Friday, October 3, 2014 7:00PM - 7:36PM –
Session A1 Plenary Session I Thomas Building 101 - Ken O’Hara, Pennsylvania State University

7:00PM A1.00001 Why condensed matter physicists should pay attention to atomic physics WILLIAM PHILIPS, NIST/University of Maryland — AMO physics has been revolutionized by the advent of ultracold atomic gases, including quantum degenerate Bose and Fermi gases. Much of the activity with cold atoms brings AMO physics into close contact with Condensed Matter. Atoms in optical lattices (externally imposed periodic potentials) can mimic the behavior of electrons in crystals; Bose-Einstein condensed gases or Cooper-paired degenerate Fermi gases can mimic superfluid helium or superconducting materials; atomic gases can exhibit phase transitions that are traditionally studied in solids. These and other atomic phenomena offer possibilities for measurement and control that can be quite different from those available in materials. This talk will explore some of the current intersections of AMO and CM physics and speculate about the future of the relationship.

Saturday, October 4, 2014 9:00AM - 9:36AM –
Session B1 Plenary Session II Thomas Building 101 - Jun Zhu, Pennsylvania State University

9:00AM B1.00001 Graphene and the Magic of Physics in Two Dimensions, EVA ANDREI, Rutgers University — Since its first scotch-tape extraction from graphite in 2004, Graphene - a one atom-thick crystal of carbon - has metamorphosed from the poor relative of diamond into a wonder material. By now it has amassed an impressive string of superlatives lightest, thinnest, strongest etc. and it is rapidly moving from research laboratories into industrial, medical and electronics applications. Furthermore, graphene has recently spawned a new class of two dimensional materials which can be stacked together to engineer bespoke electronic properties. For physicists much of the continuing excitement about graphene stems from its exotic charge carriers - Dirac fermions - which resemble two dimensional massless neutrinos. I will review the physics of graphene with emphasis on its unusual electronic properties and will describe the experiments and techniques which provided access to the two-dimensional world of Dirac fermions, their interactions with each other and with the environment.

Saturday, October 4, 2014 10:30AM - 12:30PM –
Session C2 Topology in Condensed Matter Life Sciences Building 004 - Jay Kikkawa, University of Pennsylvania

10:30AM C2.00001 Detection and utilization of topological superconductors in solid state systems1, JAY SAU, Department of Physics, Condensed Matter Theory Center and Joint Quantum Institute, University of Maryland, College Park — Majorana modes are fermion-like excitations that were originally proposed in particle physics by Ettore Majorana and are characterized as being their own anti-particle. In condensed matter systems Majorana modes occur as fractionalized excitations with topologically protected degeneracy associated with such excitations. In this talk, I will start by reviewing a recent set of proposals for realizing Majorana modes in a large class of spin-orbit coupled, time-reversal symmetry broken superconducting systems. I will then discuss the possibility of confirming topological superconductivity using the fractional Josephson effect. Finally, I will discuss the possibility of using such Majorana modes for topological quantum computation.

1This work was supported by the Start-up funds at the University of Maryland and the Physics Frontier Center

11:06AM C2.00002 Numerical studies on magnetoconductance of the topological insulator nanotubes, HSU-CHUAN HSU, AJIT COIMBATORE BALRAM, JAINENDRA JAIN, CHAOXING LIU, The Pennsylvania State University — It has been shown that the conductance oscillates as a function of the parallel magnetic flux with a period of $\phi_0$ ($\phi_0 = h/e$), one flux quantum in a topological insulator (TI) nanowires. A pair of gapless helical modes arise on the cylindrical surface of a TI nanowire when a magnetic flux of half-integer of $\phi_0$ threads through it. This conductance oscillation has been a direct evidence of the transport of the surface helical modes of TI. Nonetheless, consider a TI nanotube, there are two cylindrical surfaces giving rise to two oscillation periods in terms of magnetic field. In an effort to study the magnetoconductance oscillation of TI nanotubes, we calculated the conductance within the Landauer formalism in clean and disordered limit. We found an unambiguous oscillation feature and discuss the origin of the magnetoconductance oscillation. This feature demonstrates a transport signature of the helical surface modes of the TI nanotube.

