarization switching and an emittance exchanger for swapping the transverse and longitudinal phase space, will also be presented.

1This work was supported by the U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. DE-AC02-06CH11357

2:30PM S17.00003 The “Big-Bang” Process for the Division of Physics of Beams. STAN SCHRIBER, Michigan State University — The Division of Physics of Beams had an interesting creation: starting with inflation, a quite period, and then formations - recognizable events when viewed back in time, interesting “stars” and now in a state where expansion of surrounding events is having impacts.

2:54PM S17.00004 The Making of the U.S. Particle Accelerator School, JEAN DELAYEN, Thomas Jefferson National Accelerator Facility —

2:00PM - 2:00PM .
Session T1 APS: Poster Session III (14:00-17:00) Exhibit Hall -

T1.00001 TESTS OF PHYSICAL LAWS —

T1.00002 Critical Analysis of the Mathematical Formalism of Theoretical Physics. II. Foundations of Vector Calculus, TEMUR Z. KALANOVA, Home of Physical Problems, Pisatetskaya 6a, 100200 Tashkent, Uzbekistan — A critical analysis of the foundations of standard vector calculus is proposed. The methodological basis of the analysis is the unity of formal logic and of rational dialectics. It is proved that the vector calculus is incorrect theory because: (a) it is not based on a correct methodological basis – the unity of formal logic and of rational dialectics; (b) it does not contain the correct definitions of “motion,” “direction” and “vector”; (c) it does not take into consideration the dimensions of physical quantities (i.e., number names, denote names, concrete numbers), characterizing the concept of “physical vector,” and, therefore, it has no natural-scientific meaning; (d) operations on “physical vectors” and the vector calculus propositions relating to the “physical vectors” are contrary to formal logic.

T1.00003 Critical Analysis of the Mathematical Formalism of Theoretical Physics. III. Pythagorean Theorem, TEMUR Z. KALANOVA, Home of Physical Problems, Pisatetskaya 6a, 100200 Tashkent, Uzbekistan — The critical analysis of the Pythagorean theorem and of the problem of irrational numbers is proposed. Methodological basis of the analysis is the unity of formal logic and of rational dialectics. It is proved that the Pythagorean theorem (i.e., a\(^2\) + b\(^2\) = c\(^2\)) where segments a, b, and c are the legs and the hypotenuse of the right-angled triangle, respectively) does not represent an absolute scientific truth: this theorem represents a conventional theoretical proposition. The essence of the Pythagorean theorem is that the Pythagorean theorem is a logical error and, therefore, leads to appearance of irrational numbers when the sum a\(^2\) + b\(^2\) cannot be transformed into the area of the square having side c. Irrational number is image of calculation process and, therefore, it does not exist on the number scale.

T1.00004 A New Left-Right Antisymmetric Theory of Force Unification, RASULKOZHSA S. SHARAFID-DINOV, Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan — Any of neutrinos similarly to a kind of charged lepton has a non-zero mass responsible as well as for its Coulomb behavior. Such a neutrino can possess both electric charge and vector dipole moment. Their form factors appear, for example, at the polarized neutrino scattering in the field of a spinless nucleus. We derive an equation which relates the masses to a lepton has a non-zero mass responsible as well as for its Coulomb behavior. Such a neutrino can possess both electric charge and vector dipole moment. Their form factors appear, for example, at the polarized neutrino scattering in the field of a spinless nucleus. We derive an equation which relates the masses to
The United Theory of the Two Fields of the Electric and Magnetic Nature. RASULKHOZHA S. SHARAFIDDINOVA, Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan — The nature has been created so that to form the compounds of mass and charge. They can explain also the availability of fundamental differences in the masses as well as in the charges of Dirac particles. Such pairs are united in families of a definite flavor, confirming that the same neutrino possesses the magnetic field B, that initially aligns all of the spins of the nuclei along the same axis, after the spin flip and before the neutron is detected. Ww info would be changed only if the detection occurs, the spin flip of the nucleus would reverse before any detection is made. It would no longer be possible to determine which nucleus the neutron scattered off. The result is only interference in the distribution of the neutrons. This change from ww info to interference would be affected by a change in info regarding the nuclei in the crystal since there is no physical process whereby the change in the nuclei can affect the distribution of the neutrons. Altering relaxation time relative to neutron detection time could provide a delayed choice. Another possibility would be to shut off the uniform, strong, external magnetic field B, that initially aligns all of the spins of the nuclei along the same axis, after the spin flip and before the neutron is detected. Ww info would be eliminated since the spin directions of all the nuclei would quickly become essentially random. Maintaining or turning off B could be a delayed choice.

T1.00009 On the Compound Structures of the Neutrino Mass and Charge. RASULKHOZHA S. SHARAFIDINOVA, Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan — The nature has been created so that to form the compounds of mass and charge. They can explain also the availability of fundamental differences in the masses as well as in the charges of Dirac particles. Such pairs are united in families of a definite flavor, confirming that the same neutrino possesses simultaneously both mass and charge. This in turn implies that the force of gravity of the Newton between the two neutrons may be expressed through the force of the Coulomb among these particles and vice versa. If a given situation follows from a unified principle, the mass and charge of a particle correspond to the most diverse form of the same regularity of the nature of this field. Such a correspondence principle expresses the mass-charge duality. From its point of view, each of all possible types of charges testifies in favor of the existence of a kind of inertial mass. Therefore, to show their features, we have established the compound structures of mass and charge. They can explain also the availability of fundamental differences in the masses as well as in the charges of Dirac and Majorana neutrinos. Thereby, findings show clearly that the standard model construction is not quite in line with nature.

T1.00010 Strong Coupling and ALPHA as Boundary Conditions of Gravity. SHANTILAL GORADIA, Retired — Our quantum mechanical derivation of the strong coupling using modified Newtonian inverse square logic in (1) and the fine structure constant (ALPHA) using Boltzmann expression in our book (2) come close to Einstein (1919) merging nuclear force with gravitation and retracting his cosmological constant. Its conflict with the inflationary aspect of the universe can be reconciled with the possibility that the light coming from the receding galaxies follow a curvilinear path increasing in length due to its ever increasing curvature without receding only in the radial direction. In (1), we implicitly show gravity as nothing but the cumulative effect of quantum mechanical forces, making G vary at different locations in the universe. The subsequent effects of gravitational variation would be on the curvature of the paths of the geodesics they create. Further investigation along these lines is warranted as we do not have unification, evidence of graviton, quantum gravity or anything else very concrete after a century of hard work. Strong coupling and ALPHA may be the boundary conditions of gravitational constants.

T1.00011 NUCLEAR PHYSICS —

T1.00012 Analysis of Systematic Errors in Experimental Measurements of Fundamental Symmetries with Polarized Neutrons. JONATHAN SERPICO, IVAN NOVIKOV, Western Kentucky University — Measurements of the fundamental symmetries violation in nuclear reactions with polarized neutrons can provide valuable information on hadronic weak interaction. We have conducted an analysis of systematic sources of error in the measurement of symmetry violation effects due to neutron energy variations and depolarization in the beam. The neutron energy dependence of various observables was calculated in the framework of nuclear resonance reaction theory.

T1.00013 Nucleon and Baryons densities in heavy ion collisions at 1 to 3 GeV/A. HAMOUD ALHARBI, MAUSAUD ALMALIKI, National Center for Mathematics and Physics at KACST — Excited Baryons resonance production is investigated within the Ultra-Relativistic Quantum Molecular Dynamics model (UrQMD). The evolution of density at the collision center for different collision times was investigated. The maximum densities yields at maximum compression time was calculated at differer projectile energies. Radial and angular distribution for nucleon density was calculated for each collision energy. Baryon resonances produced in relativistic heavy ion collisions are present for time much longer than the free Baryon lifetime would suggest, which means that there is a continues baryon reproduction. Our results was in qualitative agreement with previous calculations using isospin dependent Quantum Molecular Dynamics (IQMD).
One of the authors (Z.Z) would like to acknowledge that this work is performed of the Fellowship No:2219 under the TUBITAK-TURKEY.
The stochastic process is zero, these two probabilities coincide. The Neutrosophic Probability that an event A occurs is since there are seven outcomes. The neutrosophic probability is a generalization of the classical probability because, when the chance of determinacy of a

For example, if we toss a regular die on an irregular surface which has cracks, then it is possible to get the die stuck on one of its edges or vertices in a crack with fair dice, coins, roulettes, spinners, decks of cards, random works, while neutrosophic probability deals with unfair, imperfect such objects and processes.

to occur, together with an estimation that some indeterminacy may occur, and the estimation that the event does not occur. The classical probability deals

Neutrosophic probability (or likelihood) [1995] is a particular case of the neutrosophic measure. It is an estimation of an event (different from indeterminacy)

1 Supported by the Air Force Office of Scientific Research, AFSOR 2303EP.

T1.00019 The investigation of dipole excitations in double-even $^{184}$W nuclei at the spectroscopic energy region , ZEMINAE ZENGINERLER, The University of North Carolina at Chapel Hill, FILIZ ERTUGRAL, Sakarya University, EKBER GULYEV, State Agency on Nuclear and Radiological Activity Regulation, Ministry of Emergency Situations, ALI EKBER KULIEV, Institute of Physics, National Academy of Sciences of Azerbaijan — The dipole excitations of double-even nucleus $^{184}$W are studied using the QRPA model with rotational, translational and Galilean invariant Hamiltonian. This approach not only gives opportunity to test for the validity of the present theory and it also allows for the interpretation of the experimentally spin unknown states. The analysis of calculation shows that $M_1$ strength, mainly an orbital character predicted from calculations of orbit-to-spin ratio, has a relative contribution, roughly 63% with summed $M_1$ widths $\Sigma \Gamma_{0\chi}^0(M_1) = 5.3$ meV between $2<\omega_i<3.7$ MeV, to summed ground-state decay widths of dipole mode. The experimental summed widths in the same energy interval is $\Sigma \Gamma_{0\chi}^0$ (exp.) = 4.73 $\pm$ 1.28 meV. On the other hand, several well pronounced electric dipole $K=1$ excitation in spectroscopic region where mainly fulfilled with $M_1$ dipole states is predicted. The total $E1$ widths with $K=1$ is $\Sigma \Gamma_{0\chi}^0(E1) = 2.62$ meV (30% of the summed widths), quite close to the experimental value with $K=0$ and $\Sigma \Gamma_{0\chi}^0$ (exp.) = 2.09 $\pm$ 0.59 meV. The theory also indicates a few positive $\Sigma \Gamma_{0\chi}^0(M1) = 0.24$ meV and negative parity $\Sigma \Gamma_{0\chi}^0(E1) = 0.34$ meV with $K = 0$ states with summed widths, respectively.

T1.00020 Effect of Magnesium and Calcium on Purity of Rice Husk Ash based silicon1, GBADEBO TAOFEEK YUSUF, Osun State Polytechnic - Iree — This paper describes the effect of reducing agents on purity of rice husk based silicon. The rice husk samples were subjected to thermal treatment at 900°C to extract the silica. The silica extracted was subsequently analyzed for the initial impurities and treated with magnesium and calcium powder. The silicon obtained when magnesium was used to reduce the silica resulted in higher purity than that of the Calcium. However the two products gave silicon purities in the range of 94.93% to 96.03%. The result shows that the range of purity meets the requirement as starting raw material for the semiconductor grade silicon. Keywords: Purity, Rice husk ash, Silicon, Magnesium, Calcium.

1 I wish to acknowledge the support of the Management of Osun State Polytechnic Iree for providing me a conducive environment for this publication

T1.00021 FEW BODY SYSTEMS —

T1.00022 First observation of transfer ionization between Ar$^+$ and Br$^-$, I$^-$, THOMAS M. MILLER, NICHOLAS S. SHUMAN, ALBERT A. VIGGIANO, Air Force Research Laboratory, RAINER JOHNSEN, University of Pittsburgh — We have studied reactions between noble gas positive ions and atomic halogen negative ions at thermal energies to determine mutual neutralization rate coefficients. In the cases of Ar$^+$ + Br$^-$ and Ar$^+$ + I$^-$, we have observed not only mutual neutralization, but also transfer ionization, e.g., yielding Ar + Br$^+$ + e$^-$ and Ar + I$^+$ + e$^-$, respectively. The reactions are exothermic at thermal energies, by 0.58 and 2.25 eV, and rate coefficients of 1.9(±0.5) $\times$ 10$^{-9}$ cm$^3$/s, respectively, were measured at 300 K. Transfer ionization accounts for about 40% of the loss of Ar$^+$ in reaction with Br$^-$ and 6% in the I$^-$ case, with the remainder being due to mutual neutralization. Measurements at 400 and 500 K indicate a temperature dependence between $T^{-0.5}$ and $T^{-1}$. In contrast to the Br$^-$ and I$^-$ cases, the transfer ionization reaction between Ar$^+$ and Cl$^-$ is endothermic by 0.82 eV, and only the neutralization channel is observed. We surmise that an initial electron transfer takes place in the reaction at an avoided curve crossing. That process may result in excited Ar$^*$ (perhaps in a 4s state) with enough energy to ionize Br or I.

T1.00023 Inner shell ionization of H isoelectronic series by electron impact , BIDHAN SAHA, Department of Physics, Florida A&M University, Tallahassee, FL-32307, A.K. BASAK, M.A. UDDIN, A.K.F. HAQUE, Department of Physics, The University of Rajshahi, Rajshahi, Bangladesh — An empirical model based on a recent calculation [1] on inelastic interactions of electrons in a medium with approximate expressions for evaluating the differential scattering due to distance and close interactions is reported. It is shown that for inner-shell ionization [2] the two — distance and close—interactions produce almost identical results and thus the total effect can be taken approximately twice the contribution from the distance interactions. Including both theionic and relativistic corrections this model is applied to evaluate the K-shell ionization cross sections of both neutral and ionic targets over wide ranges of incident energies with considerable success. Detail of our findings will be presented at the conference.


T1.00024 NEW PRECISION MEASUREMENT METHODS —

T1.00025 Definition of the Neutrosophic Probability , FLORENTIN SMARANDACHE, University of New Mexico — Neutrosophic probability (or likelihood) [1995] is a particular case of the neutrosophic measure. It is an estimation of an event (different from indeterminacy) to occur, together with an estimation that some indeterminacy may occur, and the estimation that the event does not occur. The classical probability deals with fair dice, coins, roulettes, spinners, decks of cards, random works, while neutrosophic probability deals with unfair, imperfect such objects and processes. For example, if we toss a regular die on an irregular surface which has cracks, then it is possible to get the die stuck on one of its edges or vertices in a crack (indeterminate outcome). The sample space is in this case: {1, 2, 3, 4, 5, 6, indeterminacy}. So, the probability of getting, for example 1, is less than $1/6$. Since there are seven outcomes. The neutrosophic probability is a generalization of the classical probability because, when the chance of determinacy of a stochastic process is zero, these two probabilities coincide. The Neutrosophic Probability that of an event A occurs is

$NP(A) = (ch(A), ch(indet_A), ch(\overline{A})) = (T, I, F),$

where $T, I, F$ are subsets of $[0,1]$, and $T$ is the chance that A occurs, denoted $ch(A)$; $I$ is the indeterminate chance related to A, $ch(indet_A)$; and $F$ is the chance that A does not occur, $ch(\overline{A})$. So, $NP$ is a generalization of the Imprecise Probability as well. If $T, I, F$ are crisp numbers then: $0 \leq T + I + F \leq 3$. We used the same notations $(T,I,F)$ as in neutrosophic logic and set.
T1.00026 An Introduction to Neutrosophic Measure, FLORENTIN SMARANDACHE — We introduce for the first time the scientific notion of neutrosophic measure. Let $X$ be a neutrosophic set, and $\Sigma$ a $\sigma$-neutrosophic algebra over $X$. A neutrosophic measure $\nu$ is defined by $\nu : X \rightarrow \mathbb{R}^2$, where $\nu$ is a function that satisfies the following properties: Null empty set $\nu(\emptyset) = (0, 0)$ and Countable additivity (or $\sigma$-additivity): For all countable collections $\{A_n\}_{n \in \mathbb{N}}$ of disjoint neutrosophic sets in $\Sigma$, one has:

$$\nu \left( \bigcup_{n \in \mathbb{N}} A_n \right) = \left( \sum_{n \in \mathbb{N}} m(\text{determinant}(A_n)), \sum_{n \in \mathbb{N}} m(\text{indeterminant}(A_n)) \right)$$

$$\nu(A) = (\text{measure (determinant part of } A), \text{measure (indeterminant part of } A))$$

The neutrosophic measure is practically a double classical measure: a classical measure of the determinant part of a neutrosophic object, and another classical measure of the indeterminate part of the same neutrosophic object. Of course, if the indeterminate part does not exist (or its measure is zero), the neutrosophic measure is reduced to the classical measure. An approximate number $N$ can be interpreted as a neutrosophic measure $N = d + i$, where $d$ is its determinant part and $i$ its indeterminate part. For example if we don’t know exactly a quantity $q$, but only that it is between let’s say $q \in [0.8, 0.9]$, then $q = 0.8 + i$, where $0.8$ is the determinant part of $q$, and its indeterminate part $i \in [0, 0.1]$.

T1.00027 ACCELERATORS AND STORAGE RINGS —

T1.00028 Achieving Higher Energies via Passively Driven X-band Structures, TAYLAN SIPAHI, NIHAN SIPAHI, STEPHEN MILTON, SANDRA BIEDRON, Colorado State Univ, COLORADO STATE UNIVERSITY TEAM — Due to their higher intrinsic shunt impedance X-band accelerating structures significant gradients with relatively modest input powers, and this can lead to more compact particle accelerators. At the Colorado State University Accelerator Laboratory (CSUAL) we would like to adapt this technology to our 1.3 GHz L-band accelerator system using a passively driven 11.7 GHz traveling wave X-band configuration that capitalizes on the high shunt impedances achievable in X-band accelerating structures in order to increase our overall beam energy in a manner that does not require investment in an expensive, custom, high-power X-band klystron system. Here we provide the design details of the X-band structures that will allow us to achieve our goal of reaching the maximum practical net potential across the X-band accelerating structure while driven solely by the beam from the L-band system.

T1.00029 The CSU Accelerator and FEL Facility, SANDRA BIEDRON, STEPHEN MILTON, ALEX D’AUDNEY, JONATHAN EDELEN, JOSH EINSTEIN, JOHN HARRIS, CHRIS HALL, KAHERN HÖROVITZ, JORGE MARTINEZ, AURALEE MORIN, NIHAN SIPAHI, TAYLAN SIPAHI, JOEL WILLIAMS, Colorado State Univ, COLORADO STATE UNIVERSITY TEAM — The Colorado State University (CSU) Accelerator Facility will include a 6-MeV L-band electron linear accelerator (linac) with a free-electron laser (FEL) system capable of producing Terahertz (THz) radiation, a laser laboratory, a microwave test stand, and a magnetic test stand. The photocathode drive linac will be used in conjunction with a hybrid undulator capable of producing THz radiation. Details of the systems used in CSU Accelerator Facility are discussed.

T1.00030 The origin of mass is velocity of The basic particles, YONGQUAN HAN, 15611860790 — The inside part of substances are composed by the “prototype” of electromagnetic waves— The basic particles are the two particles which moves in circle, the speed of these particles is the result of the mass.internal and external velocity of the objects is zero, the mass of any object is zero too, the mass and velocity Should be proportional, the proportion constant is $4.2 \times 10^{-15}$, mass depends on velocity and mass is measured on the basis of certain velocity. Electromagnetic waves is the smallest particle that can Independent existence and composition material, Revolving velocity of electromagnetic waves decide thereof colour. Now the objects mass is measured which velocity is $2.13 \times 10^{14}$. All object’s temperature is the higher and the higher. The root cause of wave-particle dualism of basic particles is that the two high-speed revolving electrons form flexible “energy ring,” the mass of $\gamma$-rays is $2m = 2k \times v = 2 \times 4.2 \times 10^{-45} \times \left(3 \times 10^8 + 2.1 \times 10^{11}\right) = 1.77 \times 10^{-34}$, the visible light mass is $2m = 2k \times v = 2 \times 4.2 \times 10^{-45} \times \left(1 \times 10^8 + 2.1 \times 10^8\right) = 4.28 \times 10^{-36}$ Author: hanyongquan TEL: 15611860790

T1.00031 BEAM PHYSICS —

T1.00032 Discussion of emittance of a low-energy secondary beam from a long particle production target, HISHAM SAYED, SCOOT BERG, HAROLD KIRK, Brookhaven National Laboratory, KIRK MCDONALD, Princeton University, ROBERT PALMER, Brookhaven National Laboratory — Particle production using high power beam impinging on high z material has various applications for muon accelerators and neutrino factories. A key parameter of the secondary beam is its 6D emittance, where a substantial efforts are exerted to cool down the 6D emittance of the secondary beam utilizing ionization cooling techniques. The physics process of particle production creates a secondary beam with a large angular divergence, which leads to a transverse emittance growth. An axially symmetric magnetic field may act as a mitigator (damping effect) to the initial emittance growth of the secondary beam. In this work we show the dependence of the secondary beam transverse and longitudinal emittance on the axially symmetric focusing field within which the particle production takes place.

T1.00033 Multi-particle simulation of Space Charge Dominated Beam, HUNG-CHUN CHAO, SHYH-YUAN LEE, Indiana University — We develop an efficient multi-particle tracking technique to study space charge effects on beams. The simulation code is used to study the envelope instability and its effect on emittance growth. Furthermore, we examine the feasibility of stopband correction for envelope tune resonance to minimize emittance growth. We also use this code to study other intrinsic space charge resonances.

T1.00034 Relative Determination of Micronutrients of Different Species of Teff (Eragrestis) Seeds of Ethiopia Origin by Calibration Free Laser Induced Breakdown Spectroscopy Technique, DILBETIGLE ASSEFA MAMO, AŞHOK K. CHAUBEY, Addis Ababa University — The laser-induced breakdown spectroscopy technique has been used to analyze the multi-component of three different species of Teff seeds (Red, White and Sirgegna) of Ethiopia origin using a second harmonic (532 nm) of a nanosecond Q-switched Nd: YAG laser focused on the surface of the pelletized powder of Teff seed. Based on the idea of the plasma is homogeneous. The seven essential micronutrients in three species of Teff seeds are identified carbon as a matrix element. Electron density and plasma temperature are calculated applying Saha-Boltzmann equation and Boltzmann plot method. And making use of the semi-quantitative method the three species relative concentrations of (Ca, Mg, Al, Si, Mn, Fe and K) are obtained using Calibration Free Laser Induced Breakdown Spectroscopy (CF-LIBS) technique. The result demonstrated that the relative concentrations of the some elements in the species are different. In Red Teff species Ca is more, but Mg is least. On the contrary Mg is high in Sirgegna and White Teff as compared to Red Teff. And High content of Calcium, Magnesium and Iron micronutrients are found in the three species.

T1.00035 COMPUTATIONAL PHYSICS —
we investigate the use of a two frequency back-bombardment current causes heating of the cathode, and this reduces the ability of the cathode heater to control the bunch charge. In this paper,

HARRIS, Colorado State Univ, JOHN LEWELLEN, Los Alamos National Lab, STEPHEN MILTON, Colorado State Univ — When an un-gated thermionic (mental & physical-muscular), and be able to accomplish plans reliably & efficiently. If you know of book or articles in these topic areas, please email to

energy ... thus yielding Optimal Solutions: These “best” answers, correspond to highest mental coherence, for most facets organism response, beit mental

GURR TEAM — Princeton Physicist J. J. Hopfield’s Mathematical Model of the Mammalian Brain, (Similar To

CORMAC KELLY, South Carolina Governor’s School for Science and Mathematics — Rechargeable batteries play important role in technologies today and they are critical for the future. They are used in many electronic devices and their capabilities need to keep up with the accelerated pace of technology. Efficient energy capture and storage is necessary for the future rechargeable batteries. Charging and discharging characteristics of three popular commercially available re-chargeable batteries (NiCd, NiMH, and Li ion) are investigated and compared with regular alkaline batteries. Pasco’s 850 interface and their voltage & current sensors are used to monitor the current through and the potential difference across the battery. The discharge current and voltage stayed fairly constant until the end, with a slightly larger drop in voltage than current, which is more pronounced in the alkaline batteries. After 25 charge/discharge cycling there is no appreciable loss of charge capacities in the Li ion battery. Energy densities, cycle characteristics, and memory effects will also be presented.

T1.00039 Charge Characteristics of Rechargeable Batteries1, PONN MAHESWARANATHAN, Winthrop University,

Printable CIGS thin film solar cells , XIAOJUAN FAN, Marshall University — Among the various thin film solar cells in the market, CuInGaSe thin film cells have been considered as the most promising alternatives to silicon solar cells because of their high photo-electricity efficiency, reliability, and stability. However, many fabrication of CIGS thin film are based on vacuum processes such as evaporation sputtering techniques which are not cost efficient. This work develops a method using paste or ink liquid spin-coated on glass that would be to conventional ways in terms of cost effective, non-vacuum needed, quick processing. A mixture precursor was prepared by dissolving appropriate amounts of chemicals. After the mixture solution was cooled, a viscous paste prepared and ready for spin-coating process. A slight bluish CIG thin film substrate was then put in a tube furnace with evaporation of metal Se by depositing CdS layer and ZnO nanoparticle thin film coating to a solar cell fabrication. Structure, absorption spectrum, and photo-conversion efficiency for the as-grown CIGS thin film solar cell under study.

T1.00043 The Human Mind As General Problem Solver, Is Observed To Find “Best” Solutions, That Correspond To Highest Mental Coherence: Will Discuss “sing Glass Type Theory” of Princeton Physicist J J Hopfield, Points To How Best Use Our Own Human Mind!!1. HENRY GURR, University of South Carolina Aiken, HENRY GURR TEAM — Princeton Physicist J. J. Hopfield’s Mathematical Model of the Mammalian Brain, (Similar To

T1.00044 A Two Frequency Thermionic Cathode Electron Gun , JON EDELEN, SANDRA BIEDRON, JOHN HARRIS, Colorado State Univ, JOHN LEWELLEN, Los Alamons National Lab, STEPHEN MILTON, Colorado State Univ — When an un-gated thermionic cathode is operated in an RF gun, some fraction of the emitted electrons will return to the cathode due to the change in sign of the electric field in the gun. This back-bombardment current causes heating of the cathode, and this reduces the ability of the cathode heater to control the bunch charge. In this paper, we investigate the use of a two frequency $T_{M(102)}/T_{M(120)}$ electron gun to mitigate this effect. Simulations revealed that for a 100-pC bunch charge operating at 10MV/m gradient the harmonic field produced a 63% reduction in the back-bombardment power.