11:18AM C2.00003 Interaction effect of a topological semimetal Na3Bi in magnetic fields, RUIXING ZHANG, The Pennsylvania State University, JIMMY HUTASOIT, Leiden University, CHAOXING LIU, The Pennsylvania State University — We study the interaction induced instability of a topological semimetal Na3Bi in magnetic field based on the mean field theory. The phase diagram can be classified by two sets of order parameters, which break chiral symmetry and thus gap the system. In certain interaction parameter regions, we find these two order parameters can coexist. To understand this phase coexistence and phase transitions in the phase diagram, we analytically solve the minimum problem of free energy perturbatively. The possible experimental consequence is also studied.

11:30AM C2.00004 Spin Texture and Mirror Chern number in Hg-Based Chalcogenides1, CHAOXING LIU, QINGZE WANG, The Penn State University, SHU-CHUN WU, CLAUDIA FELSER, BINGHAI YAN, Max Planck Institute for Chemical Physics of Solids — The unique feature of surface states in topological insulators is the so-called “spin-momentum locking,” which means that electron spin is oriented along a fixed direction for a given momentum and forms a texture in the momentum space. In this work, we study spin textures of two typical topological insulators in Hg-Based Chalcogenides, namely HgTe and HgS, based on both the first principles calculation and the eight band Kane model. We find opposite helicitics of spin textures between these two materials, originating from the opposite signs of spin-orbit couplings. Furthermore, we reveal that different mirror Chern numbers between HgTe and HgS characterize different topological natures of the systems with opposite spin textures and guarantee the existence of gapless interface states.

1This work is supported by ERC Advanced Grant (291472).
11:42AM C2.00005 Giant anisotropic magneto-resistance in the magnetic topological insulator Cr$_x$(Bi,Sb)$_{2-x}$Te$_3$, ABHINAV KANDALA, ANTHONY RICHARELDELLA, CHAOXING LIU, NITIN SAMARTH, Pennsylvania State University — We report the observation of a giant anisotropic magneto-resistance (AMR) effect in the magnetic topological insulator Cr$_x$(Bi,Sb)$_{2-x}$Te$_3$, as an external field (and the magnetization $M$) is rotated from out-of-plane (azimuthal angle $\theta = 0^\circ$) to in-plane ($\theta = 90^\circ$). While the rotation of a magnetic field in-plane produces a weak, conventional anisotropic magnetoresistance (AMR) that follows the standard angular dependence ($\text{AMR} \sim \cos^2 \theta$, where $\phi$ is the angle between $M$ and the current density $J$), the AMR is much larger in magnitude and deviates from the standard $\cos^2 \theta$ dependence. We explain the observed AMR through a quantum magnetic phase transition from an “imperfect” quantum anomalous Hall (QAH) insulator to a trivial ferromagnetic semiconductor as the magnetization is tilted from out-of-plane to in-plane. We expect the AMR to become stronger in the ideal QAH regime where edge state conduction dominates over bulk conduction, thus providing a route toward proof-of-concept ferromagnetic topological insulator transistors and magnetic field sensors. Funded by DARPA.

11:54AM C2.00006 Composite-fermion trions in the fractional quantum Hall effect$^1$, AJIT COIMBATORE BALRAM, Pennsylvania State University, URSULA WURSTBAUER, Walter Schottky Institut and Physik-Department, Technische Universität, München, ARKADIUSZ WOJS, Institute of Physics, Wroclaw University of Technology, ARON PINCZUK, Department of Applied Physics and Department of Physics, Columbia University, JAINENDRA JAIN, Pennsylvania State University — Resonant inelastic light scattering experiments of the “fractional quantum Hall” state have indicated the existence of excitations below the Zeeman energy in the vicinity of the lowest Landau level filling $\nu = 1/3$. We investigate this observation in terms of composite fermions, the emergent particles of the fractional quantum Hall state that are bound states of electrons and two flux quanta. We identify the low energy excitations with positively or negatively charged composite-fermion(CF) trions, created when a photo-excited CF particle-hole pair forms a bound state with an existing CF particle ($\nu > 1/3$) or CF hole ($\nu < 1/3$). These are the smallest realizations of “skyrmions” in the fractional quantum Hall state. This identification is well supported by an excellent agreement between the calculated and the measured binding energies, and by the fact that the mode disappears for $\nu > 1/3$ when a transition to a fully spin-polarized state occurs. The spectroscopy of trion bound states serves as an extremely sensitive tool for investigating the interaction between composite fermions, which is relevant to the formation of exotic fractional quantum Hall states in this filling factor region, including those at $\nu = 4/11$ and $5/13$.