1Sponsored by the South Carolina Governor’s school for Science and Mathematics under the Summer Program for Research Interns program.

1This work is funded partially by NSF Grant CBET-0853723.
T1.00045 POSTDEADLINE —

T1.00046 GPS constellation as a dark matter detector , MAC MURPHY, GEOFFREY BLEWITT, ANDREI DEREVYANKO, Univ of Nevada - Reno — Despite solid observational evidence for the existence of dark matter, its nature remains a challenge to modern physics. In this work we use the existing GPS constellation as a 50,000 km-aperture dark matter sensor array. We focus on dark matter in a form of stable configurations of light fields (topological defects or TDs). Such defects may lead to transient changes of particle masses and coupling constants, thereby affecting atomic clock frequencies and clock phases across the GPS constellation. Based on cosmological models, the most probable speed of TDs in the barycentric reference frame is $\sim$ 300 km/sec. A TD sweep across the array would generate step-like functions in clock phase for a period of $\sim$ 200 s for the GPS constellation. Since GPS carrier phase data is acquired with few-mm precision at 1s intervals, detecting $\sim$ 1 ns signals in the atomic clock phase over a 200 s aperture is achievable. Observing such a signature would provide evidence of the existence of TDs with a high confidence level, as there is no known mechanism for background events that would mimic such a signature. We present preliminary results of our analysis.

T1.00047 Magnetic dipolar fields in quasi-one-dimensional paramagnetic metal Li$_{1.9}$Mo$_6$O$_{17}$ . GUOQING WU, College of Physics Science and Technology, Yangzhou University, W. GILBERT CLARK, STUART BROWN, Dept. of Physics and Astron., UCLA — A general calculation for the magnetic dipolar fields in paramagnetic systems with non-Cartesian lattice coordinates is described and the field in the Q1D metal Li$_{1.9}$Mo$_6$O$_{17}$ is calculated with observations at the $^7$Li site. We find that the "easy axis" is along the lattice c-axis, as it shows that, with sample rotations around the b-axis, the so called "magic angle" ($\theta_{max}$) corresponding to the magnetic dipolar field minimum is right at the angle 54.7° from the c-axis, while the principle axis (p$_r$) of the electric field gradient (EFG) is along a as determined from our $^7$Li-NMR experiments. Thus the lattice c and a axes are not only the symmetry axes of the lattice structure, but also the symmetry axis for the orientation of the magnetic dipole moments and for the distribution of the surrounding electric charges, respectively. This later character is very unusual as compared with other Q1D and 2D materials. Our calculation also shows that the dipolar field contribute to the local fields significantly at the Li site as one of its major local field sources, with a shift in maximum from $\sim$2ppm above 100 K to $\sim$7ppm at 5 K, agreeing with our $^7$Li-NMR experimental observations and helping the property understanding.

T1.00048 Can an E-space Inter-Domain Interaction potential (EIDIP) be the missing block of Unified theory? , MICHAEL HWANG$^1$. None — A Modified Newtonian Gravitational Potential (MNGP) that has a singularity at a two Normalized Spatial Unit (NSU) distance with a modified gravitational field constant in distance greater than 2 NSU region, and a saturated potential for distance less than 2 NSU region, a different E-space domain. The convolution interaction between two MNGPs results an E-space Inter-Domain Interaction potential (EIDIP), a scalar potential. Between two irrotational objects, the gradient of the scalar EIDIP produces a vector field, EIDIPd; whereas between two rotational objects, the angular EIDIP produces a different vector field, EIDIPr. The EIDIP can be used to model the upper bound of nuclear binding energy and its relationship with Higgs boson mass; the EIDIPd can be used to model the repulsive/attractive characteristic of the inter-nucleon nuclear force and inter-molecule covalent bonding force; the EIDIPr can be used to model the short range asymptotic freedom and long range color confinement behavior of the strong force in the inter-atomic range, and to model the anomalies of Pioneer 10/11 spacecraft sunward acceleration and the galaxy rotational velocity curve at the interstellar distance. A list of null hypothesis testing nodes, extracted from these EIDIP application model simulations and empirical data comparisons, indicates that the EIDIP has a 5 sigma confidence level potential to be the missing blocks in completing the Unified theory.

$^1$https://independent.academia.edu/MichaelYTHwang

T1.00049 Advanced radiation protection? , ROBERT JONES, Emporia State University — In order to have radiation-free nuclear reactions (the purported LENRs) it would be necessary that "...one could fractionate large MeV quanta into millions or even billions of smaller quanta." (P. L. Hagelstein, Infinite Energy, issue 112, page 12, 2013). See also my sci.physics.fusion post of 1 April 2004 and Kan. Sci. Teacher, vol. 7, 12, 1990. If one had such a mechanism it might be even more important for use as general radiation shielding.

T1.00050 ABSTRACT MOVED TO D1.00057 –

T1.00051 ABSTRACT MOVED TO D1.00058 –

T1.00052 ABSTRACT MOVED TO D1.00059 –

T1.00053 ABSTRACT MOVED TO D1.00060 –

T1.00054 Effective Spectral Function for Neutrino Quasielastic Scattering Event Generators , BRIAN COOPERSMITH, ARIE BODEK, University of Rochester, M. ERIC CHRISTY, Hampton University — The spectral functions that are used in modeling the dipolar field contributes to the local fields significantly at the Li site as one of its major local field sources, with a shift in maximum from $\sim$2ppm above 100 K to $\sim$7ppm at 5 K, agreeing with our $^7$Li-NMR experimental observations and helping the property understanding.

T1.00055 General Relativity Explains the Shnoll Effect and Makes Possible Forecasting Earthquakes and Weather Cataclysms , DMITRI RABOUNSKI, LARISSA BORISSOVA, Retired — The Shnoll effect is manifested in the fine structure of the noise registered in stable processes, wherein as the magnitude of signal and the average noise remain unchanged. It is periodic fluctuation of the fine structure of the noise according to the cosmic cycles connected with stars, the Sun, and the Moon. The Shnoll effect is explained herein according to General Relativity, as the twin/entangled synchronization states of the observer’s reference frame. The states are repeated while the observer travels, in common with the Earth, through the cosmic grid of the geodesic synchronization paths that connect his local reference frame with the reference frames of the other cosmic bodies. These synchronization periods are expected to be existing in the noise of natural processes of any type (physics, biology, social, etc.) and such artificial processes as the random number generation by a computer software. These periods match with the periods of the Shnoll effect. The theory gives not only to explain the Shnoll effect, but also allows forecasting the fluctuations in the stock exchange market, the fluctuations of weather, earthquakes, and other cataclysms.
T1.00056 On gravity, other forces in nature and the creation of mass particles and force fields in the universe. PETER SUJAK, Gluon o.s. — This work derives the relation between the Planck constant and currently valid Einstein’s gravitational constant \( h / \kappa = \kappa = \frac{8 \pi G c^2}{c^4} = 2.13 \times 2.11 \times 10^{-42} \). The relation between the Planck constant and Newton’s gravitational, between the Planck constant and 1 Coulomb and 1 Henry is deduced. This work establishes that the Planck constant represents the density of momentum of the void space in the Universe, and momentum of a photon \( p = h / \lambda \) represents the compression of this density, and that the momentum of the photon \( p = h / \lambda_0 \) inevitably equals internal momentum of created proton by \( p_{\text{proton}} = h / \lambda_0 = m_0 c / \pi \). In this work, we state that through generating mass particles, by compressing the density of momentum of the vacuum into a photon and bring this photon to stop, we concurrently generate a gravitational field of these particles. The value of momentum of the gravitational field on the surface of the proton is equal in size, but reversely oriented to the value of the internal momentum of the proton in explicit direction by \( p_{\text{proton}} / \pi = h / \lambda_0 = m_0 c / \pi \). This work proves that gravitational force has its opposite force in the internal momentum of atomic particles of matter. This work maintains that the essence of the composition of all mass matter, as well as force fields in its vicinity, are created in full by the compression of the momentum of the void space in the universe.

T1.00057 A Deep Chandra X-Ray Limit on the Putative IMBH in Omega Centauri. DARYL HAGGERD, Northwestern University/CIERA, ADRIENNE COOL, San Francisco State University, CRAIG HIEINKE, University of Alberta, ROELAND VANDER-MAREL, Space Telescope Science Institute, HALDANN. COHN, PHYLILL LUGGER, Indiana University, JAY ANDERSON, Space Telescope Science Institute — We report a sensitive X-ray search for the proposed intermediate-mass black hole (IMBH) in the Galactic cluster, \( \omega \) Centauri. Combining Chandra X-ray data from Cycles 1 and 13, and obtaining a deep (291 ks) exposure of the central regions of the cluster. We find no evidence for a X-ray point source near any of the cluster’s proposed dynamical centers, and place an upper limit on the X-ray flux from a central source of \( f_{\text{X}}(0.5-7.0 \text{ keV}) \leq 5.0 \times 10^{-16} \text{ erg cm}^{-2} \text{ s}^{-1} \). This corresponds to an unabsorbed X-ray luminosity of \( L_{\text{X}}(0.5-7.0 \text{ keV}) \leq 1.6 \times 10^{39} \text{ erg s}^{-1} \). For a cluster distance of 5.2 kpc, Galactic column density \( N_H = 1.2 \times 10^{21} \text{ cm}^{-2} \) and power-law spectrum with \( \Gamma = 2.3 \). If a \( \sim 10^5 M_{\odot} \text{IMBH} \) resides in the cluster’s core, as suggested by some stellar dynamical studies, its Eddington luminosity would be \( L_{\text{Edd}} \sim 10^{44} \text{ erg s}^{-1} \). The new X-ray limit would then suggest an Eddington ratio \( \lesssim 10 \) lower than even the quiescent state of our Galaxy’s notoriously inefficient supermassive black hole Sgr A*. This study leaves open three possibilities: either \( \omega \) Cen does not harbor an IMBH or, if an IMBH does exist, it must experience very little or very inefficient accretion.

1This work is supported by Chandra Award Numbers GO2-13057A and GO2-13057B issued by the CXO, which is operated by the Smithsonian Astrophysical Observatory for and on behalf of NASA under contract NAS8-03060.

T1.00058 The First Two Years of Electromagnetic Follow-Up with Advanced LIGO and Virgo. BENJAMIN FARR, Northwestern University, LEO SINGER, LARRY PRICE, California Institute of Technology, ALEX URBAN, CHRIS PANKOW, University of Wisconsin-Milwaukee, JOHN VEITCH, Nikhef, SALVATORE VITALE, WILL FARR, University of Birmingham, CHAD HANNA, Perimeter Institute for Theoretical Physics, KIPP CANNON, Canadian Institute for Theoretical Astrophysics, TOM DOWNES, University of Wisconsin-Milwaukee, PHILIP GRAFF, NASA Goddard Space Flight Center, CARL-JOHAN HASTER, MANDEL ILYA, SIDERY TREVOR, VECCHIO ALBERTO, University of Birmingham — We anticipate the first direct detections of gravitational waves later this decade with Advanced LIGO and Virgo. Though these first discoveries will be seminal on their own, they may also have electromagnetic counterparts. During the first two years of operation, 2015 through 2016, we expect the global gravitational-wave detector array to undergo several important changes: increased sensitivity and livetime, as well as expansion from two detectors to three. We model the detection rate and the sky localization accuracy across this transition by analyzing a large, astrophysically motivated population of simulated binary neutron star mergers using detection and sky localization codes that have been expressly built for real-time operation in the Advanced LIGO/Virgo era. We also evaluate how the localization of sources will evolve, from minutes to hours after detection, as more detailed analyses are completed.

T1.00059 Long Term Multiplication Behavior Studies of the 30cmx30cm prototype Gas electron Multiplier, YING WUN YVONNE NG, JAEOHOO YU, SEONGTAE PARK, ANDY WHITE, University of Texas at Arlington, UTA HEP TEAM — The Gas Electron Multiplier (GEM) technology is one of the next generation radiation detector technologies that utilized the ionization in gaseous medium and the electron avalanche to detect a magnified charge value from various radiation and charge particles. With its low building cost, low discharge rate and high resolution, GEM is currently being considered to be one of the candidate gap detectors for the International Linear Collider (ILC) in Japan. It is therefore of crucial for us to study the long term stability of amplification power of the detector. Using cosmic radiation as our radiation source, data has been taken continuously in the past 2 years by the high energy physics group in University of Texas at Arlington to characterize the stability of the 30cmx30cm detector. The effect of atmospheric pressure to the detector amplification is eliminated by a correction algorithm. Noise study has been done to eliminate excessive noise produced by the detector as well as its readout chip. Result shows that the detector gives us a stable 350C average MPV for the cosmic MIPs with few fC of chamber noise and about 0.5 of chip noise. GEM should work well as a digital calorimeter for uses in the ILC project.

T1.00060 Analyzing SN 2010ih. DOROTHY DICKSON-VANDERVELDE, Francis Marion Univ — SN 2010ih is a type Ia supernova, which is thought to come from a binary star system in which at least one of the stars is a white dwarf. The white dwarf gains mass until it reaches the Chandrasekhar limit, where the temperature and pressure set off a runaway thermonuclear explosion. We plan to analyze the light curve of the supernova to characterize late-time behavior. We reduced images of Supernova 2010ih taken with the 4m Mayall Telescope using the software Image Reduction and Analysis Facility (IRAF). I removed bad pixels and crosstalk, subtracted the darks and the zeros, divided out the flats, fit the image to a world coordinate system, and then combined the images into a final image, for each filter; B, V, R, and I. After achieving the four final images, I then performed photometry to find the magnitude for the supernova and thirty field stars.

Monday, April 7, 2014 3:30PM - 5:18PM
Session U2 DPF: Invited Session: Instrumentation for Particle Physics Chatham Ballroom A - Sally Seidel, University of New Mexico

3:30PM U2.00001 Noble Liquid Detectors for Dark Matter. ELENA APRILE, Columbia University — The detection of particle dark matter from the cosmos remains one of the most important challenges in physics today. The challenge is being addressed by experiments carried out in space and on Earth, with a variety of detection strategies and technical approaches. The direct detection approach searches for dark matter particles as XENON10, XENON100 and very recently LUX, has led to more than two orders of magnitude improvement in the sensitivity of direct detection experiments. Next generation noble liquid experiments, with several thousands of kg of liquid xenon and liquid argon, are under construction or planned, promising another two orders of magnitude sensitivity increase within this decade. I will review the state-of-the-art in dark matter detection with noble liquid detectors worldwide.

2Thanks to the NSF for the continued support of the XENON Dark Matter project.
4:06PM U2.00002 New Trigger Architectures, TED LIU, Fermilab — No abstract available.

4:42PM U2.00003 Silicon Detectors, HARTMUT SADROZINSKI, SCIPP, Univ. of California Santa Cruz — The use of silicon detectors has experienced an exponential growth in accelerator and space based experiments, similar to trends in the semiconductor industry as a whole, usually paraphrased as “Moore’s Law.” Some of the essentials for this phenomenon will be presented, together with examples of the exciting science results which it enabled. With the establishment of a “semiconductor culture” in universities and laboratories around the world, an increased understanding of the sensors results in thinner, faster, more radiation-resistant detectors, spawning an amazing wealth of new technologies and applications, which will be the main subject of the presentation.

Monday, April 7, 2014 3:30PM - 5:18PM —
Session U3 DNP: Invited Session: DNP Prize/Award Session Chatham Ballroom B - Berndt Mueller, Duke University

3:30PM U3.00001 Herman Feshbach Prize: the Quest for a Fundamental Understanding of the Structure of Nuclei and Nucleons. JOHN NEGELE, Massachusetts Institute of Technology — The inaugural Feshbach prize recognizes lifetime contributions to understanding the structure of the basic building blocks of matter in terms of their constituents and the fundamental interactions between them. Initially this meant understanding the structure of nuclei in terms of nucleons interacting via nucleon-nucleon forces. I will describe a density functional theory for calculating nuclear properties directly from nuclear forces. It identifies mechanisms for “saturation,” relates the Skyrme interaction to nuclear forces, and with two parameters characterizing experimentally unknown aspects of nuclear forces yields nuclear binding energies, single particle energies, and charge distributions close to experiment. After the discovery of quarks and QCD, the goal became understanding how the structure of nucleons and ultimately the missing physics in nuclear forces emerge from quarks interacting via QCD. I will explain the use of lattice QCD to calculate the properties of nucleons, show recent results yielding agreement with experiment for the charge and magnetization radii, magnetic moment, and quark momentum fraction, and comment on the prospects for its use to understand aspects of nuclei and nucleon-nucleon interactions.

1This research was supported in part by the DOE Office of Nuclear Physics under grant #DE-FG02-94ER40818.

4:06PM U3.00002 Bonner Prize Talk: PHENIX, Serendipity and Interferometry, WILLIAM ZAJC, Columbia University — The main portion of this talk will be devoted to the history of the PHENIX Experiment, highlighting the discoveries made in the initial years of RHIC operations, in particular the characterization of the near-perfect fluidity of quark-gluon plasma. Serendipity played a role, but not so much as did the extraordinary efforts of an entire collaboration to deploy and utilize a particularly complex detector to understand the properties of strongly-coupled matter. I will also use the opportunity of the Bonner Prize to discuss briefly the important role of serendipity in research.

4:42PM U3.00003 The Proton Radius Puzzle- A problem for all of us, GERALD A. MILLER, Department of Physics, University of Washington, Seattle WA 98195 — The extremely precise extraction of the proton radius obtained by Pohl et al and Antognini et al from the measured energy difference between the 2P and 2S states of muonic hydrogen disagrees significantly with that obtained from electronic hydrogen or elastic-electron proton scattering. This discrepancy is known as the proton radius puzzle. The talk explains the origins of this puzzle and the reasons for believing it to be important. In particular, the muon-proton interaction may differ from the electron-proton interaction in unexpected ways. Various possible solutions of the puzzle are identified and the future research needed for resolution is discussed.

2This work is partially supported by the USDOE under grant DE-FG02-97ER41014

Monday, April 7, 2014 3:30PM - 5:18PM —
Session U4 DAP: Invited Session: Cosmic Rays Chatham Ballroom C - Angela Olinto, University of Chicago

3:30PM U4.00001 Latest Results from the AMS Experiment, PAOLO ZUCCON, Massachusetts Institute of Technology — The Alpha Magnetic Spectrometer Experiment (AMS) is a US-DOE sponsored particle physics experiment on the International Space Station. The AMS experiment has been installed on the International Space Station since May 19, 2011. Up to now 40 billion high energy cosmic ray events have been collected and analyzed. Some of the latest results will be presented.

4:06PM U4.00002 DAP Young Star: What PeV neutrinos teach us about Cosmic Rays, NATHAN WHITEHORN, Univ of Wisconsin, Madison — The origin of high-energy cosmic rays is one of the most persistent mysteries in physics. Neutrinos, as unambiguous tracers of hadronic acceleration, may offer a new and unique window into this problem and others in high-energy astrophysics. As neutral particles, they travel from their sources undeflected by magnetic fields, and as weakly interacting particles, they travel undisturbed out of dense environments. I will discuss recent results from the antarctic IceCube neutrino observatory, the first operating gigaton-scale neutrino detector, showing strong evidence for a population of extremely high energy neutrinos (100+ TeV) that cannot easily be explained by processes occurring in cosmic ray showers in the Earth’s atmosphere, and the implications of neutrino astronomy for our understanding of cosmic rays.

4:42PM U4.00003 New Results on the Highest Energy Particles, TOSHIHIRO FUJII, KICP, Chicago —

Monday, April 7, 2014 3:30PM - 5:18PM —
Session U9 DAP: Cosmology 203 - Paul Anderson, Wake Forest University
3:30PM U9.00001 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part I
 supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

3:42PM U9.00002 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part II
 supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

3:54PM U9.00003 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part III
 supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:06PM U9.00004 Natural vacuum state for quantum fields in an initially radiation dominated universe and its relationship to the Bunch-Davies state
 supported in part by the National Science Foundation under grant No. PHY-1308325.

4:18PM U9.00005 Quantum instability of global de Sitter space
 supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:30PM U9.00006 Generalizing the Faddeev-Jackiw Technique to Curved Spacetimes to Study Bose-Einstein Condensates in Space
 supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:42PM U9.00007 An Early Cyclic Universe supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

3:30PM U9.00001 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part I

Eric D. Carlson, Andrew J. Lundeen, John R. Einhorn, Paul R. Anderson, Wake Forest University —

The effects of conformally invariant quantum fields on universes with future singularities are investigated. It is assumed that these singularities are caused by dark energy in the form of a perfect fluid with a known equation of state. The sing of the coefficient of the $\mathcal{R}$ term in the trace of the semi-classical backreaction equations determines the behavior of the universe. For one sign, the universe must expand forever, driving it inevitably to the singularity in all cases. For the other sign, the universe will inevitably reach a maximum size, avoiding a future singularity, for big rip (type I) and little rip cosmologies, while it may or may not reach a maximum size before encountering the singularity for type III, II, or IV singularities depending on initial conditions. Though the approach or avoidance of said singularities may occur on the Planck scale, this can be avoided if the coefficient of $\mathcal{R}$ is sufficiently large, possibly due to the presence of large numbers of quantum fields.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

3:42PM U9.00002 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part II

Andrew J. Lundeen, John R. Einhorn, Eric D. Carlson, Paul R. Anderson, Wake Forest University —

The effects of conformally invariant quantum fields on universes with future singularities are numerically investigated. It is assumed that these singularities are caused by dark energy in the form of a perfect fluid with a known equation of state. Comparison is made between the behaviors of the universe for a purely classical analysis, an order reduced quantum analysis, and a fully self-consistent semiclassical backreaction analysis. Numerical results for big rip (type I) and little rip cosmologies are presented. It is found, consistent with theory, that for one sign of the coefficient of $\mathcal{R}$ term in the trace of the semi-classical backreaction equations, the future singularity may or may not be reached, depending on the initial conditions, while for the other sign, the singularity is always reached. However, in every case where the singularity is reached, quantum effects apparently cancel or partially cancel the divergences caused by the classical dark energy.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

3:54PM U9.00003 Effects of Conformally Invariant Quantum Fields on Future Singularities - Part III

John R. Einhorn, Andrew J. Lundeen, Eric D. Carlson, Paul R. Anderson, Wake Forest University —

The effects of conformally invariant quantum fields on universes with future singularities are numerically investigated. It is assumed that these singularities are caused by dark energy in the form of a perfect fluid with a known equation of state. Numerical results for type III, type II, and type IV singularities are presented. It is found that for one sign of the coefficient of $\mathcal{R}$ term in the trace of the semi-classical backreaction equations, the future singularity may or may not be reached, depending on the initial conditions, while for the other sign, the singularity is always reached. However, in every case where the singularity is reached, quantum effects apparently cancel or partially cancel the divergences caused by the classical dark energy.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:06PM U9.00004 Natural vacuum state for quantum fields in an initially radiation dominated universe and its relationship to the Bunch-Davies state

Bradley B. Hicks, Paul R. Anderson, Wake Forest University —

It is shown that if the universe is initially radiation dominated, then for a scalar field with arbitrary mass and curvature coupling there is a natural vacuum state. The evolution of scalar fields in this vacuum state is investigated for a simple model where the presence of a cosmological constant causes the universe to expand exponentially at late times and thus to be asymptotically de Sitter. The question of whether the vacuum state approaches the Bunch-Davies state at late times is addressed.

1Supported in part by the National Science Foundation under grant No. PHY-1308325.

4:18PM U9.00005 Quantum instability of global de Sitter space

Paul R. Anderson, Wake Forest University, Emil Mottola, Los Alamos National Laboratory —

Global de Sitter space is an exact solution to the semiclassical backreaction equations when the quantum fields are in the Bunch-Davies state. For massive scalar fields it is shown that perturbations of the Bunch-Davies state result in deviations of the energy density from its value in the Bunch-Davies state which grow exponentially during the early part of the contraction phase. During the expansion phase the sizes of these deviations decrease. However, in many cases the deviations become large enough to significantly alter the evolution of the universe before the expanding phase is reached.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:30PM U9.00006 Generalizing the Faddeev-Jackiw technique to curved spacetimes to study Bose-Einstein condensates in space

Chanda Prescod-Weinstein, Edmund Bertschinger, Massachusetts Inst of Tech-MIT —

Motivated by the desire to fully understand Bose-Einstein condensates in curved spacetimes, we present a generalization of the Faddeev-Jackiw technique for constraint reduction that simplifies calculating the Poisson brackets for gauge field theories in curved backgrounds. The Faddeev-Jackiw technique is a symplectic approach to phase space coordinate reduction on singular Lagrangians which offers an alternative to the Dirac technique. This approach was generalized by Barcelos-Nieto and Wodzasek to make its application easier. We find that the technique is a useful tool that avoids some of the subtle complications of the Dirac approach to constraints. A major difference between our work and previous formulations is that we do not explicitly construct the symplectic matrix, as that is not necessary. We apply this formulation to the Ginzburg-Landau action and calculate its Poisson brackets in a curved spacetime. We sketch out steps to apply the technique to a Bose field in the gauge theory General Relativity.

1Supported in part by the National Science Foundation under grant Nos. PHY-0856050 and PHY-1308325.

4:42PM U9.00007 An Early Cyclic Universe

William Duhe, Tirthibir Biswas, Loyola University of New Orleans —

We provide a comprehensive numerical study of the Emergent Cyclic Inflation scenario. This is a scenario where instead of traditional monotonic slow roll inflation, the universe expands over numerous short asymmetric cycles due to the production of entropy via interactions among different species. This is one of the very few scenarios of inflation which provides a nonsingular geodesically complete space-time and does not require any “reheating” mechanism.

1A special thanks to Loyola University for an excellent community to help this project grow.
4:54PM U9.00008 Cosmology at \( z = 2.4 \) from the Baryon Acoustic Oscillations measured in the SDSS/DR11 BOSS-LyA quasar sample, ANDREU FONT-RIBERA, Lawrence Berkeley National Laboratory, DAVID KIRKBY, Department of Physics and Astronomy, University of California, Irvine, TIMOTHEE DELUBAC, CEA, Centre de Saclay (France) and Laboratoire d’Astrophysique, École Polytechnique Fédérale de Lausanne (EPFL, Switzerland), NICOLAS BUSCA, APC, Université Paris Diderot-Paris 7 (France), JAMES RICH, CEA, Centre de Saclay (France), ANZE SLOSAR, Brookhaven National Laboratory, STEPHEN BAILEY, Lawrence Berkeley National Laboratory, BOSS COLLABORATION — The Baryon Acoustic Oscillation (BAO) scale, imprinted in the distribution of matter in the Universe, can be used to study the geometry of the Universe as a function of redshift (or cosmic time). Using a total of 160,000 high-redshift quasar spectra at \( z > 2.15 \) from the Sloan Digital Sky Survey III (SDSS-III) Data Release 11 (DR11), we are able to measure the BAO scale at high redshift (\( z = 2.4 \)), both in the auto-correlation of the transmitted flux fraction of the observed flux of a quasar in the Lyman alpha forest region (Delubac et al., in preparation) and in its cross-correlation with the density of quasars (Font-Ribera et al. 2013). From the measurement of the BAO scale along and across the line of sight, we are able to measure the Hubble parameter and the angular diameter distance at \( z = 2.4 \) with an accuracy better than 3%.