$^1$Supported by NSF, DOE

12:06PM C2.00007 Robustness of Topological Superconductivity in Proximity-Coupled Topological Insulator Nanoribbons, PIYAPONG SITTHISON, TUDOR STANESCU, West Virginia University — A numerical study of low-energy physics of topological insulator(TI) nanoribbon proximity-coupled to $s$-wave superconductors(SCs) shows that induced gap is strongly band-dependent and collapses for low amplitude bands at the interface. The surface-type bands have most of their weight near the top or the bottom surface of the nanoribbon. It suggests that single interface TI-SC could experience a collapse of the induced gap. On the other hand, the nanoribbons sandwiched between two superconductors are capable of realizing the full potential of TI-based structures to harbor robust topological superconducting phases.

12:18PM C2.00008 Quantum Interference Control of Currents in Bi$_2$Se$_3$ Topological Insulators$^1$, DEREK BAS, West Virginia University — Quantum interference control of photocurrents are investigated in Bi$_2$Se$_3$ films ranging from 3 to 40 quintuple layers in thickness. The films are grown with a two-step method on sapphire substrates and protected with an MgF$_2$ capping layer that prevents oxidation. Co-polarized harmonically related pulses excite carriers through interference of single- and two-photon absorption pathways, which have a polar distribution in momentum space leading to a ballistic photocurrent. The current is measured using time-domain terahertz spectroscopy. Dependences of the relative phase between two pulses and intensity of each pulse show the correct signatures confirming the third-order nonlinear quantum interference control. Azimuthal angle dependence allows the injection current to be separated from a relative-phase independent shift current generated by the fundamental pulses alone. The shift current is a second-order nonlinear optical process arising from the surface states, while the injection current arises from surface-to-surface transitions at an energy of 1.6 eV. A thickness dependence of the injection current in the Bi$_2$Se$_3$ film is dominated by the product of the linear and nonlinear absorption. The two-photon absorption coefficient is explored as a function of film thickness for the first time.

$^1$Work supported by West Virginia Higher Education Policy Commission (HEPC.dsr.12.29).

Saturday, October 4, 2014 10:30AM - 12:42PM —
Session C3 Gravitation and Cosmology —
Life Sciences Building 005 - Wolfgang Wieland, Pennsylvania State University

10:30AM C3.00001 From cosmological observations to fundamental physics: past, present, and future, CORA DVORKIN, Harvard University —

11:06AM C3.00002 Searching for Gravitational Waves from the Coalescence of High Mass Black Hole Binaries, SOPHIA XIAO, Univ of Virginia, LIGO Scientific Collaboration, LIGO SCIENTIFIC COLLABORATION — We search for gravitational waves from the coalescence (inspiral, merger and ringdown) of binary black holes with data from the Laser Interferometer Gravitational-Wave Observatory (LIGO). Provided with well-described waveform models from General Relativity, matched filtering is employed in the GSTLAL analysis pipeline as the optimal detection technique for weak signals in Gaussian noise. The GSTLAL analysis pipeline filters data with waveform template banks, identifies triggers with SNR greater than 4, forms coincident triggers between multiple detectors in the LIGO Scientific Collaboration, and attempts to optimally separate signal from detector background noise fluctuations using a Chi-squared test. We run high-statistics simulations of binary merger waveforms injected into LIGO recooled S6 data to evaluate the pipeline search sensitivity, to test the readiness of the pipeline for Advanced LIGO. With Advanced LIGO fully in operation by 2015 and the upgraded analysis pipelines, the expected detection rate is increased to as much as 100 events/year or more as compared to 0.01-1 events/year in Initial LIGO. Our work will make it possible to detect gravitational waves from binary black hole coalescence in Advanced LIGO data with high confidence.
11:18AM C3.00003 Supernova Constraints on Modified Theories of Gravity . NATHAN PRINS, JAMES OVERDUIN, Towson University, JOOHAN 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 extra 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 are strongly disfavored by recent data on the magnitudes of Type Ia supernovae.

11:30AM C3.00004 Asymptotics with a positive cosmological constant I . ARUNA KESAVAN, ABHAY ASHTEKAR, BEATRICE BONGA, 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 asymptotically flat to asymptotically de Sitter space-times. If one mimics the boundary conditions used in asymptotically anti-de Sitter context, then one concludes that the asymptotic symmetry group is the de Sitter group. However, these conditions severely restrict radiation and in fact rule out non-zero flux of energy, momentum and angular momentum carried by gravitational waves. Therefore, such a definition of asymptotically de Sitter space-times is uninteresting beyond non-radiative space-times. A new proposal is expounded to remedy the situation for non-stationary space-times.

11:42AM C3.00005 Asymptotics with a positive cosmological constant II: Illustration with linear fields on de Sitter space-time , BEATRICE BONGA, ABHAY ASHTEKAR, ARUNA KESAVAN, The Pennsylvania State University — The framework that allows the study of isolated systems is well-developed for space-times with a vanishing cosmological constant λ and it lies at the foundation of research in diverse areas in gravitation physics. However, the standard extension of this framework to space-times with a positive λ fails for non-stationary space-times. Here, I will outline a new proposal that does allow the study of isolated systems with λ > 0 in a physically meaningful manner and has the additional benefit of providing a natural comparison with asymptotically flat space-times. This proposal is illustrated by calculations with test fields in de Sitter space-time. The results are contrasted with test fields in Minkowski space-time. It is expected that the results for test fields will share many features with gravitating systems. The linear analysis provides a first step to study the errors one makes by assuming λ = 0 when studying general relativistic gravitating systems.

11:54AM C3.00006 Derivation of the Biot-Savart Law from Coulomb’s Law and Implications for Gravity , DANIEL ZILE, JAMES OVERDUIN, Towson University — We explore links between classical electromagnetism and general relativity in the low-velocity, weak-field limit. We confirm that it is possible to derive the Biot-Savart law for 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. We discuss some physical interpretations and implications of this result.

12:06PM C3.00007 Characteristics of Gravitational and Electromagnetic Radiation , MARIA BABIUC, Marshall University, Huntington, WV — Both gravitational and electromagnetic radiation travel along light rays, which are principal null directions in space-time. They are characteristic surfaces of Einstein and Maxwell equations. We start with the coupled Einstein-Maxwell equations together with the Maxwell equations, for a space-time given by the null Bondi-Sachs line element, and a null electromagnetic gauge field. In this characteristic framework, we deduce analytical expressions describing the gravitational waves and the electromagnetic counterparts at infinity, as well as the nonlinear effects of the interaction between them, such as radiation memory. The source of gravitational and electromagnetic radiation is treated as a black box, and therefore the approach is very flexible, with potentially large applicability.

12:18PM C3.00008 The emergence of spacetime from quantum gravity , MARC GEILLER, Institute for Gravitation and the Cosmos, Penn State — I will present some recent ideas and developments in non-perturbative quantum gravity, and illustrate how loop gravity and spin foam models could possibly describe the emergence of continuum spacetime from discrete elementary building blocks.

12:30PM C3.00009 Cosmological Coincidence without Fine Tuning , JOOHAN LEE, Towson University/ University of Seoul, JAMES OVERDUIN, Towson University/ Johns Hopkins University, TAE HOON LEE, Soongsil University, PHILLILAL OH, Sungkyunkwan University — We present a simple cosmological model in which a single, non-minimally coupled scalar field with a quartic potential and a non-canonical kinetic term is responsible for inflation at early times and acceleration at late times. No fine tuning is needed to explain why the present density of dark energy is comparable to that of pressureless matter. Dark energy in this theory originates in the potential energy of the scalar field, which in turn is sourced by the trace of the energy-momentum tensor. This becomes significant when the bulk of the matter content of the universe has decoupled from radiation and become fully non-relativistic, so that $\phi \propto \rho_{m,0}^{1/3} \propto \rho_{m,0}^{1/3} (a_0/a) \sim (10^{-120})^{1/3} (10^{10}) \sim 10^{-30}$ and $V \sim \phi^4 \sim 10^{-120}$ in Planck units, as observed.