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3Baryon Oscillation Spectroscopic Survey

5:06PM U9.00009 DESI and other Dark Energy experiments in the era of neutrino mass measurements, PATRICK MCDONALD, ANDREU FONT-RIBERA, NICK MOSTEK, BETH REID, Lawrence Berkeley Natl Lab, HEE-JONG SEO, Ohio State University, ANZE SLOSAR, Brookhaven National Laboratory — We present projections for future cosmological parameter measurements, including neutrino masses, Dark Energy, curvature, modified gravity, the inflationary perturbation spectrum, non-Gaussianity, and dark radiation. We focus on DESI and generally redshift surveys (BOSS, HETDEX, eBOSS, Euclid, and WFIRST), but also include CMB (Planck) and weak gravitational lensing (DES and LSST) constraints. The goal is to present a consistent set of projections, for concrete experiments, which are otherwise scattered throughout many papers and proposals. We include neutrino mass as a free parameter in most projections, as it will inevitably be relevant – DESI and other experiments can measure the sum of neutrino masses to \( \sim 0.02 \text{ eV} \) or better, while the minimum possible sum is \( \sim 0.06 \text{ eV} \).

Monday, April 7, 2014 3:30PM - 5:18PM
Session U11 GGR DAP: Invited Session: The Transient Gravitational Wave Sky
Oglethorpe Auditorium - Nicolas Yunes, Montana State University

3:30PM U11.00001 Overview of the Transient Gravitational Wave Sky, PABLO LAGUNA, Georgia Inst of Tech — Interferometric detectors will very soon give us an unprecedented view of the gravitational-wave sky, and in particular of the explosive and transient Universe. Now is the time to challenge our theoretical understanding of short-duration gravitational-wave signatures from cataclysmic events, their connection to more traditional electromagnetic and particle astrophysics, and the data analysis techniques that will make the observations a reality. This talk provides an overview of a recent community paper that summarized the state of the art, future science opportunities, and current challenges in understanding gravitational-wave transients.

4:06PM U11.00002 Gamma-Ray Bursts in the Gravitational Wave Era, ROSALBA PERNA, Stony Brook University — The observation of gravitational waves will open a new, unexplored window onto the Universe. Among the sources of gravitational wave transients, compact objects such as neutron stars (NSs) and black holes (BHs) will likely play the most important role. In this talk, I will discuss the expected gravitational wave signal in two important situations: when an NS or a BH is born during a core collapse supernova, and when two compact objects (either NS-NS or NS-BH) in a binary merge. These events are believed to be accompanied by a strong electromagnetic signature in gamma rays – a long Gamma-Ray Burst from the core collapse event, and a Short Gamma-Ray Burst from the binary merger. I will further discuss what we can learn from the complementary observations of the electromagnetic and the gravitational wave signals during these events.

4:42PM U11.00003 Gravitational Wave Observations Expected from the Transient Gravitational Wave Sky, LAURA CADONATI, University of Massachusetts, Amherst and Cardiff University — A new observational era in gravitational wave astronomy is poised to begin in this decade, with the upcoming start of Advanced LIGO and Advanced Virgo: the direct detection of gravitational wave transients promises new insights into the engines powering some of the most energetic astrophysical events. In this talk, I will outline the path towards their detection with the second generation of gravitational wave interferometers, with focus on gravitational wave transients: coalescences of neutron star and/or black hole binary systems, core-collapse supernovae, isolated neutron star instabilities. I will discuss the open analysis challenges, the prospects for astrophysical inference and the potential for multi-messenger astronomy with combined information from the electromagnetic and neutrino sectors.

Monday, April 7, 2014 3:30PM - 5:18PM
Session U12 DPF: Neutrino Experimental Considerations
100 - Robert Bernstein, Fermi National Accelerator Laboratory

3:30PM U12.00001 Studies of the cosmic ray flux in MicroBooNE, KATHERINE WOODRUFF, New Mexico State University, MICROBOONE COLLABORATION — We present a characterization of the cosmic ray rate in MicroBooNE, a 170-ton Liquid Argon Time Projection Chamber (TPC) being built at Fermilab. In order to verify computer simulations of the rates and angular dependence of cosmic muons, we have built a plastic-scintillator detector at the Liquid Argon Test Facility, where MicroBooNE will be located during its run. This will allow us to determine the cosmic ray muon flux through the TPC active volume independently of the MicroBooNE reconstruction efficiency. Preliminary results will be presented.
3:42PM U12.00002 The Coherent Elastic Neutrino Nucleus Scattering (CENNS) Experiment at Fermilab , ROBERT COOPER, Indiana University — Low energy neutrinos (< 50 MeV) with a wavelength larger than target nuclei can engage in coherent elastic scattering with low momentum transfer. Coherent scattering is important in supernovae, low-Q^2 weak nuclear form factors, and low-energy tests of the Standard Model. Despite a large interaction cross section, it has remained unobserved because of its low energy deposition and neutron backgrounds. The CENNS collaboration is proposing to deploy a 1-ton, single-phase, liquid argon detector for a first measurement of coherent neutrino scattering near the booster neutrino beam (BNB) at Fermilab. By placing the detector near the beam target in a far off-axis position, a flux of low-energy neutrinos is produced with a similar energy spectrum as stopped pion sources. The proximity to the BNB introduces a potential background of beam-correlated neutrons whose elastic scatterings are indistinguishable from the neutrino signal. In this talk, I will describe the proposed detector, our completed beam-correlated neutron background measurements, and upcoming shielding and background neutron studies.

3:54PM U12.00033 Neutron Background Characterization for a Coherent Neutrino-Nucleus Scattering experiment at SNS . MARK GERLING, Sandia National Laboratories — Coherent Neutrino Nucleus Scattering (CNS) is a theoretical well-grounded, but as yet un-verified process. The Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL) may provide an optimal platform for detection of CNSs, possibly with existing detector technology. A proto-collaboration of groups from several institutions has come together to investigate this option and propose an experiment for the first-time observation of CNSs. Currently, the largest risk to such an experiment comes from an unknown background of beam-induced high-energy neutrons that penetrate the existing SNS concrete shielding. We have deployed a neutron scatter camera at the SNS during beam operation and performed preliminary measurements of the neutron backgrounds at a promising experimental location. In order to measure neutrons as high as 100 MeV, we need to make modifications to the neutron scatter camera and expand its capabilities beyond its standard operating range of 1-14MeV. We have identified sources of high-energy neutrons and continue to investigate other possible locations that may allow a successful CNSs experiment to go forward. The imaging capabilities of the neutron scatter camera will allow more optimal shielding designs that take into account neutron flux anisotropies at the selected experiment locations.

4:06PM U12.00004 Cosmogenic Backgrounds for Double Beta Decay , JOSHUA ALBERT, Indiana University, EXO COLLABORATION — 136Xe is a very promising candidate isotope for neutrino-less double-beta decay searches, so reducing backgrounds that can mimic signals of this rare decay is a critical task for current and future experiments, such as EXO-200 and nEXO. One important category of backgrounds are those induced by neutrons produced by cosmic ray muons. These backgrounds can be studied in EXO-200 by selecting data shortly after the muon panels are triggered, making a “neutron enriched” data sample. This data is then checked against Monte Carlo simulations of these backgrounds. The results and insights from this study will be discussed.

4:18PM U12.00005 Simulation of the detector response of the 1-kton option of WATCHMAN , MARC BERGEVIN, UC Davis, WATCHMAN COLLABORATION — WATCHMAN (Water CHerenkov Monitoring of AntiNeutrinos) is a new US based experiment that will exploit the low energy antineutrino signal from reactors, supernova and decay-at-rest antineutrino beams to pursue a broad physics program. WATCHMAN aims to be the first detector in the world to detect low energy antineutrinos in water, by adding a gadolinium dopant that increases the efficiency for the final-state neutron arising from the antineutrino interactions on protons in the water. In this talk, I will provide an overview of the expected detector response to the different low-energy physics - including reactor antineutrinos, fast-neutron contamination, radionuclide contamination and U/Th contamination. I will also discuss expected rates for each of these processes at the current preferred underground installation-site, the Fairport mine in Painesville Ohio. I will focus on the unique advantages of the gadolinium dopant, which enables WATCHMAN to significantly reduce the background contamination and allows a lower energy threshold compared to other Water Cherenkov Imaging detectors.

4:30PM U12.00006 Measurements of neutron spectra underground relevant for remote detection of antineutrinos , CAI0B ROECKER, Univ of California - Berkeley, PETER MARLEAU, MARK GERLING, Sandia National Labs, JIM BRENNAN, Sandia National Lab, WATCHMAN COLLABORATION — High energy neutrons (>100 MeV) created through muon spallation have the potential to bypass the shielding of large rare event detectors. As such they present an unknown background for the long range antineutrino detector WATCHMAN. We have built and are operating a capture-gate Gd-doped scintillation detector for measuring the background neutron spectrum at the Kimballton Underground Research Facility (KURF). The detector measures the joint response of high energy neutron scatter events and neutron capture events allowing for a large dynamic range of neutron energies from 30 to hundreds of MeV. To amplify the number of neutrons for capture we use a lead multiplier in the center of the detector. At KURF we plan on taking measurements at ~300, 600, and 1450 m.w.e. Using the measured and Geant4 simulated response we plan on unfolding the neutron energy spectrum and rate as a function of underground depth. This information will allow for the calculation of a significant background for WATCHMAN and provide a lower bound on the depth requirement for future remote reactor monitoring deployments.

4:42PM U12.00007 Measurement of cosmogenic radioisotope production on water at the Kimballton Underground Research Facility , MORGAN ASKINS, University of California Davis, WATCHMAN COLLABORATION — The next generation of large water detectors, such as the kiloton-scale Water Cherenkov Monitor for Antineutrinos (WATCHMAN) and the megaton-scale Japanese Hyper-K project, aim to pursue a diverse physics program including low energy antineutrino physics. Muogenic backgrounds in water have been measured by the SuperKamiokande collaboration, but for reactor and other low energy antineutrinos these backgrounds are only weakly constrained and may prove important for large water-based reactor-antineutrino detectors. The WATCHMAN collaboration has deployed a water Cherenkov detector to measure the rate of long-lived β^-/ν decay radioisotopes - 8He, 7Li, 11B, 11B - produced by cosmic ray interactions in water. Our emphasis is on measuring those β^-/ν decay isotopes which mimic the positron-antineutrino signal from inverse beta decay of antineutrinos from reactors. Our detector is a 2 ton cylindrical target of pure water doped with gadolinium for neutron identification, surrounded by a 1.4-meter thick pure water muon veto and neutron/gamma shield. Presented here are the preliminary results of data taken beginning July 2013 at the KURF mine in Virginia at a depth of approximately 300 meters water equivalent with intermittent periods of detector off time.

4:54PM U12.00008 Determination of Detection Efficiency in Double Chooz Experiment , GUANG YANG, Argonne National Lab/Illinois Institute of Technology, DOUBLE CHOÖZ COLLABORATION — Double Chooz Experiment is designed to perform a very precise measurement of the neutrino oscillation mixing angle theta-13. The Double Chooz detector system consists of a main detector, an outer veto system and several calibration systems. The main detector has a cylindrical structure. It consists of the target vessel, a liquid scintillator loaded with Gd, surrounded by the gamma-catcher, a non-loaded liquid scintillator. A buffer region of non-scintillating liquid surrounds the gamma-catcher and serves to host 390 photomultiplier tubes and to decrease the level of accidental background. The Inner Veto region is outside the buffer, and the Outer Veto system covers all detector components. The detector is calibrated with light sources, radioactive point sources, cosmics and natural radioactivity. Far detector is operational and the near detector is under construction. Neutron detection efficiency is one of the major systematic components in the measurement of anti-neutrino disappearance. Neutrons from inverse beta decay and an untagged 252 Cf source are the tools used to determine fractions of neutron captures on Gd, as well as neutron capture time and neutron delayed energy systematics. Details will be presented in the talk along with most recent oscillation results.
5:06PM U12.00009 NOνA ℓνℓ Appearance Analysis and Near Detector Spectrum. DANIEL PERSHEY, Caltech, NOVA COLLABORATION — The NOνA experiment has developed an analysis to measure the \( \nu_e \rightarrow \nu_\mu \) conversion rate using the NUMI beam at Fermilab. The experiment has recently started taking data and is finalizing initial physics analyses with Monte Carlo studies. An overview of the \( \nu_e \) appearance analysis is discussed. Specifically, a method used to decompose the near detector neutrino spectrum is shown.

Monday, April 7, 2014 3:30PM - 5:18PM – Session U13 GPMFC DPF: LHC Searches II

101 - Nikos Varelas, University of Illinois at Chicago

3:30PM U13.00001 Search for Vector-like Quarks using a Combination of Decay Channels in pp Collisions at \( \sqrt{s} = 8 \) TeV Collected with the ATLAS Detector. SARAH JONES, University of Arizona, ATLAS COLLABORATION — Vector-like quarks are predicted in several beyond the Standard Model theories. In some models, there is strong coupling to third generation quarks. The vector-like heavy quarks T and B can decay into several different channels involving third generation quarks. The ATLAS experiment has searched for vector-like quarks in several different decay channels using data collected in pp collisions at \( \sqrt{s} = 8 \) TeV. We present search results by combining the results from the individual decay channel searches. The combination search improves the sensitivity to observing or excluding vector-like quarks.

3:42PM U13.00002 Search for New Physics in the Photon+MET Final State. ZEYNEP DEMIRAGLI, Brown University, CMS COLLABORATION — With the recent discovery of the Higgs boson at the Large Hadron Collider, the next goals of the Compact Muon Solenoid (CMS) Experiment include characterizing this new particle and probing for new physics beyond the Standard Model (SM). We present a search for new physics which results in a final state consisting of a low pt photon, low missing transverse energy and low jet multiplicity, which can arise from models involving dark matter production or exotic decays of the Higgs in low scale supersymmetry breaking scenarios. This analysis is extremely challenging due to the lack of a fully reconstructed final state, the low energy spectrum of the final state objects, as well as the large SM backgrounds.

3:54PM U13.00003 Search for Monotop Production in Leptonic Decays of Top Quarks at \( \sqrt{s} = 8 \) TeV Using the ATLAS Detector. ANDREW CHEGWIDDEN, Michigan State University — This beyond the Standard Model search looks for events where single top quarks are produced in association with missing transverse energy. This missing transverse energy can be attributed to a neutral, long lived or stable, non-interacting particle which could be considered a dark matter candidate. The final state topology can either be created via baryon number violating or flavor changing neutral current interactions. Data collected at a center-of-mass energy of 8 TeV during 2012 corresponding to an integrated luminosity of 20.3 fb\(^{-1}\) are used. The current search status will be presented along with planned improvements on the analysis.

4:06PM U13.00004 Search for a heavy higgs bosons that decays to light higgs bosons in the minimally supersymmetric standard model using \( \tau \tau \) final states. STEPHANE COOPERSTEIN, University of Wisconsin Madison, CMS COLLABORATION — A search for the extension of the higgs sector to the two higgs doublet model is presented. Decays of the heavy scalar (\( H \)) and pseudo-scalar (\( A \)) higgs bosons in their decays \( H \rightarrow hh \rightarrow \tau\tau b\bar{b} \) and \( A \rightarrow Zh \rightarrow \ell\ell TT \) include the standard model-like higgs in the final state. Background estimations use a data driven approach. A binned maximum likelihood fit to the signal Monte Carlo using the di-tau secondary vertex fit algorithm improves discrimination as compared to previous analyses. This search is performed using a 19.5 fb\(^{-1}\) data sample at \( \sqrt{s} = 8 \) TeV collected by the CMS experiment at the LHC.

4:18PM U13.00005 Discovering Unexpected Signals through Background Ranking\(^1\). JAMES GAINER, KONSTANTIN MATCHEV, University of Florida, MYEONGHUN PARK, IPMU — The Matrix Element Method (MEM) has become an important tool in experimental particle physics, as it provides optimal sensitivity in using data to distinguish between models that could explain that data. However, it has generally required some concrete model to describe the potential signal. Motivated by the possibility of surprises at the Large Hadron Collider (LHC), we develop MEM-based methods for determining the presence of new physics without assumptions about the signal process responsible for the new physics. One such method, which we believe is especially robust with respect to systematic uncertainties, involves the ranking of events with respect to the value of background matrix element.

\(^1\)U.S. Department of Energy Grant No. DE- FG02-97ER41029

4:30PM U13.00006 ABSTRACT WITHDRAWN —

4:42PM U13.00007 Improved search for \( ZH \rightarrow \ell^+\ell^- b\bar{b} \) using 9.7 fb\(^{-1}\) of data collected by the D0 detector. JIAMING YU, University of Michigan, D0 COLLABORATION — We present an improved search for the standard model Higgs boson produced in association with a Z boson, using 9.7 fb\(^{-1}\) of pp collision data collected by D0 detector at \( \sqrt{s} = 1.96 \) TeV. Events are selected with two electrons or two muons that are consistent with the decay of a Z boson, and at least two reconstructed jets (including at least one b-tagged jet). Four dedicated random forests of decision trees (RFs) are trained in order to distinguish the signal with \( t\bar{t}, Z+\)Heavy Flavor Jets, \( Z+\)Light Flavor jets and diboson background events respectively. The final discriminant is trained separately in five regions according to the output of the RFs. Upper limits on the \( ZH \) production cross-section times branching ratio to two b-jets are set at 95% C.L. We also use the minimum walking technicolor model \( (\rho_{TC} \rightarrow Z\pi_{TC} \rightarrow \ell^+\ell^- b\bar{b}) \) to interpret the results we obtained.

5:04PM U13.00008 Search for Supersymmetry in Diphoton Events with Large Missing Transverse Momentum in 8 TeV pp collisions with the ATLAS Detector. BENJAMIN AUERBACH, Argonne National Laboratory — We describe a search for physics processes beyond the standard model using events with two photons and large missing transverse energy. The search analyzes 20.3 fb\(^{-1}\) of data taken with pp collisions at \( \sqrt{s} = 8 \) TeV by the ATLAS experiment at the Large Hadron Collider. The search for new physics considers two different production modes, electroweak and strong, as well as lower and higher mass bins which yield different kinematic distributions. The rates and kinematic distributions are found to be consistent with Standard Model expectations, and limits are set on possible new physics scenarios with the final state of two photons and missing transverse energy.
of our numerical analysis of intraband optical transitions within the valance band of pyramidal Quantum Dot (QD) of type $\text{In}_x\text{As}/\text{InGaAs/GaAs}$ Dots-in-Well (DWELL) systems are more sensitive to $X$-polarized light which has intensities 2 orders of magnitude higher than the absorption intensity for $Z$-polarized light.

**Monday, April 7, 2014 3:30PM - 5:18PM**

**Session U14 Data and Simulations: Methods and Implementation**

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**3:30PM U14.00001 Sampling saddle points on the free energy surface**, AMIT SAMANTA, Princeton Univ — We develop an algorithm for finding the saddle points on the free energy surface "on-the-fly" without having to find the free energy function itself. This is done by using the general strategy of the heterogeneous multi-scale method, applying a macro-scale solver, here the gentlest ascent dynamics algorithm, with the needed force and Hessian values computed on-the-fly using a micro-scale model such as molecular dynamics. The algorithm is capable of dealing with problems involving many coarse-grained variables. The utility of the algorithm is illustrated by studying the saddle points associated with (a) the isomerization transition of the alanine dipeptide using two coarse-grained variables, specifically the Ramachandran dihedral angles, and (b) the beta-hairpin structure of the alanine decamer using twenty coarse-grained variables, specifically the full set of Ramachandran angle pairs associated with each residue.

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**3:42PM U14.00002 An iterative minimization scheme for saddle search**, XIANG ZHOU, Department of Mathematics, City University of Hong Kong — The gentlest ascent dynamics (E and ZHOU, 2011 *Nonlinearity*) transforms saddles of energy potential into a stable fixed point. Inspired by GAD, in this talk, I introduce a new formulation of iteratively minimizing a sequence of modified potential to find the saddles of the original function. We show that the iteration converges quadratically. An 175-atom example is illustrated as an application. This is the joint work with Weiguo Gao and Jing Leng.

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**3:54PM U14.00003 Equation Solution Figures of Merit, Metaheuristic Search, and the Schrodinger Equation**, PAUL MACNEIL, Mercer University/School of Engineering — This presentation deals with: a definition of "equation error"; a consideration of equation solution figures of merit based on equation error, and on other measures; and the use of metaheuristic techniques in the search for approximate solutions. These considerations are illustrated by application to the Schrodinger equation for a simple system. Models suitable for computation are produced. Computation results are used to compare the consequences of selection of different figures of merit. "Equation error" is defined to be the quantity by which an approximate solution fails to satisfy an equation. "Equation error variance" is defined to be the squared modulus of the equation solution figure of merit. "Equation solution figures of merit" are compared to equation error variance, and to other measures.

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**4:06PM U14.00004 Space-Time Finite Element Approach for the Semilinear Wave Equation**, HYUN LIM, South Dakota State Univ, MATTHEW ANDERSON, Indiana University, JUNG-HAN KIMN, South Dakota State Univ — For certain formulations of partial differential equations, proper time-parallel pre conditioners can be successfully applied in space-time finite element simulations. Such an approach may enable the extraction of more parallelism to better utilize high performance computing resources. In this work, we examine the behavior of the semi linear wave equation in 1+1 dimensions using space-time finite elements. We discretize space and time together for the entire domain using a finite element space which does not separate time and space basis functions. We also explore the effectiveness of the time additive Schwarz preconditioner for this problem. We explore the semi linear wave equation at the threshold of singularity formation using $\text{p}=7$ for the nonlinear term and search for self-similarity using a non-uniform mesh in both space and time.

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**4:18PM U14.00005 Intraband Optical Transitions in $\text{InGaAs/GaAs}$ quantum dot and $\text{InAs/InGaAs/GaAs}$ Dots-in-Well**, VENKATA CHAGANTI, VADYM APALKOV, Georgia State University — We present the results of our numerical analysis of intraband optical transitions within the valance band of pyramidal Quantum Dot (QD) of type $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$ and conduction band of Pyramidal Quantum Dot-in-Well (DWell) structure of type $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$. The electronic states and optical transitions within the valence bands of p-doped semiconductor QD were found numerically within 8 band kp model and the intraband optical absorptions within the conduction bands of n-doped semiconductor DWELL structure were obtained within effective mass model with the use of NEXTNANO software and our Fortran program. In application to quantum dot photodetectors, we study how the size of the dot and its composition affect the optical transition within the dot. With increasing the QD size the absorption spectra are shifted to lower energies. The optical spectra are more sensitive to X-polarized light, with corresponding intensity one order magnitude greater than the absorption intensity of Z-polarized light. In application to DWELL photodetectors we study how the size of the dot and the position of the dot in the well affect the optical transitions within the system. For small QD size (<12 nm), the main optical transitions occur either between the QD and quantum well states or between the QD and substrate states. The wavelengths of optical transitions for such small QDs vary between 2 μm and 6 μm. DWELL systems are more sensitive to X-polarized light which has intensities 2 orders of magnitude higher than the absorption intensity for Z-polarized light.

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**4:30PM U14.00006 Density-Independent Technique for Modeling Self-Propelled Particles**, PAUL OHMANN, DANIEL SCHUBRING, University of St. Thomas — We present an algorithm for modeling a two-dimensional system of self-propelled particles independent of their density. In this system, we define the nearest neighbors of each particle in terms of a Voronoi tessellation. Specifically, each particle is associated with a region closer to that individual than to any other; we call this region a cell. Neighbors are then defined as those individuals in adjacent cells, no matter their metric distances — and it is these neighbors that influence the subsequent motion of a particle. This density-independent model holds promise in realistically simulating flocking behavior; however, a challenge in developing these simulations is with the efficiency of the updates. We present an algorithm to efficiently update these systems using Delaunay triangulation.
4:42PM U14.00007 Medical Impairment and Computational Reduction to a Single Whole Person Impairment (WPI) Rating Value, JERRY ARTZ, Hamline University, Saint Paul MN, JOHN ALCHEMY, ANNE WEILEPP, MICHAEL BONGIOVANNI, Alchemy Logic Systems, Santa Rosa CA, KUMAR SIDDHARTHA, CEO Greyfast LLC AND CTO Alchemy Logic Systems, Mumbai, India — A medical, biophysics, engineering collaboration has produced a standardized cloud-based application for creating automated WPI ratings. The project assigns numerical values to injuries/illness in accordance with the American Medical Association Guides to the Evaluation of Permanent Impairment, Fifth Edition, AMA Press handbook, 5th edition (with 63 medical contributors and 89 medical reviewers). The AMA Guide serves as the industry standard for assigning impairment values for 32 US states and 190 other countries. Clinical medical data is collected using a menu-driven user interface which is computationally combined into a single numeric value. A medical doctor performs a biometric analysis and enters the quantitative data into a mobile device. The data is analyzed using proprietary validation algorithms, and a WPI Impairment rating is created. The findings are imbedded into a formalized medicolegal report in a matter of minutes. This particular presentation will concentrate upon the WPI rating of the spine—cervical, thoracic, and lumbar. Both common rating techniques will be presented—i.e., Diagnosis Related Estimates (DRE) and Range of Motion (ROM).

4:54PM U14.00008 The Extent of the Superglass Phase of Binary Mixtures, SEA HOON LIM, BOB BELL, None — In this work, we attempt to map the extent of the superglass phase of Kob-Anderson Lennard-Jones (KALJ) binary mixtures via Path Integral Monte Carlo (PIMC). At low temperatures, KALJ binary mixtures are capable of avoiding crystallization, yet exhibit superfluidity only for certain parameterizations of the KALJ potential. Using PIMC, we observe superfluidity in our mixtures for $\varepsilon \leq 1.375 \varepsilon_{he}$, For $\varepsilon > 1.375 \varepsilon_{he}$, exchange among particles is dramatically reduced. Future work will explore the dynamics of our mixtures for $\varepsilon \leq 1.375 \varepsilon_{he}$ to ascertain whether they are not just superfluid, but glassy as well.