Saturday, October 4, 2014 10:30AM - 12:18PM
Session C4 Cosmic Rays, Dark Matter Searches and Original Concepts Life Sciences Building 007 - Azadeh Keivani, Pennyslvania State University

10:30AM C4.00001 Origin of Galactic Cosmic Rays , JASON LINK, NASA Goddard Space Flight Center CRESST-USRA — Despite their discovery over 100 years ago, we are only recently beginning to understand and identify the cosmic sources of galactic cosmic rays. In this talk I will discuss what we know and what we hope to learn about the cosmic-ray source. I will focus in particular on efforts to measure cosmic rays with an atomic number Z>30. These ultra-heavy cosmic rays are only produced in supernova explosions as a result of neutron capture and provide an excellent indicator of the nature of the cosmic-ray source. I will present data from past balloon and satellite experiments as well as the recent SuperTIGER balloon experiment which flew over Antarctica for a record 55 day flight and discuss what the future holds for ultra-heavy galactic cosmic-ray measurements.
11:06AM C4.00002 The Pierre Auger Observatory: Overview and recent results. FOTEINI OIKONOMOUI, Pennsylvania State University — The Pierre Auger Observatory is the largest cosmic ray detector ever built to study cosmic rays with energies $E > 10^{18}$ eV. These are the highest energy particles to have ever been observed and their study can teach us about the most extreme accelerators in the Universe as well as about hadronic interactions at unprecedentedly high-center-of-mass energies. The observatory, which covers 3000 km$^2$ in Argentina, has accumulated the world’s largest data set of extensive air showers since 2004, when operation started. In this talk, I will give an overview of the experiment and summarize some of the latest results, including the status of searches for a correlation of ultra-high energy cosmic rays with extragalactic astrophysical accelerators.

11:18AM C4.00003 Searching for the source of the highest energy cosmic ray detected with the Pierre Auger Observatory, BRYAN REYNOLDS, MIGUEL MOSTAFA, Pennsylvania State University. PIerre AUGER OBSERVATORY COLLABORATION — The origins of ultra-high energy cosmic rays, particles capable of reaching energies on the order of $10^{20}$ eV, remain largely unknown. The Pierre Auger Observatory uses an array of surface detectors to record air showers of secondary particles and infer information about the primary cosmic ray particle, including its arrival direction and energy. According to the most recent analysis, the highest energy cosmic ray detected with the Pierre Auger Observatory, a particle with an energy of $1.3 \times 10^{20}$ eV, does not correlate with any known extra-galactic source. To further investigate this specific event, its arrival direction was cross-correlated with the location of nearby active galactic nuclei (AGNs). Energy losses during propagation imply that possible sources of a cosmic ray of such energy must be within 100 Mpc. The angular separation between a candidate AGN and the arrival directions of cosmic rays with energies above $4 \times 10^{19}$ eV was examined to determine the viability of the potential sources. Both the angular deflections as a function of energy obtained from data and the expectation from an isotropic distribution of cosmic rays will be presented.

11:30AM C4.00004 Determining the Particle Identification of Ultra High Energy Cosmic Rays. ANDREA BISCoveANu, MIGUEL MOSTAFA, Pennsylvania State University — The mass composition of cosmic rays is of primary interest for determining their origin. The Pierre Auger Observatory uses both surface and fluorescence detectors to measure the depth of shower maximum, from which the mass of the primary particle can be inferred. The mean depth of shower maximum, $X_{\text{max}}$, and the standard deviation from the mean are studied as a function of energy for cosmic rays with energies above $10^{18.8}$ eV reconstructed using the fundamental principle of shower universality. The results are compared with simulations for different nuclear primaries as well as with the official reconstruction used by the Pierre Auger Collaboration. Because the official reconstruction uses hybrid events that were recorded using both the surface and fluorescence detectors, there are insufficient statistics for determining $X_{\text{max}}$ for energies above $10^{19.6}$ eV. The present analysis uses events recorded only with the surface detectors, so the measurements of $X_{\text{max}}$ and its standard deviation can be extended up to $10^{19.9}$ eV. The $X_{\text{max}}$ distribution seems consistent with a mixed composition even at the highest energies and is independent of zenith angle above $10^{19}$ eV.