5:06PM U14.00009 By-passing the sign-problem in Fermion Path Integral Monte Carlo simulations by use of high-order propagators, SUI A. CHIN, Texas A and M University — The sign-problem in PIMC simulations of non-relativistic fermions increases in severity with the number of fermions and the number of beads (or time-slices) of the simulation. A large number of beads is usually needed, because the conventional primitive propagator is only second-order and the usual thermodynamic energy-estimator converges very slowly from below with the total imaginary time. The Hamiltonian energy-estimator, while more complicated to evaluate, is a variational upper-bound and converges much faster with the total imaginary time, thereby requiring fewer beads. This work shows that when the Hamiltonian estimator is used in conjunction with fourth-order propagators with optimized parameters, the ground state energies of 2D parabolic quantum-dots with approximately 10 completely polarized electrons can be obtain with ONLY 3-5 beads, before the onset of severe sign problems.

1 This was made possible by NPRP GRANT #5-674-1-114 from the Qatar National Research Fund (a member of Qatar Foundation). The statements made herein are solely the responsibility of the author.

Monday, April 7, 2014 3:30PM - 4:54PM
Session U15 Alternate Theories of Gravity 103 - Sam Gralla

3:30PM U15.00001 Spontaneous Scalarization of Massive Fields, FETHI M. RAMAZANOGULU, FRANS PRETORIUS, Princeton University — Spontaneous scalarization is a phenomenon in certain scalar-tensor theories where large deviations from general relativity can be observed inside compact stars, while the known observational bounds can also be satisfied far away. This scenario has been investigated for massless scalars and binary neutron stars using numerical relativity, but the parameter space for such theories have been severely restricted by recent observations. Here, we present our results on the spontaneous scalarization of massive scalars. We simulate cases with different equations of state and scalar field parameters, and comment on the detectability of the scalar field effects from the gravitational wave signal.

3:42PM U15.00002 Bursty Gravitational Waves, NICHOLAS LOUTREL, Montana State University, FRANS PRETORIUS, Princeton University, NICO YUNES, Montana State University — Compact objects in highly elliptical binaries, unlike their circular counterparts, emit most of their gravitational radiation during pericenter passage. Such events would look like a sequence of bursts in time-frequency space, which would be difficult to extract with a matched filtering approach. However, if we could predict the time and frequency of the next burst, we could then search over that region of time-frequency space until the next burst is detected and then stack the power of the bursts to create an enhanced data product. We here present a proof of concept burst model, where we treat the bursts as boxes in time-frequency space and model the evolution of the system to Newtonian order. From this, we develop an algorithm to determine the mapping between boxes. We study the accuracy of the model by comparing the burst model to numerical solutions of the system under Newtonian order radiation reaction and by studying the strength of the 1PN corrections to the energy and angular momentum flux. Finally, we explain how this model can be used to test General Relativity and alternative theories of gravity.

3:54PM U15.00003 Applicability of the Newman-Janis Algorithm to Modified Gravity Theories, DEVIN HANSEN, Montana State Univ — The Newman-Janis algorithm is an appealing method to generate rotating black hole metrics from non-rotating ones. In this talk, I investigate the applicability of this algorithm in modified gravity theories, concentrating on quadratic gravity. We find that this algorithm leads to a metric that does not agree with slowly-rotating solutions in this theory, and in fact, does not even satisfy the modified vacuum field equations. I will also show that associating the latter with a stress-energy tensor implies the existence of naked singularities in the spacetime. This suggests that the Newman-Janis algorithm is not well-suited to generate rotating black hole solutions in modified gravity theories.

4:06PM U15.00004 Gravitational radiation from compact binaries in scalar-tensor gravity, RYAN LANG, University of Florida — General relativity (GR) has been extensively tested in the solar system and in binary pulsars, but never in the strong-field, dynamical regime. Soon, gravitational-wave (GW) detectors like Advanced LIGO will be able to probe this regime by measuring GWs from inspiraling and merging compact binaries. One particularly interesting alternative to GR is scalar-tensor gravity. We present the calculation of second post-Newtonian (2PN) gravitational waveforms for inspiraling compact binaries in a general class of scalar-tensor theories. The waveforms are constructed using a standard GR method known as “Direct Integration of the Relaxed Einstein equations,” appropriately adapted to the scalar-tensor case. We find that differences from general relativity can be characterized by a reasonably small number of parameters. Among the differences are new hereditary terms which depend on the past history of the source. In one special case, mixed black hole-neutron star systems, all differences from GR can be characterized by only a single parameter. In another, binary black hole systems, we find that the waveform is indistinguishable from that of general relativity.
4:18PM U15.00005 Dynamical scalarization of neutron stars in scalar-tensor gravity theories, CARLOS PALENZUELA, Canadian Institute for Theoretical Astrophysics, ENRICO BARAUSSE, Institut d’Astrophysique de Paris, MARCELO PONCE, University of Guelph, LUIS LEHNER, Perimeter Institute — We present a framework to study generic neutron-star binaries in scalar-tensor theories of gravity. Our formalism achieves this goal by suitably interfacing a post-Newtonian orbital evolution with a set of non-linear algebraic equations to describe the scalar charge of each binary’s component along the evolution in terms of isolated-star data. We validate this semi-analytical procedure by comparing its results to those of fully general-relativistic simulations, and use it to investigate the behavior of binary systems in large portions of the parameter space of scalar-tensor theories. This allows us to shed further light on the phenomena of “dynamical scalarization,” which takes place in tight binaries even for stars that have exactly zero scalar charge in isolation. Finally, we discuss the extent to which deviations from General Relativity can be detected, either directly by the emitted gravitational waves, or by their electromagnetic counterparts.

4:30PM U15.00006 Is Quadratic Gravity Stable?, DIMITRY AYZENBERG, KENT YAGI, NICOLAS YUNES, Montana State Univ — As the advanced gravitational wave detector era approaches it is vital to understand and analytically test the wide range of alternative theories to General Relativity. An important analytical test is a stability analysis as any instabilities arising due to perturbations suggest the theory to be invalid. In this talk I present our results of a stability analysis of dynamical, quadratic gravity to linear order in the perturbation and coupling constant in the high-frequency, geometric optics approximation. This analysis is based on a study of gravitational and scalar modes propagating on spherically-symmetric and axially-symmetric, vacuum solutions of the theory. We find dispersion relations that do not lead to exponential growth of the propagating modes, suggesting the theory is linearly stable on these backgrounds. The modes are found to propagate at subluminal and superluminal speeds, depending on the propagating modes’ direction relative to the background geometry.

4:42PM U15.00007 Dark matter as an integral part of an alternative gravity model, HONTAS FARMER, Northern Illinois University — The purpose of this paper is to reconcile observations of dark matter effects on the galactic and cosmological scales with the null results of astroparticle physics observations such as CDMS and ANTARES. This paper will also provide a candidate unified and simpler mathematical formulation for the Lambda CDM model. Unification is achieved by a combination of the f(R) approach, with the standard LCDM approach and inflationary models. It is postulated that dark matter-energy fields depend on the Ricci curvature R. Standard methods of classical and quantum field theory on curved space time are applied. When this model is treated as a quantum field theory in curved space-time, the dark matter-dark matter fermion annihilation cross section grows as the square of the Ricci scalar. It is proposed and mathematically demonstrated that in this model dark matter particles could have shorter lifetimes in regions of relatively strong gravity such as near the sun, near the Earth, or any other large mass. The unexpected difficulties in directly observing fermionic particles of dark matter in Earth based observatories are explained by this theory. The gravitational field of the Sun and Earth may effect them in ways the standard WIMP models would never predict.

Monday, April 7, 2014 3:30PM - 5:18PM –
Session U17 FPS: Invited Session: Physics Research and Innovation 105-106 - Pushpalatha Bhat, Fermi National Accelerator Laboratory

3:30PM U17.00001 Transfer of the CMOS Image Sensor Technology from NASA/JPL to Your Cell Phone, ERIC R. FOSSUM, Dartmouth College — The talk will focus on the invention, development and commercialization of the CMOS image sensor technology. Invented in 1993 for space applications at the Caltech NASA Jet Propulsion Lab, it has almost completely supplanted the Charge-Coupled Device (CCD, Nobel Prize in Physics, 2009) in nearly all consumer applications, as well as in automotive, medical and machine vision markets. It was an uphill fight to displace the entrenched incumbent CCD technology despite a long list of compelling advantages for the CMOS image sensor.

4:06PM U17.00002 Superconducting RF: Joining different fields for breakthroughs, HASAN PADAMSEE, Cornell University — No abstract available.

4:42PM U17.00003 Energy Generation through Nuclear Fusion, NATHANIEL FISCH, Princeton University —
Monday, April 7, 2014 5:30PM - 6:30PM –
Session V10 FEd: FEd Business Meeting

5:30PM V10.00001 FEd Business Meeting –

Monday, April 7, 2014 5:30PM - 6:30PM –
Session V14 GFB: GFB Business Meeting

5:30PM V14.00001 GFB Business Meeting –

Monday, April 7, 2014 5:45PM - 7:00PM –
Session V17 APS: App-y Hour Hyatt Regency Savannah Scarbrough 1 -

5:45PM V17.00001 App-y Hour —APS would like your input on the April Meeting 2014 app for mobile devices. Your comments and opinions will help us as we design future apps. Light refreshments will be served.

Monday, April 7, 2014 5:30PM - 6:30PM –
Session V18 GPER: GPER Business Meeting

5:30PM V18.00001 GPER Business Meeting –

Monday, April 7, 2014 8:00PM - 10:00PM –
Session V20 APS: Special Movie Screening: Particle Fever Hyatt Regency Savannah Scarbrough 2-4 -

8:00PM V20.00001 Special Movie Screening: Particle Fever –

Tuesday, April 8, 2014 8:30AM - 10:18AM –
Session W1 APS: Plenary Session III: One Hundred Years of the Beta-Decay Spectrum Chatham Ballroom A/B - John F. Wilkerson, University of North Carolina

8:30AM W1.00001 Beta Decay: A Physics Garden of Earthly Delights\(^1\), R.G. HAMISH ROBERTSON, Center for Experimental Nuclear Physics and Astrophysics, University of Washington — From the beginning, beta decay has tormented and delighted us with puzzles and enlightenment. A significant part of our present understanding of subatomic physics has emerged from the experimental and theoretical struggle with its mysteries. We reflect on several of the epic victories in this struggle, and look ahead to where ongoing research might lead us in the understanding of fundamental symmetries and neutrinos.

\(^1\)Research supported under DOE grant DE-FG02-97ER41020.

9:06AM W1.00002 The Nuclear and Particle Physics of Neutrinoless Double Beta Decay\(^1\), WICK HAXTON, UC Berkeley and Lawrence Berkeley Laboratory — Fortuitous properties of nuclei allow us to isolate and study the rare second-order weak process of double beta decay. In particular, the decay channel in which a final state of two electrons and no neutrinos is produced – neutrinoless double beta decay – provides our best test of lepton number conservation and the Majorana mass of the electron neutrino. I will describe the connections between this process and the charge conjugation properties of the neutrino, including the possibility that the presence of both Dirac and Majorana masses accounts for the anomalous scale of neutrino masses. The extraordinary progress made over the past two decades has prepared the way for next-generation experiments that will probe Majorana masses at levels where nonzero rates may be found, given what we now know about neutrino mass splittings. I will describe some of the heroic efforts underway to develop detectors of unprecedented size, radiopurity, depth, and thus sensitivity.

\(^1\)Work supported by the Office of Science, US DOE

9:42AM W1.00003 Weak Decays as a Window to New Physics, SHELDON STONE, Syracuse University — No abstract available.

Tuesday, April 8, 2014 10:45AM - 12:33PM –
Session X2 DPF: Invited Session: Electroweak Physics Chatham Ballroom A - Jonathan Rosner, University of Chicago

10:45AM X2.00001 Top Physics Results from the Tevatron and the LHC, KI LIE, Univ of Illinois - Urbana — No abstract available.
the first glimpse of the DES SN first year data and initial results as we begin our five year survey in search of dark energy. Presenting first year supernovae data, preliminary results, survey strategy, discovery pipeline, spectroscopic target selection and data quality. This talk will give us to put increasingly accurate constraints on the expansion history of the Universe and will help us distinguish between competing theories of dark energy and search for SNeIa, and mapping out the large scale structure of the Universe by making observations of galaxies. The DES science program which saw 570 megapixel Dark Energy Camera is currently operating with the Cerro-Tololo Inter American Observatory's 4m Blanco telescope, carrying out a systematic Survey (DES) has been designed and commissioned to find to find answers to these questions about the nature of dark energy and modified gravity. The new as a ‘Supernova Type Ia’. (SNeIa) Since the discovery of the accelerating Universe, one of the biggest questions in modern cosmology has been to determine This astonishing discovery of Universal acceleration was made in the late 1990s by two teams who made observations of a special type of exploded star known as a ‘Supernova Type Ia’. (SNeIa) Since the discovery of the accelerating Universe, one of the biggest questions in modern cosmology has been to determine 1 The speaker acknowledges support from NASA Grant No. NNX11AC37G and NSF Grant PHY-1068243. 1 AWS is supported by DOE Grant No. DEFG02-00ER41132. 1 On behalf of the Dark Energy Survey collaboration.
of the jet yield on the angle with respect to the reaction plane. The current methods used in ALICE for studies of full jets will be discussed. Full jets are
with the QGP, which reduces the jet energy. In non-central collisions, the asymmetry of the hot and dense matter profile is expected to lead to a dependence
collimated shower of hadrons produced by a parton resulting from a hard scattering early in the collision. In heavy ion collisions, partons undergo interactions
as a Quark Gluon Plasma (QGP) is formed. One way of probing the QGP is by measuring the resulting energy loss from the suppression of jets. A jet is the
Knoxville, ALICE COLLABORATION — High energy heavy ion collisions allow the study of nuclear matter at high temperatures and energy densities, where
for the calculation of two jet production in p-A scattering at LHC energies which allows us to probe a nuclear partonic distributions at moderate to large Bjorken
ADAM FREESE, MISAK SARGSIAN, Florida International University, MARK STRIKMAN, Penn State University — We have developed a theoretical framework
Cu
PHENIX
FVTX will be discussed, along with the analysis status of FVTX data. As a silicon tracker, it can efficiently detect secondary vertices, as well as allow separation of decay muons from charm and bottom hadrons produced in heavy ion collisions. In this talk, the design and capabilities of the
tracks with high precision before any interactions occur in the hadron absorber, the FVTX will enhance the mass resolution of dimuon resonance measurements
as well as allow separation of decay muons from charm and bottom hadrons produced in heavy ion collisions. In this talk, the design and capabilities of the
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of silicon mini-strip sensors with a 75 micron pitch in the radial direction, and is located in front of the existing PHENIX muon arms. By determining muon
tracks with high precision before any interactions occur in the hadron absorber, the FVTX will enhance the mass resolution of dimuon resonance measurements
as well as allow separation of decay muons from charm and bottom hadrons produced in heavy ion collisions. In this talk, the design and capabilities of the
FVTX will be discussed, along with the analysis status of FVTX data.

11:57AM X4.00003 Weak lensing in the Dark Energy Survey. JOSEPH CLAMPITT, University of Pennsylvania — We show tests of weak lensing on ~200 sq. deg. of DES Science Verification data, with a focus on validation of galaxy-shear and mass mapping measurements. These tests include shear around stars and random points, tests of the PSF model, and cross-correlations with various sources of systematic errors. We show preliminary results for stacked galaxy lensing and wide-field mass maps. We conclude with new lensing measurements that we have carried out with SDSS and will apply to DES.

Tuesday, April 8, 2014 10:45AM - 12:09PM — Session X6 DNP: Relativistic Heavy Ions: A+A

10:45AM X6.00001 Measurement of the Total Cross Section of Uranium-Uranium Collisions at √NN = 192.8 GeV, A.J. BALTZ, W. FISCHER, M. BLASKIEWICZ, D. GASSNER, K.A. DREES, Y. LUO, M. MINTY, P. THIEBERGER, M. WILINSKI, Brookhaven National Laboratory, I.A. PSHENICHNOV, Institute for Nuclear Research, Moscow — The total cross section of Uranium-Uranium at √NN = 192.8 GeV has been measured to be 515 ± 13^{stat} ± 22^{sys} barn, which agrees with the calculated theoretical value of 487.3 barn within experimental error[1]. That this total cross section is more than an order of magnitude larger than the geometric ion-ion cross section is primarily due to Bound-Free Pair Production (BFPP) and Electro-Magnetic Dissociation (EMD). Nearly all beam losses were due to geometric, BFPP and EMD collisions. This allowed the determination of the total cross section from the measured beam loss rates and luminosity. The beam loss rate is calculated from a time-dependent measurement of the total beam intensity. The luminosity is measured via the detection of neutron pairs in time-coincidence in the Zero Degree Calorimeters. Apart from a general interest in verifying the calculations experimentally, an accurate prediction of the losses created in the heavy ion collisions is of practical interest for the LHC, where collision products have the potential to quench cryogenically cooled magnets.


10:57AM X6.00002 Forward physics at PHENIX with precision silicon tracking. J. MATTHEW DURHAM, Los Alamos National Lab, PHENIX COLLABORATION — The PHENIX experiment at RHIC has developed and installed a new silicon detector, the Forward Silicon Vertex Tracker (FVTX), to provide precise tracking at forward and backward rapidity (1.2 <|y| < 2.2). The FVTX consists of four layers of silicon mini-strip sensors with a 75 micron pitch in the radial direction, and is located in front of the existing PHENIX muon arms. By determining muon tracks with high precision before any interactions occur in the hadron absorber, the FVTX will enhance the mass resolution of dimuon resonance measurements as well as allow separation of decay muons from charm and bottom hadrons produced in heavy ion collisions. In this talk, the design and capabilities of the FVTX will be discussed, along with the analysis status of FVTX data.

11:09AM X6.00003 Heavy flavor single muon flow measurement in Cu+Au collisions from PHENIX, BRANDON SCHMOLL, University of Tennessee, Knoxville, PHENIX COLLABORATION — Asymmetric collisions of heavy nuclei, such as Cu+Au, provide unique initial geometry configurations unlike those found in symmetric nucleus-nucleus collisions. This offers us an opportunity to study the Quark-Gluon Plasma under different initial conditions. In central collisions the Cu nucleus will be completely embedded in the Au nucleus. Single muon measurements at forward rapidity allow us to quantify the effect of this embedding by studying, for example, flow in the Cu-going versus the Au-going directions. The status of the current analysis and the challenges that arise from trying to measure heavy flavor single muons will be discussed.

11:21AM X6.00004 J/psi Measurements in Cu+Au and U+U Collisions from PHENIX, ABHISEK SEN, University of Tennessee, PHENIX COLLABORATION — The measurement of quarkonia production in relativistic heavy ion collisions provides a powerful tool for studying the properties of the hot and dense matter created in these collisions. PHENIX’s ability to measure J/psi in a wide kinematic range and RHIC’s flexibility to collide different nuclei provide a unique opportunity for such measurements in order to systematically test various quarkonia suppression models. In the 2012 run, RHIC has collided Cu+Au and U+U nuclei. These collisions promise an array of unique initial geometrical configurations which present an opportunity to measure J/psi production in a wide range of initial energy densities. Recent J/psi results from Cu+Au and U+U data from PHENIX will be discussed.

11:33AM X6.00005 Two jet production at large x as a probe of superfast quarks in nuclei1. ADAM FREESE, MISAK SARGSIAN, Florida International University, MARK STRIKMAN, Penn State University — We have developed a theoretical framework for the calculation of two jet production in p-A scattering at LHC energies which allows us to probe a nuclear partonic distributions at moderate to large Bjorken x. Due to the large invariant momentum transfer involved in the reaction, the QCD evolution of partonic distributions is sensitive to the nuclear quarks with very large initial momentum fractions. Based on the few-nucleon short range correlation model of the nuclear wave function, we estimated the cross section of the reaction and the sensitivity of the measured process to a possible transition from hadronic to quark-gluon degrees of freedom in the nucleus.

This work is supported by a US DOE grant.

1/11:45AM X6.00006 Jet studies in Pb-Pb collisions with ALICE at LHC, JOEL MAZER, Univ of Tennessee, ALICE COLLABORATION — High energy heavy ion collisions allow the study of nuclear matter at high temperatures and energy densities, where a Quark Gluon Plasma (QGP) is formed. One way of probing the QGP is by measuring the resulting energy loss from the suppression of jets. A jet is the collimated shower of hadrons produced by a parton resulting from a hard scattering early in the collision. In heavy ion collisions, partons undergo interactions with the QGP, which reduces the jet energy. In non-central collisions, the asymmetry of the hot and dense matter profile is expected to lead to a dependence of the jet yield on the angle with respect to the reaction plane. The current methods used in ALICE for studies of full jets will be discussed. Full jets are reconstructed from clusters using the Electromagnetic Calorimeter (EMCal) detector and charged tracks from the ALICE tracking system. The current status of studies of jets in Pb-Pb collisions relative to the reaction plane will be presented.

11:57AM X6.00007 Measurement of pion, kaon, and proton spectra in U+U collision at √NN = 193 GeV with PHENIX, BRENNA SCHAEFER, Vanderbilt University, PHENIX COLLABORATION — The Relativistic Heavy Ion Collider at Brookhaven National Lab allows nuclear matter to be studied at extremely high temperatures and energy densities. RHIC is uniquely versatile in it’s ability to collide a wide range of species. In 2012 RHIC saw the first ever high energy collisions with the irregularly shaped uranium nuclei, providing the possibility to produce systems with different initial energy densities for the same number of participating nucleons. This allows for systematic investigation of the effects of initial geometry and density on particle production. The work in progress for measurement of the identified pion, kaon, and proton spectra as a function of centrality will be presented. The nuclear modification factor (R_{AA}) and particle ratios such as kaon/pion, proton/pion, and antiproton/proton will also be studied and compared with the ratios measured in Au+Au collisions.
10:45AM X7.00001 Scaling properties of the harmonic oscillator basis calculations for \( N = Z \) nuclei in the infrared limit with the JISP16 potential\(^1\). CHRYSOVALANTIS CONSTANTINOU, MARK A. CAPRIO, Univ of Notre Dame, JAMES P. VARY, PIETER MARIS, Iowa State University — It has recently been found [S. A. Coon et al., Phys. Rev. C 86, 054002 (2012)] that when no-core configuration interaction (NCCI) calculations of low-mass nuclei are plotted against an infrared momentum cutoff \( \Lambda \) (scaling cutoff), a universal curve is obtained for the energy and the RMS radius. The plotted results must have an ultraviolet (UV) cutoff \( \Lambda_{UU} \) greater than or equal to the intrinsic cutoff \( \Lambda_{NN} \) of the interaction. This assures that UV convergence is reached. The scaling property then allows for the performance of extrapolations in the IR limit. Here we conduct NCCI calculations in the harmonic oscillator basis with the JISP16 potential. In the IR limit we obtain universal curves for \( N = Z \) nuclei up to and including \(^{9}\text{Be}\). An extrapolation in the IR limit for the ground state energy and the RMS radius is performed, and extrapolated results are obtained.

\(^1\)Supported by US DOE (DE-FG02-95ER40934, DESC0008485 SciDAC/NUCLEI, DE-FG02-87ER40371), US NSF (0904782), and Research Corporation for Science Advancement (Cottrell Scholar Award). Computational resources provided by NERSC (US DOE DE-AC02-05CH11231).

10:57AM X7.00002 Global performance of covariant energy density functionals: ground state observables of even-even nuclei and error estimates\(^1\). SYLVESTER AGBEMAVA, A.V. AFANASJEV, D. RAY, Mississippi State University, P. RING, Technical University of Munich, Germany — Covariant density functional theory [1] is a modern theoretical tool for the description of nuclear structure phenomena. In this theory, the nucleus is described as a system of nucleons which interact by the exchange of various mesons. The goal of the current investigation is a first ever global assessment of the accuracy of the description of physical observables related to the ground state properties of even-even nuclei and establishing theoretical uncertainties in their description using the set of four modern covariant energy density functionals (CEDF) such as NL3*, DD-ME2, DD-ME\(\delta\) and DD-PC1. Calculated binding energies, the deformations, radii and two-particle separation energies are compared in a systematic way with available experimental data [2,3]. The comparison of theoretical results obtained with these CEDFs allows to establish theoretical uncertainties in the description of physical observables in known regions of nuclear chart and extrapolate them towards neutron-drip line.


\(^1\)This work has been supported by the U.S. Department of Energy under the grant DE-FG02-07ER41459 and by the DFG cluster of excellence “Origin and Structure of the Universe” (www.universe-cluster.de).

11:09AM X7.00003 Reflection asymmetric shapes in covariant density functional theory\(^1\), A.V. AFANASJEV, S. AGBEMAVA, Mississippi State University, P. RING, Technical University of Munich, Germany — Reflection asymmetric (octupole deformed) shapes play an important role in some areas of nuclear chart. For example, the outer fission barriers in actinides and superheavy nuclei are strongly affected by such shapes [1]. The recent progress in the study of such shapes and octupole softness at ground states of lanthanides \((A \sim 145)\) and actinides \((A \sim 224)\) as well as at outer fission barriers of actinides and superheavy [1] nuclei within the covariant density functional theory [2] will be reviewed. New results obtained within the relativistic Hartree-Bogoliubov framework with separable limit of finite range Gogny D1S pairing in the pairing channel will be discussed. The experimental data will be systematically compared with model calculations. The work on the extension of the relativistic Hartree-Bogoliubov formalism to the description of odd, odd-odd and rotating nuclei with reflections asymmetric shapes is currently in progress. New results obtained with these extensions will be reported.


\(^1\)This work has been supported by the U.S. Department of Energy under the grant DE-FG02-07ER41459 and by the DFG cluster of excellence “Origin and Structure of the Universe ” (www.universe-cluster.de).

11:21AM X7.00004 Building Relativistic Mean-Field Models for Atomic Nuclei and Neutron Stars , WEI-CHIA CHEN, JORGE PIEKAREWICZ, Florida State University — Nuclear energy density functional (EDF) theory has been quite successful in describing nuclear systems such as atomic nuclei and nuclear matter. However, when building new models, attention is usually paid to the best-fit parameters only. In recent years, focus has been shifted to the neighborhood around the minimum of the chi-square function as well. This powerful way with available experimental data [2,3]. The comparison of theoretical results obtained with these CEDFs allows to establish theoretical uncertainties in the description of physical observables in known regions of nuclear chart and extrapolate them towards neutron-drip line.


\(^1\)This work has been supported by the U.S. Department of Energy under the grant DE-FG02-07ER41459 and by the DFG cluster of excellence “Origin and Structure of the Universe ” (www.universe-cluster.de).

11:33AM X7.00005 Examining nuclear pairing correlations in the continuum via a Monte Carlo algorithm \(^1\). MARK LINGLE, ALEXANDER VOLYA, Florida State University — Pairing correlations and pair scattering into the continuum of reaction states play an important role in determining the properties of exotic, near dripline nuclei. Unfortunately, the particle number non-conservation and problems in the limit of weak pairing make the traditional approaches based on the BCS theory ill suited for exploration of these near-dripline nuclei. In this presentation we put forth a Monte Carlo algorithm that suffers none of the drawbacks of traditional theories. The advantages of the Monte-Carlo approach include the ability to handle truly large-scale problems exactly, the absence of the fermionic sign problem, and a probabilistic interpretation of quantum-mechanical amplitudes. Excited states corresponding to pair vibrations are also accessible with this approach. We apply our algorithm to the problem of pairing correlations that extend into the reaction continuum. We model the continuum of reaction states by placing the system of interest in a large box. Using the resulting set of one-body states the pairing problem is then solved exactly. We present benchmarking and model studies as well as applications to oxygen isotopes.

\(^1\)This work is supported by the U.S. Department of Energy under contract number DE-SC0009883.
11:45AM X7.00006 Bjorken-x dependence of many-body correlations in DIS cross section ratios off nuclei

ALLEN BARR, DREW FUSTIN, ATHANASIOS PETRIDIS, Drake University — Many-body correlations in nuclei determine the behavior of Deep-Inelastic-Scattering (DIS) cross section ratios off heavy over light nuclei especially for Bjorken-x > 1, obtained at Jefferson Laboratory. Such correlations can be described in terms of quark-cluster formation in nuclei due to wave-function overlapping. In clusters (correlated nucleons) the quark and gluon momentum distributions are softer than in single nucleons and extend to x > 1. The probabilities for such clusters are computed using a network-defining algorithm in which the initial nucleon density is either standard Woods-Saxon or is input from lower energy data while the critical radius for nucleon merging is an adjustable parameter. The exact choice of critical radius depends on the specific nucleus and it is anti-correlated to the rescaling of the Bjorken-x for bound nucleons. The calculations show that there is a strong dependence of the cross section ratios on Bjorken-x in agreement with the data and that four-body correlations are needed to explain the experimental results even in the range 2 < Bjorken-x < 3.

11:57AM X7.00007 Analytical expression for the functional dependence between complex scattering length and binding energy

QUAMRUL HAIDER, Department of Physics & Engineering Physics, Fordham University, Bronx, N.Y. 10458, LON-CHANG LIU1, Theoretical Division — We derive the analytical expressions that relate the binding energy and half-width of an unstable bound state to the corresponding complex scattering length and vice versa [1]. This analytical dependence is interaction-model independent. It provides a check on the consistency between theoretical calculations (respectively, experimental measurements) of bound-state formation and low-energy scattering for any given particle-target system. Numerical examples are presented for eta-nucleus systems.


12:09PM X7.00008 The Sp(3,R) Sympletic Model: a comparison of exact and approximate matrix elements

ANNA MCCOY, MARK CAPRIO, Univ of Notre Dame, DAVID ROWE, Univ of Toronto — The Sp(3,R) symplectic model has a close physical connection to both the microscopic shell model and the collective deformation and rotational degrees of freedom, and it is a natural extension of the Elliott SU(3) model from single-shell to multi-shell dynamics. The Sp(3,R) Lie algebra — which contains the angular momentum operators, the quadrupole and vibrational momentum operators and the quadrupole flow tensor operators — is the smallest algebra containing both the shell model Hamiltonian and the rotor algebra. In the limit of large number of oscillator quanta, the Sp(3,R) algebra contracts to the U(3) boson algebra. For large values of the Casimir operator of the SU(3) subalgebra, the sp(3,R) algebra further contracts to the algebra of the collective coupled rotor-vibrator model. The exact Sp(3,R) matrix elements, calculated using the vector coherent state method, are compared with approximate matrix elements calculated in the U(3) boson limit.

Tuesday, April 8, 2014 10:45AM - 12:09PM – Session X8 DAP: Supernovae and Gamma Ray Bursts

10:45AM X8.00001 Models of Core-Collapse Supernova Explosions and Uncertainties in Pre-supernova Stellar Structure

CHRISTIAN D. OTT, TAPIR, Caltech, SEAN M. COUCH, Flash Center, University of Chicago — Stars are not perfectly spherical. There are strong indications from the first set of multi-dimensional simulations of the late stages of stellar evolution that precollapse stellar structure may harbor large scale deviations from spherical symmetry. We discuss current uncertainties in presupernova stellar structure and show results from a numerical experiment that demonstrates that asphericities caused by vigorous convective Si/O shell burning can have a pivotal effect on supernova dynamics.

10:57AM X8.00002 Simulating Radiation Transport in Curved Spacetimes

EIRIK ENDEVÉ, CORY HAUCK, YULONG XING, CHRISTIAN CARDALL, Oak Ridge National Lab, ANTHONY MEZZACAPPA, University of Tennessee — We are developing methods for simulation of radiation transport in systems governed by strong gravity (e.g., neutrino transport in core-collapse supernovae). By employing conservative formulations of the general relativistic Boltzmann equation we aim to develop methods that are (i) high-order accurate for computational efficiency; (ii) robust in the sense that the phase space density f preserves the maximum principle of the physical model (f ∈ [0,1] for fermions); and (iii) applicable to curvilinear coordinate systems to accommodate curved spacetimes, which result in gravity-induced frequency shift and angular aberration. Our approach is based on the Runge-Kutta discontinuous Galerkin method which has many attractive properties, including high-order accuracy on a compact stencil. We outline our numerical methods, and show results from implementations in spherical and axial symmetry. Our tests show that the method is high-order accurate and strictly preserves the maximum principle on f. We also demonstrate the ability of our method to accurately include effects of a strong gravitational field.

10:45AM X8.00001 Models of Core-Collapse Supernova Explosions and Uncertainties in Pre-supernova Stellar Structure

11:09AM X8.00003 Three-dimensional simulation of core-collapse supernovae with CHIMERA

O.E.B. MESSER, Oak Ridge National Laboratory, ERIC J. LENTZ, University of Tennessee, Knoxville, STEPHEN W. BRUENN, Florida Atlantic University, J.A. HARRIS, University of Tennessee, Knoxville, W. RAPHAEL HIX, Oak Ridge National Laboratory, ANTHONY MEZZACAPPA, University of Tennessee, Knoxville, JOHN M. BLONDIN, North Carolina State University, EIRIK ENDEVÉ, Oak Ridge National Laboratory, PEDRO MARRONETTI, National Science Foundation, KONSTANTIN YAKUNIN, University of Tennessee, Knoxville — Core-collapse supernovae are driven by a multidimensional neutrino radiation hydrodynamic (RHD) engine, and full simulation ultimately requires symmetry-free three-dimensional (3D) RHD simulation. We present ongoing 3D simulation with our multidimensional RHD supernova code CHIMERA that includes all of the most important physical components. The 3D simulation will be compared to completed axisymmetric (2D) simulations that have shown robust explosions in agreement with observational measurements. The impact of symmetry (dimension) and its consequences for our understanding of the explosion mechanism will be discussed in the context of current simulations.

11:21AM X8.00004 The Magnetorotational Explosion Mechanism in Full 3D Core-Collapse Supernova Simulations

SHERWOOD RICHERS, PHILIPP MOESTA, CHRISTIAN OTT, ANTHONY PIRO, ROLAND HAAS, KRISTEN BOYDSTUN, ERNARAZ ABDIKAMALOV, CHRISTIAN REISSWIG, Caltech, ERIK SCHNETTER, Perimeter Institute — We present the first fully 3D general-relativistic magneto-hydrodynamics (GRMHD) simulations of stellar collapse in rapidly rotating, magnetized progenitors using a microphysical equation of state and a Leakage neutrino transport approximation. We perform simulations in 3D both with octant symmetry and with no imposed symmetries of the same 25 M_☉ progenitor. We show that in the simulation without symmetries a kink instability disrupts the initial formation of a jet, while octant symmetry allows the jet to stably propagate and leads to a jet-driven explosion. Rising magnetic bubbles expand the shock of the symmetry-free simulations at later times, but the star’s ultimate fate is uncertain.
11:33 AM X8.00005 Toward Connecting Core-Collapse Supernova Explosions with Observations of their Supernova Remnants. TIMOTHY HANDY, TOMASZ PLEWA, Florida State University, ANDRZEJ ODRZYWOLEK, Jagellonian University — We study the process of collapse of a massive star and the following explosion process until the formation of a young supernova remnant in a single simulation. These new models are critically evaluated against a database of core-collapse supernova (ccSNe) explosion models obtained with a standard supernova code. We develop a multiphysics hydrocode capable of accounting for physics from before collapse occurs until the supernova remnant phase. This enables ccSNe studies with a single code without the need of remapping or transferring data between multiple codes. The code uses a new algorithm to account for the effects of neutrino-matter interaction in the collapsing stellar core. The algorithm uses ray-casting in three dimensions and enables performing collapse and explosion simulations on AMR meshes, including non-radial discretizations. Heating due to radioactive decay, and magnetization of the ejecta are included in the model. The asymmetry of the explosion continues to play a role well beyond the shock breakout phase. In particular, the lateral momentum deposited in the process of shock revival helps shape the supernova ejecta. Another important contributing factor shaping the ejecta is due to radioactive decay of nucleosynthetic products of the explosion.

11:45 AM X8.00006 Catching the First Cosmic Explosions: Explosion and Mixing of Pair-Instability Supernovae, KE-JUNG CHEN, UC Santa Cruz, ALEXANDER HEGER, Monash University, STAN WOOSLEY, UC Santa Cruz — We present multidimensional simulations of the thermonuclear supernovae from massive primordial stars. Numerical and theoretical study of the primordial star formation in the early Universe suggest that these stars could have been very massive. Primordial stars with initial masses of 150-260 solar masses may have died as energetic thermonuclear supernovae, so-called pair-instability supernovae (PSNe). We model the explosion of PSNe by using a new radiation-hydro code, CASTRO and find the fluid instabilities driven by nuclear burning and hydrodynamics during the explosion. For red supergiant models, amplitudes of these instabilities are sufficient to break down the spherical symmetry of the supernova ejecta.

11:57 AM X8.00007 “Pseudo-cyclotron” radiation of non-relativistic particles in small-scale magnetic turbulence1, BRETT KEENAN, ALEX FORD, MIKHAIL V. MEDVEDEV, U. Kansas — Plasma turbulence in some astrophysical objects (e.g., weakly magnetized collisionless shocks in GRBs and SN) has small-scale magnetic field fluctuations. We study spectral characteristics of radiation produced by particles moving in such turbulence. It was shown earlier that relativistic particles produce jitter radiation, which spectral characteristics are markedly different from synchrotron radiation. Here we study radiation produced by non-relativistic particles. In the case of a homogeneous fields, such radiation is cyclotron and its spectrum consists of just a single harmonic at the cyclotron frequency. However, in the sub-Larmor-scale turbulence, the radiation spectrum is much richer and reflects statistical properties of the underlying magnetic field. We present both analytical estimates and results of ab initio numerical simulations. We also show that particle propagation in such turbulence is diffusive and evaluate the diffusion coefficient. We demonstrate that the diffusion coefficient correlates with some spectral parameters. These results can be very valuable for remote diagnostics of laboratory and astrophysical plasmas.

Supported by grant DOE grant DE-FG02-07ER54940 and NSF grant AST-1209665.

Tuesday, April 8, 2014 10:45 AM - 12:33 PM
Session X10 FEd: Invited Session: Open Innovation Labs for Physics Undergraduate Independent Research

10:45 AM X10.00001 Open Innovation Labs for Physics Undergraduate Independent Research, DUNCAN CARLSMITH, University of Wisconsin-Madison — Open undergraduate laboratory Garage Physics at the University of Wisconsin-Madison is home to a variety of independent physics and multidisciplinary research projects. Its maker-style environment encourages innovation and entrepreneurship. Experience establishing and staffing the laboratory will be described.

Supported by grant DOE grant DE-FG02-07ER54940 and NSF grant AST-1209665.

11:21 AM X10.00002 Physics as a Platform for Teaching Innovation, JOHN R. BRANDENBERGER, Department of Physics — Teaching or encouraging innovation in the context of undergraduate physics has been explored in several settings in the Department of Physics at Lawrence University. The purpose, rationale, impetus, methodology, background materials, and descriptions of the different settings used in this investigation are discussed along with an assessment of the programmatic successes and challenges.

Supported by the National Science Foundation and Lawrence University.

11:57 AM X10.00003 The Innovation Hyperlab: a Physical and Curriculum Framework for Fostering Innovation From Grade School to Grad School, RANDALL TAGG, University of Colorado Denver — A versatile laboratory for open innovation has been created in a former auto-shop-instruction building adjacent to Gateway High School in the Aurora Public Schools district in Colorado. We have equipped this 2500 square foot space with resources to support fifty-two technologies, such as mechanical design, electronics, optics, and nanotechnology. Correspondingly, we are developing a web site to provide modular instruction around each of these technologies. The goal is to enable collaborations of secondary school students, university students, teachers, professors, and industry partners in an environment richly supported by both physical and educational resources. An Innovation Academy is currently in progress in the lab with projects such as surgery in zero-G and using music to script the motion of actuator arrays in robots and rehabilitation devices.

Supported by the National Science Foundation and Lawrence University.

Tuesday, April 8, 2014 10:45 AM - 12:33 PM
Session X11 DCOMP DAP: Invited Session: New Computational Techniques for Astrophysics

10:45 AM X11.00001 Porting Legacy LQCD Application to GPUs, M.A. CLARK, NVIDIA — The exponential growth of floating point power in GPUs, combined with high memory bandwidth, has given rise to an attractive platform upon which to deploy HPC applications. When it comes to legacy applications there is a danger that entire codebases have to be rewritten to fully embrace this computational power. In this paper, we discuss how to efficiently port legacy lattice quantum chromodynamics (LQCD) applications, e.g., MILC and Chroma, onto GPUs avoiding this rewriting overhead. The approach taken is a community-wide library (QUDA) which provides high-performance implementations for the time-critical LQCD algorithms, which can be linked into any legacy lattice QCD application, providing instant GPU acceleration. We discuss some of the bleeding-edge strategies taken by QUDA to maximize performance, including the use of communication reducing algorithms, mixed-precision methods and an aggressive auto-tuning methodology. While algorithms and routines that are not offloaded to QUDA will typically not be time-critical, they can potentially limit the overall speedup due to the onset of Amdahl’s law. We discuss various compile-and-run strategies to circumvent this, including the use OpenACC directives or retargeting the underlying domain-specific language (DSL) to generate GPU code directly from the original source.
11:57AM X11.00003 Chemora: A Scalable PDE Solving Framework for Modern HPC Architectures, ERIK SCHNETTER, Perimeter Inst for Theo Phys — Modern HPC architectures consist of heterogeneous multi-core many-node systems with deep memory hierarchies. Modern applications continue to employ advanced discretisation methods to study multi-physics problems. Developing such applications that explore cutting-edge physics on cutting-edge HPC systems has become a complex task that requires significant HPC knowledge and experience. Chemora is a generic framework for solving systems of Partial Differential Equations (PDEs) that targets modern HPC architectures. Chemora is based on Cactus, which sees prominent usage in the general relativistic astrophysics community. PDEs are expressed either in a high-level latex-like language or in Mathematica. Discretisation stencils are defined separately from equations, and discretisation can include Finite Differences, Discontinuous Galerkin Finite Elements, Adaptive Mesh Refinement (AMR), and multi-block systems.

We use Chemora in the Einstein Toolkit to implement the Einstein Equations on CPUs and on accelerators, and study astrophysical systems such as black hole binaries, neutron stars, and core-collapse supernovae.

Tuesday, April 8, 2014 10:45AM - 12:33PM - Session X12 DPF: Instrumentation & Methods II 100 - Nikos Varelas, University of Illinois at Chicago

10:45AM X12.00001 Beam test of a large-area GEM detector prototype for the upgrade of the CMS muon endcap system, VALLARY BHOPATKAR, Florida Inst of Tech, CMS GEM COLLABORATION — Gas Electron Multiplier (GEM) technology is being considered for the forward muon upgrade of the CMS experiment in Phase 2 of the CERN LHC. The first such implementation is planned for the GE1/1 system in the 1.5<|r|<2.2 region of the muon endcap. With precise tracking and fast trigger information, this system can significantly improve the CMS muon trigger as shown previously in simulations. We assembled a 1m full-size prototype of a GE1/1 triple-GEM detector with 3,072 radial readout strips at Florida Tech and tested it in hadron beams at Fermilab in October 2013. Construction of this largest GEM detector type built to-date is briefly described. Strip cluster parameters, detection efficiency, and spatial resolution for charged particles are studied with position and high voltage scans and at different inclination angles. Strip cluster sizes increase with high voltage. We find a plateau detection efficiency of (97.7 ± 0.2)%. All eight eta sectors of the prototype detector show similar high efficiencies. Results of response uniformity and spatial resolution studies using four GEM-based reference tracking detectors will be presented.

10:57AM X12.00002 The ATLAS Hadronic Tau Trigger, ELIZABETH CAITLIN BROST, University of Oregon, ATLAS COLLABORATION — As proton-proton collisions at the LHC reach luminosities close to \( 10^{34} \) cm\(^{-2}\) s\(^{-1}\), the strategies for triggering have become more important than ever for physics analyses. Simplicistic single tau lepton triggers suffer from severe rate limitation, despite the sophisticated algorithms used in the tau identification. The development of further fast algorithms and the design of topological selections are the main challenges to allow a large program of physics analysis. The tau triggers provide many opportunities to study new physics beyond the Standard Model, and to get precise measurements of the properties of the Higgs boson decaying to tau-leptons. We present the performance of the hadronic tau trigger taken in Run 1 data with the ATLAS detector at \( \sqrt{s} = 8 \text{ TeV} \) p-p collision. One of the major challenges is to sustain high efficiencies in events with multiple interactions. To do this we introduced faster tracking methods, multivariat selection techniques, and new topological criteria in the software trigger. We present measurements of the trigger efficiency using Z to tau lepton events as the application testcases for tau tau resonances, such as the Higgs boson searches. We also outline the upgrade plan expected for Run 2 for the 14(13) TeV LHC pp collisions.

11:09AM X12.00003 The Design of an Upgrade to the Level-1 Trigger for the Endcap Muon System of the CMS Experiment, MATTHEW CARVER, University of Florida, CMS COLLABORATION — We present a description of a novel track finding algorithm and associated hardware to be implemented as an upgrade to the L1-Trigger of the endcap muon system of the CMS experiment at the LHC in Geneva, Switzerland. To handle the increased luminosity and pile-up expected from the LHC after the current shutdown, the algorithm uses predefined patterns to identify tracks left by muons in the detector at a rate of 40 MHz. If multiple tracks are found they are sorted on the quality of the muon, defined by the number of hit detectors and straightness of the pattern. The track finding logic is pipelined such that the trigger will operate with no deadtime and has an available latency on the order of 1.1\( \mu \text{s} \) to make a decision. The electronics board housing this logic makes use of state-of-the-art field-programmable gate arrays and large memory lookup tables to accomplish its track finding purpose. Preliminary studies on simulated data show roughly 99.5% efficiency for both single and multiple muon tracks.

11:21AM X12.00004 The Trigger and Data Acquisition System of the ATLAS experiment in preparation for Run 2, LUKAS HEINRICH, CERN, ATLAS TDAQ COLLABORATION — After its first shutdown, LHC will provide pp collisions with increased luminosity and energy. In the ATLAS experiment, aimed at recording these collisions, the Trigger and Data Acquisition (TDAQ) system is upgrading to deal with increased event rates. A new trigger strategy is deployed, exploiting new methods and technologies that will further increase robustness and flexibility. The first stage of the trigger, hardware based, will increase the number and complexity of the input signals, while accommodating new hardware for improved performance. The high-level trigger, software based, will become more flexible in operating over both limited regions of the detector, the so-called Regions-of-Interest (RoI), or complete events. Higher rejection power is achieved by incorporating more elements of the offline reconstruction in the trigger. The data-acquisition architecture is simplified, with a single network for automatically balanced distribution of the computing resources and a single node execution for improved performance. The current design of the data acquisition system will be discussed, with a focus on the developments that will influence its operation in Run 2 and beyond.

11:33AM X12.00005 Phase 1 Upgrade of the CMS Pixel Detector: Module Assembly and Testing, ASHISH KUMAR, SUNY at Buffalo, CMS COLLABORATION — The CMS pixel detector is the innermost component of the all-silicon tracking system located closest to the interaction point and thus operates in a high-occupancy/high-radiation environment created by particle collisions. The performance of the current pixel detector has been excellent during Run 1 of the LHC. However, the foreseen increases of the instantaneous and integrated luminosities at the LHC necessitate an upgrade of the pixel detector in order to maintain the excellent tracking and physics performance of the CMS detector. The new pixel detector is expected to be installed during the extended end-of-year shutdown in 2016/17. The main new features of the upgraded pixel detector would be ultra-light mechanical design with four barrel layers and three end-caps on either side of the interaction point, digital readout chip with higher rate capability and new cooling system. These and other design improvements, along with the current status on module assembly and testing, will be discussed.
the speed of light and do not interact with conserved electric currents. Hence, they have three properties in common with dark energy.

Waves. They superimpose linearly with electromagnetic waves. We show that the nonelectromagnetic waves, besides having negative pressure, propagate with solutions of the extended Maxwell equations. The nonelectromagnetic waves consist of coupled scalar and electric waves and coupled magnetic and pseudoscalar waves. In rebounding from a wall, they would pull rather than push. In this presentation we use standard methods of analyzing energy and momentum. By retrograde momentum we mean waves carrying momentum pointing in the opposite direction of energy flow. If such waves exist, they would be a useful tool for analyzing wave propagation. We use geometric algebra to explore the concept of negative pressure. In free space a straightforward extension of Maxwell’s equations using geometric algebra yields a theory in which classical electromagnetic waves coexist with nonelectromagnetic waves having retrograde momentum. By retrograde momentum we mean waves carrying momentum pointing in the opposite direction of energy flow. If such waves exist, they would have negative pressure. In rebounding from a wall, they would pull rather than push. In this presentation we use standard methods of analyzing energy and momentum conservation and their flow through the surface of an enclosed volume to illustrate the properties of both the electromagnetic and nonelectromagnetic solutions of the extended Maxwell equations. The nonelectromagnetic waves consist of coupled scalar and electric waves and coupled magnetic and pseudoscalar waves. They superimpose linearly with electromagnetic waves. We show that the nonelectromagnetic waves, besides having negative pressure, propagate with the speed of light and do not interact with conserved electric currents. Hence, they have three properties in common with dark energy.

11:45AM X12.00006 CMS Forward Hadron Calorimeters Phase II Upgrade. BURAK BILKI, University of Iowa, Argonne Nati Lab, CMS COLLABORATION — Phase II Upgrade of the CMS forward hadron calorimeters necessitates from the fact that these calorimeters will not be able to survive the HL-LHC (High Luminosity LHC) conditions. The upgrade path is tentatively divided into two scenarios: The replacement of the active media in the endcap hadron calorimeter section keeping the existing mechanical and electronics structure in place; the construction of a new forward hadron calorimeter system. This talk will discuss various upgrade options based on these two scenarios. Brief explanation of the detector concepts and future test plans will be presented.

11:57AM X12.00007 Novel Cerenkov Detector for Particle Identification. KAMURAN DILSIZ, HASAN OGUI, EMRAH TIRAS, University of Iowa, FERMILAB T1041 COLLABORATION — Particle identification based on Cerenkov radiation has been utilized in many detector systems mostly with ring imaging Cerenkov detectors. Gas Cerenkov detectors have also been implemented in the Fermilab and CERN test beam lines for beam users. Here we describe a novel, tracking Cerenkov detector constructed with a quartz-based crystal read out with multiple, directly coupled photomultiplier tubes. Upon optimization, the idea can be generalized to particle identification systems in the future collider detector experiments as well as Compton polarimeters.

12:09PM X12.00008 Secondary Emission Ionization Calorimetry R&D. EMRAH TIRAS, University of Iowa, FERMILAB T1041 COLLABORATION — Secondary Emission (SE) Calorimetry is a new promising technique to measure the electromagnetic showers in extreme radiation environment and very high rate. In this detector type, SE dynode planes are used as the active medium where the SE electrons are generated from these SE surfaces when charged particles penetrate an SE sampling module. Here we report on the response of a dedicated SE sampling module in electromagnetic showers. Projections for a full-scale calorimeter will also be discussed.

12:21PM X12.00009 Beam test results for a large-area GEM detector read out with radial zigzag strips1. AIWU ZHANG, VALLARY BHOPATKAR, MARCUS HOHLMANN, ERIC HANSEN, NICHOLAS LOWING, MIKE PHIPPS, ELIZABETH STÄRLING, JESSIE TWIGGER, KIMBERLY WALTON, Florida Institute of Technology — The FLYSUB consortium conducted a beam test at the Fermilab Test Beam Facility in October 2013 to study performances of several Gas Electron Multiplier (GEM) prototype detectors that are being considered for forward tracking and particle identification in an experiment at a future Electron Ion Collider (EIC) in the US. Our group operated five GEM tracking detectors with different areas including one of the two largest GEM detectors built and operated in the US to-date. This detector, a trapezoidal 1m-long Triple-GEM with 22.45 cm width, was designed with a readout using radial zigzag strips. This allows a substantial reduction of the total number of strips and electronics channel - and consequently system cost - while preserving good spatial resolution for tracking purposes. The design and manufacturing of the readout board with 1.024 zigzag strips is briefly described. We find that this detector performed well in the beam. The charged-particle detection efficiency is ∼ 98%, strip cluster charge distributions closely follow a Landau shape, and measured spatial resolution is ∼ 0.5 mm using charge sharing among adjacent zigzag strips with 2.5 mm pitch. We discuss how the details of the interleaving of adjacent zigzag strips could be further improved in a re-designed readout board to get even better spatial resolution.

The authors would like to acknowledge the Brookhaven National Laboratory for supporting this research, and we also appreciate the experts from the Fermilab Test Beam Facility for their great help.