11:42AM C4.00005 Neutron Veto Prototype for the proposed SuperCDMS Experiment, ABaZ KryemAdhi, KatrinA schrock, Matthew bressler, Messiah College, FNAL SUPERCDMS TEAM — Both cosmology and particle physics converge on Weakly Interactive Massive Particles as a good candidate for dark matter. We helped develop a neutron veto detector for SuperCDMS experiment because neutrons produce the same interaction as Weakly Interacting Massive Particles. The detector is made of liquid scintillator doped with an agent that captures neutrons and produces alpha particles that interact and create light, which then gets captured by fibers and routed to photodetectors. We designed a fourth scale prototype in order to understand the light output, characterize the photodetectors, compare to simulation, and understand the process of construction.

11:54AM C4.00006 Energy required to knock the Earth out of its own orbit, (cosmic catastrophe). AHmad reza estakh, Physics Research Center — How much energy would be required to knock the Earth out of its own orbit? (throwing Earth out of orbit) Sometimes I wondering how the Earth could be thrown out of orbit! The gravitational disturbance that results will form a wave that travels across the spatial fabric in much the same way that a pebble dropped into a pond makes ripples that travel across the surface of the water. So we wouldn’t feel a change in our orbit around the Sun until this G-wave reached the Earth all of sudden, and without any warning, these ripples of gravity travel at exactly the speed of light! when a beam of G-wave is incident on a planet; in the process, the G-wave entirely absorbed by the planet. If Energy of G-wave is larger than the planet’s work function $W$, the energy required to dislodge the planet from the orbit (the minimum energy required to free the planet from the orbit is called the work function of that planet)–the planet can be thrown out of orbit, unless $E > W$, where $K_p$ represents the kinetic energy of the planet leaving the orbit. The formula is the following: $E = K_p + W$, in the case of the Earth Work function $W = -30 \times 10^{15}c^2$ where the $E$ represents total Energy of G-wave and $K_p$ represents the kinetic energy of the Earth leaving the orbit.

12:06PM C4.00007 Direct Calculation of Size and Mass of Universe using Speed of Light and Gravitational Constant. PAUL OBRIEN, None — How I calculated the mass and size of the universe. My theory says the universe we live in started as a so called black hole that is imploding. The size and mass of this original black hole is what I calculated. The equation is very similar to $E=MC^2$. The underlying basis for my equation is mass, length, and time, which after all is the only real variables we can measure. At first sight I thought my units were all wrong, until you consider black hole thermodynamics. First I calculated the radius of this original black hole using $C^2/G$ (Speed of light$^2$)/Gravitational constant = $1.34668374e+27$ Kg/m As you can see the units are in Kg/m which would appear incorrect. But black whole thermodynamics stipulates that the mass of a black hole is a function of it surface area. That means that for the specific case of black holes, mass does become equivalent to surface area, so by equality you can substitute mass with area. This sounds bizarre but it is true for black holes. Mass = surface area, and in metric units Kg = m$^2$. When you go back to my equation and do the substitution you get your radius in meters (Speed of light$^2$)/Gravitational constant = $1.34668374e+27$ m$^2$/m = $1.34668374e+27$ m Thus the mass of our universe becomes Radius$^2C^2/2G$ = $9.0677855e+53$ Kg