Tuesday, April 8, 2014 10:45AM - 12:33PM —
Session X13 GPMFC DPF: Formal Theory 101 - Nicholas Hadley, University of Maryland

10:45AM X13.00001 Knot physics, spacetime in co-dimension 2. CLIFFORD ELLGEN, none — Attempts to describe particles as topological phenomena go back as far as Kelvin’s conjecture that atoms are knots in the ether. A modern parallel is to ask whether the spacetime manifold of general relativity can be knotted and what properties those knots might have. However, if the manifold is everywhere Lorentzian, then a change of the topology of a spacelike slice of spacetime requires violation of causality. A consistent model emerges if we assume that the spacetime manifold is a 4-dimensional manifold embedded in a 6-dimensional Minkowski space and that each spacelike slice of the manifold has finite energy. A finite energy embedding allows the metric on the manifold to be degenerate on a set of measure zero, therefore the manifold may not be everywhere Lorentzian, which allows for certain types of topology change. An n-dimensional manifold embedded in an n+2-dimensional space can be knotted. We show that the possible knots on the spacetime manifold have properties corresponding to the known elementary particles. If we include the electromagnetic potential then we can use a simple Lagrangian to describe all of the forces including gravity. A simple extension of the assumptions produces quantum field theory.

10:57AM X13.00002 A six-dimensional Jordan model for electroweak interactions. ALDO MARTÍNEZ MERINO1, OCTAVIO OBREGÓN, Universidad de Guanajuato — We present a model for the electroweak interactions based on the commutative but non-associative exceptional Jordan algebra of Hermitian matrices valued on the octonions. By means of this, we propose a construction of a gauge theory which take values in this algebra. Following closely the six-dimensional model proposed by D. Fairlie years ago and using a supergroup, we found a natural structure that provides the weak interaction action with some additional terms; we will briefly comment on their possible meaning.

1Postdoctoral Fellow at Universidad de Guanajuato

11:09AM X13.00003 ABSTRACT WITHDRAWN —

11:21AM X13.00004 Using Clifford Algebra to Understand the Nature of Negative Pressure Waves. GENE MCCLELLAN, Applied Research Associates, Inc. — The geometric algebra of 3-D Euclidean space, a sub-discipline of Clifford algebra, is a useful tool for analyzing wave propagation. We use geometric algebra to explore the concept of negative pressure. In free space a straightforward extension of Maxwell’s equations using geometric algebra yields a theory in which classical electromagnetic waves coexist with nonelectromagnetic waves having retrograde momentum. By retrograde momentum we mean waves carrying momentum pointing in the opposite direction of energy flow. If such waves exist, they would have negative pressure. In rebounding from a wall, they would pull rather than push. In this presentation we use standard methods of analyzing energy and momentum conservation and their flow through the surface of an enclosed volume to illustrate the properties of both the electromagnetic and nonelectromagnetic solutions of the extended Maxwell equations. The nonelectromagnetic waves consist of coupled scalar and electric waves and coupled magnetic and pseudoscalar waves. They superimpose linearly with electromagnetic waves. We show that the nonelectromagnetic waves, besides having negative pressure, propagate with the speed of light and do not interact with conserved electric currents. Hence, they have three properties in common with dark energy.
11:33AM X13.00005 Meson Spectra from a Three-Field Model of AdS/QCD. JOSEPH KAPUSTA, University of Minnesota — The Anti-de Sitter Space/Conformal Field Theory (AdS/CFT) correspondence may offer new and useful insights into the non-perturbative regime of strongly coupled gauge theories such as Quantum Chromodynamics (QCD). We present an AdS/CFT-inspired model that describes the spectra of light mesons. The conformal symmetry is broken by a background dilaton field, and chiral symmetry breaking and linear confinement are described by a chiral condensate field. These background fields, along with a background glueball condensate field, are derived from a potential. We describe the construction of the potential, and the calculation of the meson spectra, which match experimental data well. We also argue that the presence of the third background field is necessary to properly describe the meson spectra. The outlook for application of this model to finite temperature systems is also discussed.

11:45AM X13.00006 Generalized entanglement entropy and the Ryu-Takayanagi proposal. OCTAVIO OBREGÓN, Universidad de Guanajuato — Non-equilibrium systems with a long-term stationary state that possess as a spatio-temporally fluctuating quality \( \beta \) can be described by a superposition of several statistics, “superstatistics” [1]. Recently [2,3] we have proposed entropy(ies) that depend only on the probability distribution \( \rho \) and which expansion has as first term the Shannon-entropy. We find the corresponding generalization of the von-Neumann entropy and calculate it for the model considered by Ryu and Takayanagi. This results in \( S = e^2(1 - e^{-\frac{E}{\sqrt{N}}} - \frac{E}{\sqrt{N}} + ...) \), where \( S \equiv \log \left( \frac{1}{\sqrt{N}} \sin \left( \frac{\sqrt{N}}{2} \right) \right) \), is the usual (2D CFT) entanglement entropy. In this set up the proposed “area law” \( S_A = \frac{\text{Area of } A}{4G_N} \) would need to be modified in order to have agreement with the entropy Eq.(1). It is beyond the scope of this abstract to suggest an expression for \( S_A - \text{modified} \) and its implications for a modified theory of gravity. [1] C. Beck and E.G.D. Cohen, Phys. A 322 (2003) 267. [2] O. Obregon, Entropy 12(2010) 2067. [3] O. Obregon and A. Gil-Villegas. Phys. Rev. E 88 (2013) 062146.

11:57AM X13.00007 Towards Scaling Relations in Relativistic Hydrodynamics and Gravity. JOHN WESTERNACHER-SCHNEIDER, Univ of Guelph, LUIS LEHNER, Perimeter Institute for Theoretical Physics — Turbulence is ubiquitous in hydrodynamics, and its study is dominated by statistical methods and dimensional arguments. Even so, analytic results tend to rely heavily on statistical symmetries. I will discuss some such results in non-relativistic turbulence, and possible extensions to the relativistic case. The 2+1 dimensionality of our setup allows for gaining insight about 3+1 gravity through the fluid/gravity duality. This work aims to further our understanding of the fluid side in its own right. This partly entails determining the robustness of some recently derived relativistic hydrodynamic scaling relations, which may have holographic applications.

12:09PM X13.00008 The Yang-Mills Mass Gap Solution. JAY R. YABLON, MIT Alumnus — The Yang-Mills Mass Gap problem is solved by deriving SU(3)C Chromodynamics as a corollary theory from Yang-Mills gauge theory. The mass gap is filled from finite non-zero eigenvalues of a configuration space inverse perturbation tensor containing vacuum excitations. This results from carefully developing six equivalent views of Yang-Mills gauge theory as having: 1) non-commuting (non-Abelian) gauge fields; 2) gauge fields with non-linear self-interactions; 3) a “steroidal” minimal coupling; 4) perturbations; 5) curvature in the gauge space of connections; and 6) gauge fields related to source currents through an infinite recursive nesting. Based on combining classical Yang-Mills electric and magnetic source field equations into a single equation, confinement results from showing how magnetic monopoles of Yang-Mills gauge theory exhibit color confinement and meson flow and have all the color symmetries of baryons, from which we conclude that they are one and the same as baryons. Chiral symmetry breaking results from the recursive behavior of these monopoles coupled with viewing Dirac’s gamma matrices as Hamiltonian quaternions extended into spacetime. Finally, with aid from the “steroidal” view, the recursive view of Yang-Mills enables polynomial gauge field terms in the Yang-Mills action to be stripped out and replaced by polynomial source current terms prior to path integration. This enables an exact analytical calculation of a non-linear path integral using a closed recursive kernel and yields a non-linear quantum amplitude also with a closed recursive kernel, thus proving the existence of a non-trivial relativistic quantum Yang-Mills field theory on \( \mathbb{R}^4 \) for any simple gauge group \( G \).

12:21PM X13.00009 An Integrated Theory of Everything (TOE). ANTONIO COLELLA, Retired — An Integrated TOE unifies all known physical phenomena from the Planck cube to the Super Universe (multiverse). Each matter/force particle is represented by a Planck cube string. Any Super Universe object is a volume of contiguous Planck cubes. Super force Planck cube string singularities exist at the start of all universes. An Integrated TOE foundations are twenty independent existing theories and without sacrificing their integrities, are replaced by twenty interrelated unified theories. Amplifications of Higgs force theory are key to an Integrated TOE and include: 64 supersymmetric Higgs particles; super force condensations to 17 matter particles/associated Higgs forces; spontaneous symmetry breaking is bidirectional; and the sum of 8 permanent Higgs force energies is dark energy. Stellar black hole theory was amplified to include a quark star (matter) with mass, volume, near zero temperature, and maximum entropy. A black hole (energy) has energy, minimal volume (singularity), near infinite temperature, and minimum entropy. The precursor universe’s super supermassive quark star (matter) evaporated to a super supermassive black hole (energy). This transferred total conserved energy/mass and transformed entropy from maximum to minimum.

1 CONACYT Project 135023


Tuesday, April 8, 2014 10:45AM - 12:21PM –
Session X14 GHP: Hadron Structure

10:45AM X14.00001 Phenomenology of light hadrons in a chiral effective theory. TIMOTHY HOBBS, JOHN LONDERGAN, Indiana University, CHUENG-RYONG JI, North Carolina State University, WALLY MELNITCHOUK, Jefferson Lab — We present the results of a recent calculation of the pion production cross section as might be determined in proposed Jefferson Lab measurements involving spectator tagging. We also assess the role of the \( \Delta \) isobar in generating the light quark sea asymmetry using \( \chi PT \).
10:57AM X14.00002 Polarization Observables for Double-Pion Photoproduction using a Linearly Polarized Photon Beam and a Transversely Polarized Target from FROST†, P. ROY, V. CREDE, Florida State University, CLAS COLLABORATION — One of the prominent ways to understand quark-gluon interactions in hadron in the low-energy regime is studying the baryon spectrum. The present world database of baryon resonances is inadequate to interpret the spectrum in terms of the relevant degrees of freedom. Double-pion photoproduction, which dominates the total photoabsorption cross section above 1.7 GeV, serves as an important reaction to get access to the higher mass resonances. Cross sections and polarization observables for the double-pion reaction will provide information about the scattering amplitudes and assist in isolating the resonant contributions to the reaction. Here we report on the analysis technique and preliminary results on polarization observables obtained from the study of \( \pi^+\pi^- \) photoproduction using a transversely polarized FROzen Spin butanol Target (FROST) and a linearly polarized photon beam. The experiment was conducted at Jefferson Lab using the CLAS spectrometer. The coherent edge of the linearly polarized beam ranged from 0.9 to 2.1 GeV and we were able to bin the data in 3 kinematic variables. A salient feature of this analysis was the use of an event-based quality factor technique to separate signal from background that originated from bound nucleons present in the target.

†This work is supported by DOE # DE-FG02-92ER40735.

11:09AM X14.00003 MOVED TO M7.008 —

11:21AM X14.00004 Analysis of anti-Kaon-induced Cascade baryon production, BENJAMIN JACKSON, KANZO NAKAYAMA, The University of Georgia, HELMUT HABERZETTL, The George Washington University, YONGSEOK OH, Kyungpook National University, Daeju, Korea — In preparation for the forthcoming experiments on multi-strangeness baryon production at JLab and JPARC, we analyze the general features of Cascade production in both the anti-kaon- and photon-induced reactions. Particular attention is paid to the spin structure of the reaction amplitude for producing Cascade resonances with the emphasis on identifying the spin observables required to determine the production amplitude as well as the spin-parity of the resonance. For the production of Cascade resonances with spin higher than 1/2, the spin-density-matrix formalism is proven to be particularly useful. The \( \gamma N \to K K \Xi \) and \( K N \to K \Xi \) reactions are investigated within a simple model. Emphasis will be placed on the results of the model calculations.

11:33AM X14.00005 Decays of Scalar Mesons in the Light-Front Quark Model†, MARTIN DEWITT, High Point University — The light-front quark model (LFQM) is used to investigate the structure of the scalar mesons, mainly focusing on the three heavy isoscalar states \( f_0(1370), f_0(1500) \), and \( f_0(1710) \). The spectrum of scalar mesons is computed by diagonalizing a relativized, QCD-inspired model Hamiltonian.

The masses are then used to perform a mixing analysis which assumes that the heavy isoscalars are mixtures of \( n\bar{n} = \begin{pmatrix} 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & 0 \end{pmatrix} \), \( s\bar{s} \), and \( g\bar{g} \). The resulting quark-gluon content is used along with the meson wave-functions determined from the spectrum to compute the decay rates for \( f_0 \to \pi\pi \), \( f_0 \to K\bar{K} \), and \( f_0 \to \eta\eta \). When the glueball contribution to the decays is ignored, the results are in poor agreement with the available data. However, when the effect of including the glueball contribution is considered, a solution is found that matches the data quite well. In this solution, the \( f_0(1710) \) is mostly glueball, while the \( f_0(1500) \) and \( f_0(1370) \) are dominantly mixtures of \( n\bar{n} \) and \( s\bar{s} \).

†This work was done in conjunction with Dr. Chueung-Ryong Ji of NC State University and was supported by a SURF/ Jefferson Lab fellowship.

11:45AM X14.00006 Measurement of two-photon exchange effects in CLAS†, DIPAK RIMAL, BRIAN RAUE, Florida International University, DASUN ADIKARAM, LAWRENCE WEINSTEIN, Old Dominion University, CLAS COLLABORATION — There is a significant discrepancy between the Rosenbluth and the polarization transfer measurements of the proton’s electric to magnetic form factor ratio.

One possible explanation of this discrepancy is the contribution from two-photon exchange (TPE) effects, which are not typically accounted for in standard radiative corrections. The ratio of positron-proton to electron-proton elastic scattering cross sections, \( R = \frac{\sigma(e^- p)/\sigma(e^+ p)}{\sigma(e^- p)}/\sigma(e^+ p)) \), provides a model independent measurement of the TPE contribution to elastic electron-proton scattering. We measured this ratio at Jefferson Lab using a mixed electron-positron beam. Both electrons and positrons were elastically scattered from a liquid hydrogen target. The resulting scattered particles were detected in CLAS. The experimental details and results will be discussed.

†U.S. Dept. of Energy

11:57AM X14.00007 Positron-proton to electron-proton elastic cross section ratios from CLAS , DASUN ADIKARAM, Old Dominion University, DIPAK RIMAL, Florida International University, LARRY WEINSTEIN, Old Dominion University, BRIAN RAUE, Florida International University, CLAS COLLABORATION — There is a significant discrepancy between the ratio of the electromagnetic form factors of the proton measured by the Rosenbluth and the polarization transfer technique. The most likely explanation of this discrepancy is the inclusion of two-photon exchange (TPE) amplitude contributions to the elastic electron-proton cross section. The CLAS TPE experiment measured the TPE contribution in the wide range of \( Q^2 \), and \( E \) range using a comparison of positron-proton to electron-proton elastic cross sections (\( R = \sigma(e^- p)/\sigma(e^- p)) \)). Preliminary results will be presented, along with the estimations of systematic uncertainties. A detailed comparison of new results with previous \( R \) measurements and theoretical calculations will be presented. Implications of the CLAS TPE measurements on the elastic electron-proton cross section will also be discussed.

12:09PM X14.00008 A Radiative Event Generator for OLYMPUS†, AXEL SCHMIDT, MIT, OLYMPUS COLLABORATION — The OLYMPUS Experiment, which completed data taking in 2013, will determine the ratio of positron-proton to electron-proton elastic scattering cross sections over a range of momentum transfer from 0.4 to 2.2 (GeV/c)^2. A deviation in this ratio from unity is evidence of two-photon exchange, which is a possible explanation for the discrepancy in measurements of the proton’s electromagnetic form factors. However, the ratio is also sensitive to other radiative effects, such as the interference of lepton and proton bremsstrahlung. To isolate the contribution of hard two-photon exchange, the OLYMPUS MIT group has developed a Monte Carlo radiative generator, so that the various contributions to the cross section ratio can be studied by simulation. With this method, radiative effects can be properly convolved with detector-specific properties such as acceptance and efficiency. It is a goal of the collaboration to make this generator publicly available so that unbiased comparisons can be made between OLYMPUS and other two-photon exchange experiments. The MIT generator will be presented in detail along with a description of radiative corrections in the OLYMPUS analysis.

†This work is supported by DOE Grant DE-FG02-94ER40818.
10:45AM X15.00001 On incorporating post-Newtonian effects in N-body dynamics


11:21AM X15.00004 Mode coupling mechanism for late-time Kerr tails

11:33AM X15.00005 A smoother effective source for scalar self-force simulations

11:45AM X15.00006 Self-force in nonvacuum spacetimes

11:57AM X15.00007 Gravitational Self-Torque and Spin Precession in Compact Binaries
12:09PM X15.00008 Compact Binaries and Supermassive Black Holes, SHANE LARSON, Northwestern University, ERIC ADDISON, Utah State University, PABLO LAGUNA, Georgia Tech — Given the stellar density near the galactic center, close encounters between compact object (CO) binaries and the supermassive black hole (SMBH) are plausible. Tidal disruptions resulting from such encounters have been proposed as possible sources of extreme-mass-ratio inspirals (EMRIs) and hyper velocity stars (HVS) in the galaxy, however the surviving binaries merit attention as they will suffer perturbations to their orbital parameters. We show the conditions under which CO binaries are able to survive the tidal field of supermassive black holes during a parabolic encounter, as well as the distribution of orbital parameters post-encounter. The effect of the tidal field on binaries that remain unbound from the SMBH is to de-circularize and shrink them, thus accelerating merger due gravitational radiation emission and affecting the predicted compact binary coalescence (CBC) rates. For disrupted binaries we show that the component of the compact object binary becoming bound to the supermassive black hole initial eccentricities $\approx 1 - O(10^{-2})$ but circularize dramatically by the time they enter the LISA band, consistent with previous studies.

12:21PM X15.00009 Differential rotation of the unstable nonlinear r-mode\(^1\), JOHN FRIEDMAN, University of Wisconsin-Milwaukee, LEE LINDBLOM, Caltech, KEITH LOCKITCH, Ayn Rand Center — To second order in perturbation theory, the r-modes of uniformly rotating stars include an axisymmetric part that can be identified with a growing differential rotation of the background star. If one does not include radiation-reaction, the differential rotation is constant in time and has been computed by Sä. It has a gauge dependence associated with a choice of equilibrium configuration: Adding to the time-independent second-order solution arbitrary differential rotation that is stratified on cylinders: $\Omega_\Sigma = \Omega_\Sigma(z)$. For the radiation-reaction driven r-mode, however, the differential rotation includes an exponentially growing part that is unique, gauge-independent, and vorticity-conserving. We compute this differential rotation for slowly rotating Newtonian models, acted on by the radiation-reaction force of the unstable mode.

\(^1\)Work supported in part by NSF grants PHY 1001515 and DMS1065438 and by a grant from the Sherman Fairchild Foundation.

Tuesday, April 8, 2014 1:30PM - 3:18PM –
Session Y2 DPF: Invited Session: Higgs Boson II Chatham Ballroom A - Nikos Varelas, University of Illinois at Chicago

1:30PM Y2.00001 Higgs Boson Studies at the Tevatron, WADE FISHER\(^1\), Michigan State University — Searches for Higgs bosons took place at the Tevatron collider for more than a decade, continuing after the end of Tevatron operations in 2011. These searches evolved and steadily improved over this time, reaching the sensitivity required to exclude Higgs masses in the range of 90-200 GeV. These searches covered a large range of production and decay modes, and were highly complementary to the Higgs boson search at the LHC. On July 2, 2012, the two Tevatron, CDF and D0, together reported evidence for a new particle decaying to bottom quarks. The mass of this new resonance was highly compatible with the Higgs discovery announced by the LHC two days later, at 125 GeV. Since this time, the Tevatron experiments have been performing measurements of the Higgs properties, including sensitive probes of the dominant bbH coupling for this mass. This presentation will discuss the results of the Tevatron’s Higgs studies and the potential future directions of study with their data.

\(^1\)Speaking on behalf of the CDF and D0 experiments from the Tevatron collider program.

2:06PM Y2.00002 What can we learn from Higgs coupling measurements?, SALLY DAWSON, BNIL — With the discovery of the Higgs boson, the important task becomes understanding the Higgs properties and in particular the couplings to fermions and gauge bosons. The measurement of these couplings can be used to probe possible new physics at high energy scales. I will discuss the uncertainties on the theoretical predictions of Higgs couplings and the interpretation of these measurements in terms of models with extended Higgs sectors or with other new heavy particles.

2:42PM Y2.00003 Higgs Studies at Future Facilities, TIMOTHY BARKLOW, SLAC National Accelerator Laboratory — The prospects for Higgs studies at future accelerators are reviewed. Detailed studies of the 126 GeV Higgs Boson are presented, including the measurement of the mass, the CP properties, the cross section times branching ratio for several Higgs production mechanisms and decay modes, the total cross section for Higgs production in association with the Z boson, and the invisible Higgs width. The extraction of the Higgs couplings and the total Higgs width from these measurements is examined. In addition, a survey of searches for Higgs Bosons beyond the Standard Model is presented. The following future facilities are considered: the Compact Linear Collider (CLIC), the International Linear Collider (ILC), the Muon Collider (µC), the Triple-Large Electron-Positron Collider (TLEP), and a 100 TeV proton-proton collider (VLHC).

Tuesday, April 8, 2014 1:30PM - 3:18PM –
Session Y3 DNP DAP: Invited Session: R-Process Nucleosynthesis Chatham Ballroom B - Charles Horowitz, Indiana University

1:30PM Y3.00001 Kilonovae: Electromagnetic Counterparts of Neutron Star Mergers Powered by the Radioactive Decay of R-Process Nuclei, BRIAN METZGER, Columbia University — The coalescence of binary neutron stars (NSs) are the most promising sources for the direct detection of gravitational waves by Advanced LIGO and Virgo. However, maximizing the scientific opportunities from such a discovery will require the detection of a coincident electromagnetic counterpart. One possible counterpart is a short gamma-ray burst (GRB), powered by the accretion of NS debris left over from the merger onto the newly-formed black hole. However, GRBs are thought to be relativistically beamed and hence to accompany only a small fraction of mergers. NS mergers also produce isotropic supernova-like emission, powered by the radioactive decay of heavy (r-process) elements which are synthesized in the neutron-rich ejecta from the merger. I will describe the first calculations of such “kilonovae” which include realistic nuclear physics and radiative transport. In addition to providing a smoking gun for detecting binary NS mergers, kilonovae inform the unknown origins of the heaviest elements in the Universe. The first kilonova may have been discovered by the Hubble Space Telescope last year.

2:06PM Y3.00002 Rare Isotopes Heating and Cooling the Crust of Accreting Neutron Stars, HENDRIK SCHATZ, Michigan State University — Observations of accreting neutron stars in X-ray binaries provide a unique window into the structure of neutron stars and the properties of dense matter. Observables such as thermonuclear bursts and cooling behavior are strongly affected by nuclear processes in the crust that involve neutron captures and beta decays on extremely neutron rich rare isotopes. These nuclear processes control nuclear heating, neutrino cooling, and compositional changes that affect thermal transport and need to be understood to interpret X-ray observations. The challenges for nuclear physics are similar to understanding the extremely neutron rich nuclei in the r-process. I will discuss recent progress in delineating the nuclear processes in accreting neutron stars, including a novel neutrino cooling process based on electron-capture and beta decay Urca cycles on nuclei in the outer crust. I will also discuss attempts to address the nuclear physics questions through laboratory measurements at rare isotope facilities and the prospects of obtaining most of the nuclear data in the near future with the new FRIB accelerator facility.
Tuesday, April 8, 2014 1:30PM - 2:54PM –
Session Y7 DNP: Nuclear Theory II 201 - Anatoli Afanasjev, Mississippi State University

1:30PM Y7.00001 Study of nuclear clustering using the modern shell model approach

ALEXANDER VOLYA, Florida State University, YURY TCHUVIL’SKY, Lomonosov Moscow State University — Nuclear clustering, alpha decays, and multi-particle correlations are important components of nuclear dynamics. In this work we use the modern configuration-interaction approach with most advanced realistic shell-model Hamiltonians to study these questions. We utilize the algebraic many-nucleon structures and the corresponding fractional parentage coefficients to build the translational invariant wave functions of the alpha-cluster channels. We explore the alpha spectroscopic factors, study the distribution of clustering strength, and discuss the structure of an effective 4-body operator describing the in-medium alpha dynamics in the multi-shell valence configuration space. Sensitivity of alpha clustering to the components of an effective Hamiltonian, which includes its collective and many-body components, as well as isospin symmetry breaking terms, are of interest. We offer effective techniques for evaluation of the cluster spectroscopic factors satisfying the orthogonality conditions of the respective cluster channels. We present a study of clustering phenomena, single-particle dynamics, and electromagnetic transitions for a number of nuclei in p-sd shells and compare our results with the experimentally available data.

1:42PM Y7.00002 Application of shell model with non-orthogonal basis to nuclear clustering

KONSTANTINOS KRAVVARIS, ALEXANDER VOLYA, Florida State University — Our goal is to study nuclear structure and reactions from ab initio principles. To do so we use a no-core shell model with non-orthogonal basis and apply the framework of the Resonating Group Method. In this presentation we discuss the overlap norm kernel and study the role of the orthogonality condition for channel wavefunctions. Some simple examples will be used to illustrate the techniques and the physics behind our approach.

2:06PM Y7.00004 Sp(3,R) decomposition of the SU(3) no-core shell model basis

FENGQIAO LUO, MARK A. CAPRIO, University of Notre Dame, TOMAS DYTRYCH, Louisiana State University — Numerical evidence shows an important role of the symplectic Sp(3,R) symmetry in the ab initio no-core shell model results for light nuclei. Therefore, the construction of symplectic states from SU(3) states is necessary, as a prerequisite and crucial step of understanding the symplectic structure for those nuclei. This presentation will provide an introduction to our numerical calculation that decomposes the basis states of Sp(3,R) irreducible representations in terms of SU(3) nuclear basis. We use the null space of the Sp(3,R) generator B(102) to find the extremal states, and then ladder them with the generator J(20) to build the entire irreps.

Supported by the Research Corporation for Science Advancement for a Cottrell Scholar Award, by the US DOE under grants DE-FG02-95ER-40934 and DE-SC0005248, and by the US NSF under grant OCI-0904874.
2:18PM Y7.00005 Operator evolution in the three-body space via the similarity renormalization group

Debispree Ray, Anatoli Afanasiev, Sylvester Agbemava, Mississippi State University, Peter Ring, (Technische Universität München, Germany)
— Neutron and proton drip lines represent the limits of nuclear landscape. While proton drip line is measured experimentally, the location of neutron drip line for absolute majority of elements is based on theoretical predictions which imply extreme extrapolations. The first ever systematic investigation of the location of the proton and neutron drip lines in the relativistic Hartree-Bogoliubov (RHB) approach has been performed by us employing the set of modern covariant density functional parameterizations. Separable pairing is used in particle-particle channel of the RHB. This study covers all even-even nuclei with $Z \leq 120$ between proton and neutron drip lines. The accuracy of the description of ground state (masses, two-particle separation energies, deformations, radii etc) properties of known nuclei and its dependence on parametrization have been analysed. Statistical errors in the predictions of neutron-drip line are estimated within the RHB. The comparison with the results of non-relativistic approaches (Skyrme density functional theory, macroscopic+microscopic approach) allows to define systematic errors in the predictions of neutron-drip line. * This work has been supported by the U.S. DOE under the grant DE-FG02-07ER41459 and by an allocation of advanced computing resources.

2:30PM Y7.00006 Nuclear landscape and drip lines in covariant density functional theory

Debispree Ray, Anatoli Afanasiev, Sylvester Agbemava, Mississippi State University, Peter Ring, (Technische Universität München, Germany)
— Neutron and proton drip lines represent the limits of nuclear landscape. While proton drip line is measured experimentally, the location of neutron drip line for absolute majority of elements is based on theoretical predictions which involve extreme extrapolations. The first ever systematic investigation of the location of the proton and neutron drip lines in the relativistic Hartree-Bogoliubov (RHB) approach has been performed by us employing the set of modern covariant density functional parameterizations. Separable pairing is used in particle-particle channel of the RHB. This study covers all even-even nuclei with $Z \leq 120$ between proton and neutron drip lines. The accuracy of the description of ground state (masses, two-particle separation energies, deformations, radii etc) properties of known nuclei and its dependence on parametrization have been analysed. Statistical errors in the predictions of neutron-drip line are established within the RHB. The comparison with the results of non-relativistic approaches (Skyrme density functional theory, macroscopic+microscopic approach) allows to define systematic errors in the predictions of neutron-drip line. * This work has been supported by the U.S. DOE under the grant DE-FG02-07ER41459 and by an allocation of advanced computing resources.

1:30PM Y8.00001 Computational Study of White Dwarf Stars

Jose Pacheco, Aijit Hira, Danelle Jaramillo, Northern New Mexico College — We begin our interest in the computational simulation of the astrophysical phenomena with a study of white dwarf stars. Of particular interest to astrophysicists are the conditions inside a white dwarf star in the time frame leading up to its explosive end as a type Ia supernova, for an understanding of the massive stellar explosions. In addition, the studies of the evolution of white dwarfs could serve as promising probes of theories of gravitation. First, we set up the equations of equilibrium for the star of interest. Then we derived the appropriate equation of state. Next, a FORTRAN computer program was developed to implement our model for white dwarfs. This code allows for different sizes and masses of stars. Simulations were done in the mass interval from 0.4 to 0.8 solar masses. Our goal was to obtain both atmospheric and orbital parameters. The computational results thus obtained are compared with relevant observational data. The data are further analyzed to identify trends in terms of sizes and masses of stars. We hope to extend our computational studies to red giant stars in the future.

1:42PM Y8.00002 Nuclear Mixing Meters for Classical Novae

K.J. Kelly, C. Iladiis, L.N. Downen, A.E. Champagne, University of North Carolina at Chapel Hill and Trinity Universities Nuclear Laboratory, J. José, Universitat Politècnica de Catalunya and Institut d’Estudis Espacials de Catalunya — Mass transfer from a main sequence star onto a white dwarf partner can lead to a thermonuclear runaway (TNR) followed by a violent mass expulsion episode known as a classical nova. Characteristics of novae depend upon evolutionary parameters such as the composition of matter undergoing the TNR and observations suggest mixing between accreted material (presumed to be of solar composition) and the underlying white dwarf prior to the TNR. Using results of models of oxygen-neon novae, the elemental abundance ratios $\Sigma$CNO/H, Ne/H, Mg/H, Al/H, Si/H are found to be indicators of this mixing. The impact of nuclear physics uncertainties on these results was investigated through Monte Carlo post-processing calculations using $T$-$\rho$ profiles for all mass zones as computed by the hydrodynamic models. Although $^{16}$O($p,\gamma$)$^{17}$O significantly affects the Si/H abundance ratio, overall the mixing meters are found to be robust against nuclear physics uncertainties. A comparison of our results with observations provides strong constraints for nova models. * This work was supported in part by the US DOE, NSF, Spanish MICINN, E. U. FEDER funds, and the ESF EUROCORES Program EuroGENESIS

1:54PM Y8.00003 Visible and Near-infrared Light Curves of SN 2009nr

Jonathan Heath, Ginge Bryngelson, Francis Marion University — This study explores the behavior of SN 2009nr, an apparently normal type Ia supernova (SN Ia). A plot of this object’s brightness over time is known as a light curve. Because of the uniformity of their light curves, SNe Ia are valuable markers for determining the expansion of the universe and other cosmological parameters. Understanding the properties of these supernovae is vital in order to build our confidence in their use as standard candles. A small, but increasing number of SN Ia late-time observations have been made in the near-infrared (NIR). Most exhibit a flattening of the NIR power even as the visible light declines at a steady rate. It is still unclear as to why they exhibit this behavior and how typical this is. In order to characterize the late behavior of SNe Ia, images of SN 2009nr were analyzed using the Image Reduction and Analysis Facility (IRAF). NIR (J, H, K) images were taken with the 4m Mayall Telescope at Kitt Peak National Observatory using the FLAMINGOS IR Imaging Spectrometer while visible (B, V, R, I) images used the Mosaic 1 imager. The supernova’s apparent magnitude for each night of observation (by filter) was found by using reference stars. We present preliminary light curves of SN 2009nr and a comparison to another SN observed at similar epochs.
2:06PM Y8.00004 The Power of Thermonuclear Supernovae at Late Epochs, GINGER BRYNGELSON, Francis Marion University, PETER MILNE, University of Arizona Steward Observatory, MARK LEISING, Clemson University — Type Ia supernovae (SNe Ia) shape our understanding of the expansion of the universe in their use as distance indicators. Thought to be the runaway thermonuclear explosion of a white dwarf star in a binary system, SNe Ia are bright enough to be seen in far-away galaxies. Their brightness fades slowly over hundreds of days, powered by radioactive isotopes synthesized in the explosion. At some point after 200 days, the continually expanding ejecta is diffuse enough to allow gamma-rays to escape, and soon the brightness of the SN is only powered by positrons trapped by the SN’s magnetic field. Only a handful of SNe Ia have been observed during epochs longer than 200 days after explosion in both visible and near-infrared light. We discuss our observations of multiple SNe Ia which exploded in nearby galaxies. These were bright enough to be observed out to late epochs (about 525 days post peak). Their brightness was monitored over time in visible light (B,V,R,I bands) and near-infrared (J,H,K) bands, and light curves were constructed. We convert these observations to luminosity and compare them to a simple positron deposition model to estimate the feasibility of positron escape.

2:18PM Y8.00005 On the similarities of the prompt gamma-ray emissions in Short and Long Gamma-Ray Bursts, AMIR SHAHMORADI, Univ of Texas, Austin — Gamma-Ray Bursts (GRBs) are intense short pulses of low-energy (keV-MeV) gamma rays — the so-called “prompt emission” — followed by afterglow radiation in X-ray, optical, infrared or radio wavelengths. Extensive evidence has been accumulated over the past two decades pointing to at least two separate classes of Long and Short GRBs with different progenitors: death of supermassive stars and compact object binary mergers respectively. Despite having different progenitors, here I show that the prompt gamma-ray emissions from both classes of GRBs exhibit highly similar features and correlations, possibly indicating a unified mechanism for the generation of the observed correlations among the gamma-ray spectral and temporal parameters of both classes of GRBs. I highlight similar correlations that are also observed in Blazars’ spectral energy distributions (SED) and discuss the potential effects of observational biases on these relations and their implications for the theoretical models of GRB prompt emission.

2:30PM Y8.00006 Observing gamma-ray bursts with the scaler system of the HAWC Observatory, DIRK LENNARZ, IGNACIO TABOADA, Georgia Institute of Technology, HAWC COLLABORATION — The origin and acceleration mechanisms of gamma-ray bursts (GRBs) are important questions in contemporary astrophysics. Several models are competing to explain the recent observations at higher energies (HE, above ~ 20 MeV). The detection and temporal evolution of GRB emission at the highest energies (> 10 GeV) would have important implications for the GRB physics. The High Altitude Water Cherenkov (HAWC) observatory is a new very-high-energy (VHE, > 100 GeV) gamma-ray detector currently under construction at Sierra Negra in Mexico at an altitude of 4100 m above sea level. Unlike Imaging Atmospheric Cherenkov Telescopes, it has a large field of view and near 100% duty cycle that will allow for observations of the prompt GRB phase. HAWC has two data acquisition (DAQ) systems - one reading out full air-shower events (TDC-DAQ) and the other one counting the hits in each photomultiplier tube (scaler DAQ). GRB 130427A was the most energetic GRB so far detected at a redshift z < 0.5. It featured an unprecedented long high-energy emission and the most energetic photon so far detected from a GRB. In this contribution the results of the scaler analysis of GRB 130427A and other GRBs of interest are shown.

2:42PM Y8.00007 A Search for VHE Emission from GRBs using the HAWC Observatory Air Shower Data, KATHRYNE SPARKS WOODLE, Pennsylvania State University, HAWC COLLABORATION — At an altitude of 4100 m near the peak of Sierra Negra in Mexico, the High Altitude Water Cherenkov Observatory (HAWC) is a second generation water Cherenkov detector that primarily looks for very high-energy gamma-rays from the galaxy and beyond. Due to its wide field of view (~2 sr) and high duty cycle, this extensive air shower detector can observe the beginning of the prompt phase of GRBs occurring overhead. HAWC is sensitive to showers in the sub-TeV to TeV energy range and will be able to help constrain the shape and cutoff of high-energy GRB spectra, especially in conjunction with observations from other detectors such as Fermi. With the design improvement and higher elevation than its predecessor Milagro, HAWC will be almost two orders of magnitude more sensitive to GRBs at 100 GeV when complete. Existing instruments identify about 5 GRBs within HAWC’s field of view per month. The detector has been operated throughout construction, and we will present a search for high-energy emission from GRBs, triggered by existing instruments, using HAWC directional air shower data.

2:54PM Y8.00008 Catching Fermi GBM Gamma-Ray Burst afterglows, ADAM GOLDSTEIN, NASA MSFC, VALERIE CONNAUGHTON, University of Alabama in Huntsville, FERMI GBM TEAM — The Fermi Gamma-Ray Burst Monitor (GBM) detects over 240 Gamma-Ray Bursts (GRBs) per year and is the most prolific detector of short GRBs (lasting less than 2 s). Short GRBs are believed to originate from mergers of compact objects (neutron stars and black holes), which in turn are the most likely expected source of gravitational wave (GW) radiation detectable by the next-generation GW detectors, Advanced-LIGO and VIRGO. Observing the electromagnetic counterparts of GW candidates is very important in order to strengthen the significance of the GW detection and to establish the energetics of the merger event. Neither GBM nor the GW detectors can localize the merger to the sub-degree accuracy on the sky needed to measure the redshift of the event using optical telescopes. Follow-up observations of short GRBs with GBM require a knowledge of the GBM localization uncertainties and a strategy to tile the uncertainty region with the optical follow-up telescopes. The GBM team has recently characterized the systematic uncertainties on GRB localization and is starting to determine probability maps that allow efficient covering of the uncertainty regions to any confidence level. The intermediate Palomar Transient Factory (iPTF) and other ground-based telescopes are using these new products to uncover the afterglows for GBM-detected GRBs in error boxes covering several tens of square degrees on the sky. This is encouraging for the development of strategies to observe the error boxes of short GRBs detected by GBM in the Advanced-LIGO/VIRGO era beginning in 2015-2016.

3:06PM Y8.00009 Search For Correlation Between Known GRBs and Astrophysical Neutrinos As Observed By IceCube, JAMES CASEY, IGNACIO TABOADA, Georgia Institute of Technology, ICECUBE COLLABORATION — Gamma-Ray Bursts (GRBs) have long been proposed as the sources of UHE cosmic rays. In many GRB models, high-energy neutrinos are predicted to be generated during various phases of the burst. The IceCube collaboration has reported the observation of 28 high-energy neutrinos which includes an astrophysical component. The sources of these events, however, have yet to be determined. We examine the temporal and directional correlations between the 28 events and 568 GRBs reported from May 2010 to May 2012 and find that there is no correlation between the neutrino events and the GRBs. We set an upper limit on the fraction of the astrophysical signal reported by IceCube that can be attributed to known GRBs. For correlations times up to ~20 hours, the 90% C.L. upper limit on the fraction of the astrophysical neutrino flux that can be due to known GRBs is 14%. For correlations times of up to 15 days, this upper limit is 36%.

Tuesday, April 8, 2014 1:30PM - 2:54PM – Session Y9 DAP: New Directions in Astrophysics 203 - John Beacom, The Ohio State University
1:30PM Y9.00001 New Explain of Hubble’s Red Shift — DAYONG CAO, AEEA (Avoid Earth Extinction Assoc.) — In Dopple’s frequency shift, there is a Lorentz Factor of the Einstein’s Lorentz transformation. So the mobile light source can cause the Einstein’s Lorentz transformation both of the frequency and the wavelength of the light. The paper supposes that the traveled light can cause the Einstein’s Lorentz transformation both of the frequency and the wavelength of the light too. According to Dopple Effect, Hubble’s Red Shift and the new idea,

\[ H_0 \approx \frac{\lambda_{shift}}{\Delta \nu} \approx \frac{t_{shift}}{T} + \frac{\nu_{rest}\lambda_{shift} - c}{D} \approx \frac{\nu_{rest}t_{shift} - c}{T} \]

Among it, \( H_0 \) is the Hubble’s constant, \( \lambda_{shift} \) is the shifted wavelength of a particular spectral line, The wavelength is as quantum space, \( \nu_{shift} \) is the shifted frequency of a particular spectral line, \( \nu_{rest} \) is the “rest” as the quantum time, \( t_{shift} \) is the 1/\( \nu_{shift} \), D: is the direct distance from observer to the star (travelled distance of the light), \( T \): is the travelled time of the light, \( \Delta \nu \): is the remainder between the \( \nu_{shift} \) and the \( \nu_{rest} \), \( c \): is the speed of the light, a: is the acceleration produced by the light radiation, \( \nu_{rest} \): is the acceleration of gravity. According to the above equations, the \( H_0 \) has a relationship with the \( \lambda_{shift}/D \) or \( t_{shift}/T \); Hubble’s RedShift effect equal a acceleration of a space-time field (as a negative acceleration field of gravity). When the light travels, its quantum space-time is expanded. (Cao Dayong, MEST-The universe has not the time arrowhead and space expanding, http://meetings.aps.org/link/BAPS.2012.APR.E1.2, and New explanation of Hubble’s redshift, http://meetings.aps.org/link/BAPS.2012.DNP.CG.6)

1:42PM Y9.00002 A Second Dimension of Time Explains Quantum and Classical Fields — KRISKE, University of Minnesota — This author had previously proposed that there is a Second Dimension of Time. The two times do not Commute. Usually when one says two things don’t Commute one does not mean the dimensions themselves, although E does not commute with t, and one usually means that take the E operator first and then the t operator is not the same as taking the t operator then the E. Of course in that very statement is a puzzle since it involves itself. What if t(clock) and t(information) do not commute, what that means is take t(clock) and t(information) at a point in x, is not the same as taking t(clock) and t(information) at a different point? Which is a Field and Special Relativity. So suddenly you can see that Fields arise because there are two non-commuting dimensions of time. Since the times are symmetric, what is Conserved Quantity between them? It can’t be Energy, but rather Energy total–One Energy for Clock Time, and one Energy for Information Time. The Total Energy has an interesting property, as the two Dimension of Time result in a totally Geometrical Theory, with only the two Time Dimensions themselves having a Quantum Character. Position and Momentum, Energy and time Commute with two Dimensions of time, as do their “Dark” counterparts. The Conservation “makes” the other Dimension

1:54PM Y9.00003 Experimental observation of dark matter and formation of mini-galaxies at zero speed-of-light — MEGGIE ZHANG, AISTOS — The deformation of the light from a source, such as a galaxy or star, into Einstein rings through gravitational lensing of the source’s light by an object with an extremely large mass. Such rings help in understanding the distribution of dark matter. Here we experimentally demonstrate how Einstein ring are formed and in what nature dark matter is. Through the experimental observation of the structure of dark matter, we propose reinterpretation of quantum mechanic and modification to relativity theory to arrive an unified theory which provided a new understanding about the nature of gravity, mass and mass gap. To verify this work we experimentally demonstrated the formation of “mini-planets” and “mini-galaxies.”

2:06PM Y9.00004 Creator God Rules The Universe Because Hawking Built The Big Bang On A Foundation Of Quicksand — ROBERT GENTRY, The Orion Foundation — Hawking is the world’s premier big bang cosmologist; his compatriots, vast in number, have repeatedly checked all he ever wrote. They would have discovered it earlier if he had blinded even slightly. Thus it’s impossible that he built the big bang on a foundation of quicksand. So the final verdict must be that Hawking is the winner and the God of Genesis is the loser. Despite this cosmological unanimity, we will show that Hawking and all his compatriots are guilty of that blunder and hence are now destined to collectively reap the consequences of having made it. And further that neither they nor their many followers will understand this blunder until learning of it in our presentation. And further that neither they nor their many followers will understand this blunder until learning of it in our presentation. Our presentation reveals how this false foundational assumption of in-flight expansion was identified, and why its discovery led to big bang’s disproof and conclusion that God rules the Universe.

2:18PM Y9.00005 Andromeda’s SMBH Projected Accretion Rate — JOHN WILSON, Retired — A formula for calculating the half-life of galaxy clusters is proposed. A galactic half-life is the estimated amount of time that the most massive supermassive black hole (SMBH) in the galaxy cluster will have accreted one half of the mass in the cluster. The calculation is based on a projection of the SMBH continuing its exponentially decreasing rate of accretion that it had in its first 13 billion years. The calculated half-life for the Andromeda SMBH is approximately 1.4327e14 years from the Big Bang. Several proposed has suggested that black holes could be significant factors in the formation of new universes. Part of the verification or falsification of this hypothesis could be done by an N-body simulation. These simulations require an enormous amount of computer power and time. Some plausible projection of the growth of the supermassive black hole is needed to prepare an N-body simulation budget proposal. For now, this method provides an estimate for the growth rate of the Andromeda SMBH and deposition of the outcome of most of the galaxy cluster’s mass which is either accreted by the SMBH, lost by ejection from the cluster, or lost in the form of energy.

2:30PM Y9.00006 Does Antimatter Appear Dark? — WALTON PERKINS, Retired — According to Standard Model the photon is an elementary particle and a gauge boson. However, there is another model of the photon with very interesting properties. In 1932 de Broglie suggested that the photon is a composite particle formed of a neutrino-antineutrino pair. This theory, now known as the “neutrino theory of light,” has evolved over the years. It still has problems in that it requires massless 2-component neutrinos, while there are indications that neutrinos have mass. In the composite photon theory the photon is \( \gamma = \nu_{\mu} \bar{\nu}_{\mu} \) (electron neutrinos), while the antiphoton is \( \bar{\gamma} = \nu_{\mu} T L \), two particles that have never been observed. Since the neutrino-electron interaction is V-A, the antineutrinos have the wrong helicity to interact with electrons, rendering the antiphotons undetectable. Conversely, in an antimatter world, for which the neutrino-positron interaction is V-A, photons do not interact with positrons. Thus, antimatter stars and galaxies would appear dark to us, and they would not even reflect light from matter stars.

2:42PM Y9.00007 The U-Theory of Everything (– A single Particle Theory of Universe) — WEIPING YU, NASA — A new Theory of Everything has been developed. This new Theory unifies all the field forces in the universe with one single fundamental particle. Using this theory, the author is able to settle the centennial dispute between Einstein’s Theory of Relativity and Quantum Mechanics. During this presentation, the author will reveal the secrets of the origin of Electric Charge, the origin of Mass, the nature of Gravity, Dark Matter and Dark Energy. The author will also explain the mysteries of Quantum Mechanics Double Slit Experiment and Wave-Particle Duality paradox.
1:30PM Y10.00001 Study of Electron G-2 From 1947 To Present, TOICHIRO KINOSHITA, Cornell University

In 1947 Kusch and Foley discovered in the study of Zeeman splitting of Ga atom that the electron g-factor was about 0.2% larger than the value 2 predicted by the Dirac equation. Soon afterwards Schwinger showed that it can be explained as the effect of radiative correction. His calculation, in the second order perturbation theory of the Lorentz invariant formulation of renormalized quantum electrodynamics, showed that the electron has an excess magnetic moment $a_e \equiv (g-2)/2 = \alpha/2\pi$, where $\alpha$ is the fine structure constant, in agreement with the measurement within 3%. Thus began a long series of friendly competition between experimentalists and theorists to improve the precision of $a_e$. Over the period of more than 60 years measurement precision of $a_e$ was improved by more than 10$^4$ by the spin precession technique, and further 10$^3$ by the Penning trap experiments. In step with the progress of measurement, the theory of $a_e$, expressed as a power series in $\alpha$, has been pushed to the fifth power of $\alpha$. Including small contributions from hadronic effects and weak interaction effect and using the best non-QED value of $\alpha$: $\alpha^{-1} = 137.035999049(90)$, one finds $a_e(\text{theory}) = 1159652181.72(77) \times 10^{-12}$. The uncertainty is about 0.66 ppb, where 1 ppb is $10^{-9}$. The intrinsic uncertainty of theory itself is less than 0.1 ppb. The over all uncertainty comes mostly from the uncertainty of non-QED $a_e$ mentioned above, which is about 0.66 ppb. This is in good agreement with the latest measurement: $a_e(\text{experiment}) = 1159652180.73(28) \times 10^{-12}$. The uncertainty of measurement is 0.24 ppb. An alternate approach to test QED is to assume the validity of QED (and the Standard Model of particle physics) and obtain $a_e$ by solving the equation $a_e(\text{experiment}) = a_e(\text{theory})$. This yields $\alpha^{-1}(a_e) = 137.0359991727(342)$, whose uncertainty is 0.25 ppb, better than $a_e$ obtained by any other means. Although comparison of theory and experiment of $a_e$ began historically as a test of the validity of QED, it has now evolved into a precision test of fine structure constant at the level exceeding 1 ppb, which may be regarded as a test of internal consistency of quantum mechanics as a whole.

1Supported in part by the U. S. National Science Foundation under Grant No. NSF-PHY-0757868

2:06PM Y10.00002 The First CERN G-2 Experiment, RICHARD GARWIN, IBM Fellow Emeritus — The Summary of the 16 June 1965 publication of this experiment in Il Nuovo Cimento reads, “The anomalous part of the gyromagnetic ratio, a ≡ 1/2 (g-2) of the muon has been measured by determining the precession θ = aμeBt for 100 MeV/c muons as a function of storage time t in a known static magnetic field of the form $B = B_0(1+ay^2+cy^4+dy^6)$. The result is $a_{\mu\text{exp}} = (1162 \pm 5) \times 10^{-6}$ compared with the theoretical value $a_{\mu} = \alpha/2\pi + 0.76a_0/\pi^2 = 1165 \pm 6$. This agreement shows that the muon obeys standard quantum electrodynamics down to distances ~ 1 fermi. Details are given of the methods used to store muons for ~ 10$^4$ turns in the field, and of measuring techniques and precautions necessary to achieve the final accuracy. Some of the methods of orbit analysis, magnet construction shimming and measurement, polarization analysis, and digital timing electronics may be of more general interest.” The paper is available in full at http://arxiv.org/abs/10060052 The authors valued highly the presentation of experimental details, which will be the emphasis of this talk, recounting the motivation of choices made with the tools and technology of that era.

2:42PM Y10.00003 The BNL Muon G-2 Experiment And Beyond, YANNIS SEMERTZIDIS, Brookhaven National Laboratory/KAIST — No abstract available.
2:30PM Y12.00006 A New Family with a Fourth Lepton Flavour, RASULKHOZHA S. SHARAFIDDINOV, Institute of Nuclear Physics, Uzbekistan Academy of Sciences, Tashkent, 100214 Ulugbek, Uzbekistan — We present here arguments in favor of the existence of the most lightest lepton and its neutrino. This new family with a fourth lepton flavour in the first turn must uncover so far unobserved universal properties of matter. The unity of their laws predicts the flavour symmetrical schemes for the decays of the electron and the proton. Thereby, it admitted the new modes in the decays of the muon, tau lepton and the neutron. At the same time, in all these transitions no conservation laws are violated.

2:42PM Y12.00007 Measurement of the relative strong-phase difference between $D^0$ and $\bar{D}^0 \rightarrow K^{0}_L\pi^+\pi^-$, DANIEL AMBROSE, University of Rochester, HAJIME MURAMATSU, University of Minnesota, ED THORDIKE, University of Rochester.

BES-III COLLABORATION — We present the BES-III Collaboration preliminary results for a model independent measurement of the strong phase difference between $D^0$ and $\bar{D}^0 \rightarrow K^{0}_L\pi^+\pi^-$, through a binned dalitz analysis. The BES-III $\psi(3770)$ dataset generates $D^0$ and $\bar{D}^0$ pairs in a quantum-correlated state, which gives information about the CP state of the $D^0$ decay, allowing for a model independent measurement. The strong phase difference parameters $\gamma_i$ and $\delta_i$ are determined for each phase bin of the $D^0 \rightarrow K^{0}_L\pi^+\pi^-$ dalitz plot by measuring the population of CP and flavor states present. These results represent a significant statistical improvement in a previously statistically limited measurement, which will allow for increased precision in the measurement of unitarity triangle angle $\gamma/\phi_3$ using the decay $B^+ \rightarrow D(K^{0}_L\pi^+\pi^-)K^+$ through the GGSZ method.

2:54PM Y12.00008 Study of $\psi(3770) \rightarrow non - D\bar{D}$ at BESIII, DERRICK TOTH, Univ. of Minn - Minneapolis, BESIII COLLABORATION — We describe a measurement of the branching ratio for $\psi(3770) \rightarrow non - D\bar{D}$ final states using 2.92 fb$^{-1}$ of $e^+e^-$ annihilations data collected with the BESIII detector at the BEPCII collider at $E_{CM} = 3.773$ GeV. The naive expectation is that $\psi(3770)$ decays are dominated by $D\bar{D}$ final states. Published data paint an inconsistent picture, however, with reported non-$D\bar{D}$ rates ranging from consistent with zero to $\sim 15\%$. We determine the yield for $\psi(3770) \rightarrow non - D\bar{D}$ in our sample by measuring the total number of hadronic events and subtracting the contributions from all expected processes. The $D\bar{D}$ component is directly measured in data with a double-$D$-tag counting technique. Continuum $q\bar{q}$ and most QED are determined with data collected at five energy points below $D\bar{D}$ threshold. Other processes, including initial-state radiation to $J/\psi$ and $\psi(3686)$, $\pi^+\pi^-$ and two-photon production, are estimated by Monte Carlo. Preliminary results for event yields and cross sections will be presented and interpreted.

Tuesday, April 8, 2014 1:30PM - 3:06PM –
Session Y13 DPF: Axion and Dark Matter III 101 - Nick Hadley, University of Maryland

1:30PM Y13.00001 Fast neutron measurement at Soudan Mine using a large liquid scintillation detector, CHAO ZHANG, DONGMING MEI, University of South Dakota — Characterizing neutron background is extremely important to the success of rare-event physics searching for neutrinoless double-beta decay and dark matter searches. Measuring the energy spectrum of fast neutrons for an underground laboratory is difficult and it requires intensive R&D for a given technology. EJ-301 liquid scintillator (known also as NE-213) is implemented as the target for a 12 liter neutron detector fabricated at the University of South Dakota. The light output response to atmospheric neutrons from a few MeV up to $\sim 70$ MeV has been calibrated for this detector. The detector has been taking data at Soudan Mine for over two years. We report the measured muon-induced neutrons in this paper.

1This work is supported in part by NSF PHY-0758120, PHYS-0919278, PHYS-0758120, PHYS-1242640, DOE grant DE-FG02-10ER46709, the Office of Research at the University of South Dakota and a 2010 research center support by the State of South Dakota.

1:42PM Y13.00002 Low-background Gamma Spectroscopy at Sanford Underground Laboratory, CHRISTOPHER CHILLER, ANGELA ALANSON, DONGMING MEI, Univ. of South Dakota — Rare-event physics experiments require the use of material with unprecedented radio-purity. Low background counting assay capabilities and detectors are critical for determining the sensitivity of the planned ultra-low-background experiments. A low-background counting, LBC, facility has been built at the 4850-Level Davis Campus of the Sanford Underground Research Facility to perform screening of material and detector parts. Like many rare event physics experiments, our LBC uses lead shielding to mitigate background radiation. Corrosion of lead brick shielding in subterranean installations creates radon plate-out potential as well as human risks of ingestible or respirable lead compounds. Our LBC facilities employ an exposed lead shield requiring clean smooth surfaces. A cleaning process of low-activity silica sand blasting and borated paraffin hot coating preservation was employed to guard against corrosion due to chemical and biological exposures. The resulting lead containment will allow the detection of weakly interacting massive particles (WIMPs) for white dwarf stars.

1Support provided by Sd governors research center-CUBED, NSF PHY-0758120 and Sanford Lab
2Graduate Student
3Graduate Student
4Principal Investigator

1:54PM Y13.00003 Performance of a Novel Gas Separation Research Column at Sanford Laboratory, ANGELA ALANSON, CHRISTOPHER CHILLER, DONGMING MEI, Univ of South Dakota — A world-wide rise in demand for ultra pure materials has necessitated innovation in the production of low impurity and isotopically separated materials that either has not been utilized in these new applications or relies on aging or energy intensive methods. These materials are sought after for large physics investigations, nuclear non-proliferation detection industries, medical imaging and new frontiers in electronic applications. Techniques in separating and purifying nuclear magnetic resonance isotopes of carbon, oxygen, xenon, krypton, and nitrogen are being developed at Sanford Laboratory. Lead, SD. A two-meter laboratory scale selective phase change column designed specifically for real-time sampling of the gas space at specific temperature and pressure is operated at gas/liquid and gas/solid equilibrium temperatures and pressures for selected gases. We report initial results and future applications.

1Research Funded by SD Governors 2010 Center.
2Graduate Student
3Graduate student
4Principal Investigator
2:06PM Y13.00004 Development of Ge-based Detectors with n/γ Discrimination at 77 K for Dark Matter Searches, WEN ZHAO WEI, DONGMING MEI, CHAO ZHANG, The University of South Dakota, CUBED COLLABORATION — Low background germanium (Ge) crystal detectors are a well-accepted methodology in the searches for dark matter. In this work, we report a development of micro-strip planar detectors with an effective threshold lower than 100 eV. By measuring plasma time, such a new-type Ge-based detector is expected to have capability of discriminating nuclear recoils from electron recoils due to plasma time difference of these two classes of events. Because of the extreme low energy threshold and n/γ discrimination, the proposed detector is anticipated to have great sensitivity in detecting low mass WIMPs and low-energy neutrino interactions.

2:18PM Y13.00005 LUX Trigger System, MONGKOL MOONGWELUWAN, University of Rochester/LUX, LUX COLLABORATION — The Large Underground Liquid Xenon Detector (LUX) is a dual-phase xenon TPC, operating at the Sanford Underground Research Facility (Lead, SD) designed to search for WIMPs. The LUX trigger system can trigger on S1 pulses, S2 pulses, or S1 pulses followed by S2 pulses within a time window (set by the maximum electron drift time within the detector). In the first WIMPs search run, the trigger system was set to trigger on S2 pulses. The S2 pulse area is calculated in real time and a trigger is generated when S2 pulses with areas of 8 or more photoelectrons (phe) are detected in two or more trigger channels. The performance of the system during the run was monitored using information integrated into the data stream. The noise in the system was monitored continuously by measuring the trigger rate as function of trigger threshold. These two processes are carried out in parallel with the main operation of the system. We determined that the trigger efficiency from this run was >95% for pulses with areas larger than 100 phe, which is equivalent to 3-4 ionizing electrons extracted from the liquid surface. In this talk, we will discuss our experience with the system during the first WIMPs run, and the method used to determined the trigger efficiency.

2:30PM Y13.00006 Response of the LUX Dark Matter Detector to Ultra-Low Energy Nuclear Recoils, JAMES VERBUS, Brown University, LUX COLLABORATION — The LUX dark matter search experiment is a two-phase xenon time projection chamber located at the 4850’ level of the Sanford Underground Research Facility in Lead, SD. I will describe the techniques used to calibrate the detector response to nuclear recoils for the first WIMP search result announced in October 2013 and report on subsequent calibration campaigns. A novel nuclear recoil calibration technique pioneered by LUX will be discussed and I will present a recent analysis of ultra-low energy nuclear recoil data down to ~1 keVnr obtained using this technique. Results from the calibrations will be compared to existing Lxre nuclear recoil calibrations and theory.

2:42PM Y13.00007 Low energy nuclear recoils study in noble liquids for low-mass WIMPs1, LU WANG, DONGMING MEI, University of South Dakota, CUBED COLLABORATION — Detector response to low-energy nuclear recoils is critical to the detection of low-mass dark matter particles-WIMPs (Weakly interacting massive particles). Although the detector response to the processes of low-energy nuclear recoils is subtle and direct experimental calibration is rather difficult, many studies have been performed for noble liquids, NEST is a good example. However, the response of low-energy nuclear recoils, as a critical issue, needs more experimental data, in particular, with presence of electric field. We present a new design using time of flight to calibrate the large-volume xenon detector, such as LUX-Zeplin (LZ) and Xenon1T, energy scale for low-energy nuclear recoils. The calculation and physics models will be discussed based on the available data to predict the performance of the calibration device and set criteria for the design of the device. A small test bench is built to verify the concepts at The University of South Dakota.

2:54PM Y13.00008 Precision measurement of quenching factors for low-energy nuclear recoils at TUNL, GRAYSON RICH, Triangle Universities Nuclear Laboratory and University of North Carolina at Chapel Hill, PHIL BARBEAU, CALVIN HOWELL, Triangle Universities Nuclear Laboratory and Duke University, HUGON KARROWSKI, Triangle Universities Nuclear Laboratory and University of North Carolina at Chapel Hill — With detector technologies becoming increasingly sensitive to exotic events, a thorough understanding of signal yield as a function of deposited energy is required for appropriate interpretation of results from cutting edge detector systems. Elastic neutron scattering is a probe which has been used to mimic the nuclear recoils which may be produced in detection media by light-WIMP interactions or coherent neutrino-nucleus scattering (CNS). We have built at the Triangle Universities Nuclear Laboratory (TUNL) a facility which produces pulsed, collimated, low-energy, quasi-monoenergetic neutron beams using the 7Li(p,n) reaction, resulting in fluxes of ~ 1 neutrons / (s · cm²) at ~90 cm from the neutron-production target. The first precision results from this facility are reported for ultra-low-energy recoils in Na(Tl) and Ce(Na) and future plans are outlined, including measurements on candidate materials for a CNS detector that can potentially be fielded at the Spallation Neutron Source of Oak Ridge National Laboratory as a part the Coherent Scatter Initiative (CSI). We discuss the implications of new, precise measurements of quenching factors on neutrino detectors and on current- and next-generation light-WIMP searches, particularly the DAMA experiment.

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1This work is supported by DOE grant DE-FG02-10ER46709 and the state of South Dakota.

2Supported by NSF grant PHY-1205512.

103 - Zach Etienne, University of Maryland

1:30PM Y15.00001 High Speed Alignment Control of an Optical Resonator1, DANIEL AMARIUTIE, Univ of Florida - Gainesville, UF LIGO GROUP TEAM — For interferometric gravitational wave detectors, fluctuations in the input laser beam alignment are a critical source of technical noise. In order to maintain optimal sensitivity it is necessary to control the input beam alignment. We introduce a new method for achieving this alignment control using angular actuators based on the electro-optic beam deflection. Compared to piezo-mounted mirror actuators, which have a low bandwidth and intrinsic noise due to moving parts, these actuators promise a much higher bandwidth with no moving parts. This talk presents the experimental demonstration of closed loop alignment control using the electro-optic beam deflectors and report their measured performance.

1Supported by NSF grant PHY-1205512.

1:42PM Y15.00002 Active thermal lensing elements for mode matching optimization in optical systems1, PAUL FULDA, University of Florida. UF LIGO TEAM — In interferometric gravitational wave detectors of the advanced era and beyond, the high laser power used lead to the generation of thermal lenses in the optics. This can lead to a reduction in the coupling between the various optical cavities comprising the detector, thus reducing its overall sensitivity. We present here an active device which can be used to compensate for such thermal effects, as well as static mismatches between cavities. The device uses a 4 segmented heater to heat a transmissive optic, generating a spherical or astigmatic lens which can be used to compensate other thermal lenses within an optical system. We report on in-vacuum tests of the device, including an interferometric measurement of the wavefront distortions induced by the device, and measurements of the dynamic range and response time. The device was shown to have no observable detrimental effect on wavefront distortion, a focal power dynamic range of 0 to -40mD, and a response time of the order 1000s.

1Supported by NSF grant PHY-1205512.
1:54PM Y15.00003 Measurement of Thermal Noise in Optical Coatings for Gravitational-Wave Detectors

MICHAEL HARTMAN, JOHANNES EICHHOLZ, PAUL FULDA, GIACOMO CIANI, DAVID B. TANNER, GUIDO MUELLER, University of Florida — Interferometric gravitational-wave detectors measure the gravitational-wave-induced strain in the arms of kilometer scale Michelson interferometers. Second-generation detectors, such as Advanced LIGO, are expected to be limited by optical coating thermal noise in the most sensitive region (30-300 Hz) of the detectors’ frequency bands. The direct measurement of coating thermal noise in different optical coatings is essential to both the validation of current thermal noise models as well as the research of future coating material candidates. The THERmal noise Optical Resonator (THOR) is a testbed being developed at the University of Florida to directly measure the thermal noise in optical coatings on mirrors in the frequency band around 100 Hz. This is a presentation on the status of THOR.

This work is supported by NSF grants PHY-0969935 and PHY-1306594.

2:06PM Y15.00004 Cryogenic behavior of LEDs for use in third generation LIGO position sensors and actuators

RYAN GOETZ, DAVID TANNER, GUIDO MUELLER, University of Florida, UF LIGO TEAM — The sensitivity of Advanced LIGO, the second-generation among ground-based, long-baseline interferometric gravitational-wave detectors, is expected to be limited by thermal noise of test-mass optical coatings within the frequency band of interest. To reduce the effects of thermal noise, and thereby increase the sensitivity of LIGO interferometers, the third generation of LIGO detectors will likely be operated with some optical and control components at cryogenic temperatures. In the interest of developing and investigating LIGO subsystems at low temperatures, the University of Florida LIGO Group has constructed a testbed for table-top cryogenic experiments. This presentation focuses on a preliminary investigation into cryogenic Birmingham Optical Sensors and Electro-Magnetic actuators (BOSEMs). BOSEMs are shadow sensors which are used to sense the position of and actuate on the LIGO core optics. Specifically, the low temperature I-V performance and efficiency of LEDs used in BOSEMs will be presented.

Supported by NSF grant PHY-1205512.

2:18PM Y15.00005 Investigation of Coating Thermal Noise at Cryogenic Temperatures for Third-Generation Interferometric Gravitational-Wave Detectors

JOHANNES EICHHOLZ, MICHAEL HARTMAN, PAUL FULDA, GIACOMO CIANI, DAVID TANNER, GUIDO MUELLER, University of Florida — Second-generation interferometric gravitational-wave detectors will be limited between 50 and 500 Hz by coating thermal noise (CTN). CTN originates in the motion of the mirror surfaces on the order of 10^{-20} m due to thermal excitation and mechanical loss in their coatings. The magnitude of this effect scales with the square root of the available thermal energy, but also depends strongly on coating material parameters. These in turn may also be temperature dependent, making cryogenic mirrors an option to consider for third-generation detectors. The Cryogenic THERmal noise Optical Resonator (CryoTHOR) experiment at the University of Florida aims at measuring the CTN of cryogenic mirrors by over-amplifying it using high-finesse cm-scale test cavities; this will make it an invaluable tool to assess the prospect of cryogenic test masses and explore candidate coating materials and techniques in the cryogenic regime. This presentation reports on the development of CryoTHOR.

This work is supported by the National Science Foundation through Grant Nos. PHY-0969935 and PHY-1306594.

2:30PM Y15.00006 Telescope Back-reflection and Space-based Gravitational Wave Observatories

AARON SPECTOR, GUIDO MUELLER, Univ of Florida - Gainesville — The Laser Interferometer Space Antenna (LISA) represents a class of proposed space-based gravitational wave observatories that will operate in the frequency band between 0.1 mHz and 1 Hz. The sensitivity of interferometric gravitational-wave detectors is limited by thermal noise originating from the optical coatings of mirrors. The Laser Interferometer Space Antenna (LISA) represents a class of proposed space-based gravitational wave observatories that will operate in the frequency band between 0.1 mHz and 1 Hz. These missions are characterized by a triangular constellation of three spacecraft (SC), separated by gigameters, in a heliocentric orbit. A reflecting telescope transfers the laser signals between the SC, and laser interferometry is used to measure length changes between proof masses housed on adjacent SC with pm/√Hz sensitivity. One of the proposed telescope designs is an on-axis ‘quadpod’ in which the secondary mirror is axially aligned to the primary mirror. Back-reflected (BR) light from the secondary can introduce phase noise to the measurement signal due to length changes between the telescope structure and the optical bench. We derived a set of requirements for the mode-matched power in the BR field that scale with these length changes. Simulations have demonstrated that the BR power can be sufficiently attenuated by using a specifically patterned anti-reflective region at the center of the secondary mirror. An experimental testbed was built and is currently being used to evaluate the BR light from several secondary prototypes.

2:42PM Y15.00007 Sensing and actuation system for the University of Florida Torsion Pendulum for LISA

ANDREW CHILTON, RYAN SHELLEY, TAIWO OLATUNDE, GIACOMO CIANI, JOHN CONKLIN, GUIDO MUELLER, University of Florida — Space-based gravitational wave detectors like LISA are a necessity for understanding the low-frequency portion of the gravitational universe. They use test masses (TMs) which are separated by Gm and are in free fall inside their respective spacecraft. Their relative distance is monitored with laser interferometry at the pm/rHz level in the LISA band, ranging from 0.1 to 100 mHz. Each TM is enclosed in a housing that provides isolation, capacitive sensing, and electrostatic actuation capabilities. The electronics must both be sensitive at the 1 nm/rHz level and not induce residual acceleration noise above the requirement for LISA Pathfinder (3*10^{-15} m/sec^2 Hz^{1/2} at 3 mHz). Testing and developing this technology is one of the roles of the University of Florida Torsion Pendulum, the only US testbed for LISA-like gravitational reference sensor technology. Our implementation of the sensing system functions by biasing our hollow LISA-like TMs with a 100 kHz sine wave and coupling a pair surrounding electrodes as capacitors to a pair of preamps and a differential amplifier, all other processing is done digitally. Here we report on the design of, implementation of, and preliminary results from the UF Torsion Pendulum.

2:54PM Y15.00008 The UF torsion pendulum and its role in space-based gravitational wave detectors

JOHN CONKLIN, RYAN SHELLEY, ANDREW CHILTON, TAIWO OLATUNDE, GIACOMO CIANI, GUIDO MUELLER, Univ of Florida - Gainesville — Space-based gravitational wave observatories like LISA measure picometer changes in the distances between free falling test masses separated by millions of kilometers caused by gravitational waves from sources ranging from super-massive black hole mergers to compact galactic binaries. A test mass and its associated sensing, actuation, charge control and caging subsystems are referred to as a gravitational reference sensor (GRS). LISA has consistently been ranked in the top two of future space missions in the last two Decadal Reviews. With the 2015 launch of LISA Pathfinder (LPF), the expected detection of gravitational waves by aLIGO, and the selection of The Gravitational Universe for the European Space Agency’s L3 science theme, LISA is one of the strongest candidates for the next Decadal. Following a successful demonstration of the baseline LISA GRS by LPF, the measurement principle will be carried forward, but improvements in the electronic and optical sensing and control system, the charge control system, and many other components are possible over the next ten years. These improvements will lead to cost savings and potential noise reductions. The UF LISA group has constructed the UF Torsion Pendulum to increase U.S. competency in this critical area and to have a facility where these new technologies can be developed and evaluated. This presentation will introduce this facility and its future role in LISA.
1:30PM Y16.00001 Using Dyson’s probability expression for Gerstenshtein coupling between Photons and Graviton interaction for minimum B field in Tokamak GW Detection Experiment, and possible developments if a refinement on the Gerstenshtein process is confirmed experimentally. ANDREW BECKWITH, Guest researcher at Chongqing University, PRC — As of 2012, and put in a journal in 2013, Dyson came up with criteria as to the Gerstenshtein process in photon-graviton coupling, with criteria as to the likelihood as to if the Gerstenshtein process actually can occur. This methodology is applied to a small spatial geometry as to Tokamak’s with a 100% probability of Gerstenshtein coupling of gravitons and photons, if there is a magnetic field of magnitude 10 to the 9th power, Gauss. This coupled with a GW and graviton frequency of order 10 to the 9th power, Hertz. The high GW frequency is justified in a prior analysis done by the author, and the magnetic field of 10 to the 9th power Gauss is enough to insure that within a GW detector that there is the likelihood of the Gerstenshtein process occurring. This threshold magnetic field strength is tied into a probability of measurement of the Gerstenshtein process, allowing for GW measurements as a signature, in the Tokamak GW experiment.

1:42PM Y16.00002 Gravitational radiation of the relativistic theory of gravitation, the registration of radiation and applied aspects. STANISLAV FISENKO, IGOR FISENKO, RUSTEM RYMKULOV. Ruthermosynthesis — This report is a systematic and complemented summary of the earlier published works by the authors [1,2]. The concept of gravitational radiation as a radiation of one level with the electromagnetic radiation is based on theoretically proved and experimentally confirmed fact of existence of electron’s stationary states in own gravitational field, characterized by gravitational constant K=10^{42} G (G — Newtonian gravitational constant) and by irremovable space-time curvature. The received results strictly correspond to principles of the relativistic theory of gravitation and the quantum mechanics. The given work contributes into further elaboration of the findings considering their application to dense high-temperature plasma of multiple-charge ions. This is due to quantitative character of electron gravitational radiation spectrum such that amplification of gravitational radiation may take place only in multiple-charge ion high-temperature plasma.

1:54PM Y16.00003 Rotating Metrics for Black Hole Competitors. JAMES GRABER, Library of Congress — Several plausible alternatives to the standard Kerr metric are presented. These alternatives might be useful in preparing and analyzing precision observations of black hole candidates.

2:06PM Y16.00004 Renormalization and asymptotic freedom in quantum gravity through symmetry of the functional measure. BRIAN SLOVICK, SRI International — A method of renormalization is developed for the Einstein action with a cosmological constant in four spacetime dimensions. In the method described, the renormalizable action of higher-derivative gravity is rewritten such that the higher-derivative terms are redundant (i.e., vanish on the Einstein shell), allowing them to be removed after renormalization by performing a local field transformation and redefining the coupling constants. This allows the renormalization of the couplings in the Einstein action to be calculated from the renormalized parameters of the higher-derivative theory. The Einstein action thus obtained is shown to be asymptotically free in the essential dimensionless coupling constant G/L^2, where G is Newton’s constant and L is the cosmological constant.

2:18PM Y16.00005 Closed timelike loops in homogeneous rotating Λ-dust cosmologies. DAVID LINDSAY, None — We analyze what we believe to be all known homogeneous rotating Λ-dust cosmologies, to see if they contain closed timelike loops (CTLs). We investigate only these exact GR solutions because they appear to most closely resemble our own universe (apart from rotation). These solutions are all somewhat similar to the Gödel solution, which is known to contain CTLs. Of the solutions discussed, it turns out that exactly those with Λ < 0 possess CTLs. The paper argues that many more homogeneous rotating Λ-dust solutions likely exist, but have not yet been found.

2:30PM Y16.00006 The Space Production Model of Gravity. RICHARD BOWEN, Patiently, LLC — The Space Production Model of gravity is based on the premise that mass emits space and proposes that this is the mechanism by which mass curves space-time. It states that the pressure waves created by the production of space are responsible for the “attractive force” of gravity while the actual space generated is responsible for its “repulsive force.” The Space Production Model proposes a new mechanism of attraction based on wave interference and it provides a source for dark energy that is consistent with the Friedman equation. By using only observational data it is able to accurately predict the current mass of the universe as well as changes in the Hubble constant over time. It is consistent with inflation and provides a solution to the “flatness problem.” It proposes a radically different model of a black hole that allows one to determine the amount of space emitted by a specific amount of mass per unit time. It is testable in that recession rates of galaxies should correlate to their mass. Whether it is able to reconcile General Relativity with quantum mechanics is yet to be determined.

2:42PM Y16.00007 Gravitational Waves in General Relativity, and in the Hulse-Taylor Pulsar. Supernova Models indicate that the Quantum of Gravitational Radiation is the Neutrino. VIC DANNON, Gauge Institute — (I) Einstein derived General Relativity under the erroneous assumption that Retarded Gravitational and Electromagnetic Potentials are similar, and his Gravitational Radiation is actually Electromagnetic because only photons propagate at light speed. Thus, assuming that gravitation propagates at light speed, he proved that gravitation propagates at light speed. But Gravitational Waves are not photons, do not propagate at light speed, and the formula for Mercury’s perihelion precession does not confirm General Relativity. (II) In the Hulse-Taylor Pulsar, the Magnetic Attraction dominates the gravitational, and propagates at light speed by electromagnetic waves. The radiation is electromagnetic, and the General Relativity formula gives the pulsar’s orbit precession. The formula fails for pulsars where the Magnetic attraction does not dominate the gravitational attraction. (III) The Quantum of Gravitational Radiation is the Neutrino, because Supernova Models indicate that 99% of the Gravitational Binding energy of a collapsing star is emitted in the form of Neutrinos’ Radiation; Posted to www.gauge-institute.org

Tuesday, April 8, 2014 1:30PM - 3:18PM
Session Y17 FPS: Invited Session: Popularizing Physics 105-106 - Richard Wiener, Research Corporation for Science Advancement

1:30PM Y17.00001 Explaining Today’s Physicists Through History and Biography. DAVID LINDLEY, Science Writer/Editor/Consultant — Quantum computers, string theory, holographic universes—to the general audience, today’s physics can be as mystifying as it is fascinating. But modern ideas evolved from an earlier phase of physics—Newtonian mechanics, simple cause and effect—that is in principle easier for the non-expert to grasp. I have found that writing about physics from a historical and biographical perspective is an effective way to convey modern thinking by explaining where it comes from— it is a way of carrying the reader from concepts that make intuitive sense to ideas that seem, on first encounter, utterly bizarre. Smuggling explanations into stories satisfies the reader’s desire for narrative-bearing in mind that narrative can include the evolution of ideas as well as tales about intriguing and original people.
The majority of science outreach focuses on a small group of well-educated older people (still majority male) with an already existing interest in science. The dominant paradigm of “you-come-to-us” leaves out many more people than it brings in. Most people only become interested in science when it affects something they care about, whether that be their personal or economic health, or their recreational passions. My experiences writing and promoting *The Physics of NASCAR* forced me to change my approach to science outreach in terms not only of how to do outreach, but also what impact I hope to have. There are 75 million NASCAR fans. Every fan wants to know one thing: Why isn’t my driver winning? I’ll share my experiences using television, radio and blogging to reach an oft-neglected group that is characterized by a certainty that they – even if they wanted to – are not capable of understanding science. This lack of self-efficacy is likely the biggest barrier scientists have to reaching the general public. My central thesis is that “Science for All” doesn’t necessarily mean that scientists need to convince the public that what the scientists are doing is interesting. It means that scientists doing outreach need to learn how to engage the public with science that affects things the public already cares about.

Twenty years ago we started a small outreach program at the University of Illinois called “The Physics Van,” designed to show the fun of science to assemblies of kids at local elementary schools. Many hundreds of shows - and many hundreds of thousands of excited kids, teachers, and parents later - the program is a cornerstone of the department’s outreach efforts. About fourteen years ago I stumbled into a one-time gig with the local CBS television station, which evolved into a weekly live science segment on their morning news show. Very popular with viewers across central Illinois, these science segments now include a colleague from the Department of Chemistry and cover a wide range of topics. The totally unexpected success of both has led me to ponder why these seemingly hapless efforts should have grown to be both successful and sustainable. The conclusions, I believe, are very good news for us all.