Saturday, October 4, 2014 10:30AM - 12:30PM
Session C5 2D Materials - Beyond Graphene Life Sciences Building 009 - Jie Shan, Pennsylvania State University
10:30AM C5.00001 Observation of the valley Hall effect in MoS2 transistors, KIN FAI MAK1. Penn State University — Two-dimensional (2D) atomic layers of molybdenum disulfide (MoS2) have attracted much recent attention due to their unique electronic properties. In addition to charge and spin, electrons in MoS2 monolayers possess a new valley degree of freedom (DOF) that has finite Berry curvatures. As a result, not only optical control of the valley DOF is allowed, but each valley is also predicted to exhibit an anomalous Hall effect whose sign depends on the valley index. In this talk, we will discuss our recent observation of this new valley Hall effect (VHE) in monolayer MoS2 transistors. This is manifested experimentally as a finite anomalous Hall effect when circularly polarized light is used to preferentially excite electrons into a specific valley. We will describe the dependence of the anomalous Hall conductivity on photon helicity, photon energy, doping levels and crystal symmetry, and will compare these observations with theoretical predictions. Possibilities of using the valley DOF as an information carrier in next-generation electronics and optoelectronics will also be discussed.

1In collaboration with Kathryn McGill, Jiwoong Park, and Paul McEuen, Cornell University.

11:06AM C5.00002 ABSTRACT WITHDRAWN

11:18AM C5.00003 Electronic properties of rhenium doped tungsten disulfide monolayers, EDUARDO CRUZ-SILVA, AMBER MCCREARY, NESTOR PEREA-LOPEZ, ANA LAURA ELIAS, Department of Physics and Center for 2-Dimensional and Layered Materials, The Pennsylvania State University, HUMBERTO TERRONES, Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, MAURICIO TERRONES, Department of Physics and Center for 2-Dimensional and Layered Materials, The Pennsylvania State University — Layered transition metal dichalcogenides (TMDs) have attracted attention due to their electronic and optical properties. In particular, MoS2 and WS2 show an indirect to direct electronic band gap transition when reduced to a monolayer and display strong photoluminescence. While there are proposed applications for MoS2 and WS2 as electronic and optoelectronic devices, control of their electronic properties needs to be reached before these applications can be scaled. Chemical doping has been recently shown to allow the modification of the electronic properties of MoS2 monolayers by substitution of either transition metals or the chalcogen. Here we present an experimental and computational study of the electronic and optical properties of doped WS2 monolayers. Re-doped WS2 monolayers have been produced by chemical vapor deposition (CVD). Photoluminescence and Raman spectroscopy studies suggest that rhenium atoms have been successfully incorporated into WS2 lattice. ab initio calculations indicate that substitution of W atoms by Re results in the formation of new states in the vicinity of the Fermi energy that allows tailoring of the electronic band gaps, which also results in different optical properties.

11:30AM C5.00004 Thermal Conductivity of Monolayer Molybdenum Disulfide Obtained from Temperature-Dependent Raman Spectroscopy1, J.R. SIMPSON, Towson University, R. YAN, Notre Dame, M. WATSON, Towson University, D.B. ROMERO, University of Maryland, A. BRIGGS, NIST, X.G. XING, Notre Dame, A.R. HIGHT WALKER, NIST — Atomically-thin transition metal dichalcogenides (TMDs) offer potential for an alternative to graphene in advanced devices owing to their unique electronic and optical properties. We report the temperature-dependent Raman spectra of the monolayer TMD materials molybdenum disulfide (MoS2) and MoS2. Mechanical overcoating or substitution of either transition metals or the chalcogen. Here we present an experimental and computational study of the electronic and optical properties of doped WS2 monolayers. Re-doped WS2 monolayers have been produced by chemical vapor deposition (CVD). Photoluminescence and Raman spectroscopy studies suggest that rhenium atoms have been successfully incorporated into WS2 lattice. ab initio calculations indicate that substitution of W atoms by Re results in the formation of new states in the vicinity of the Fermi energy that allows tailoring of the electronic band gaps, which also results in different optical properties.

In this work, we use CVD grown bilayer MoS2 triangles to verify the predicted results, both through optical and electrical measurements as a function of dynamic and static strains. By transferring the MoS2 onto a flexible substrate and performing Raman characterization as a function of uniaxial strain, it was observed that while the monolayer MoS2 triangles were able to withstand strains of up to 1.2% before slippage, the bilayer triangles slipped at strains less than or equal to 0.5%, suggesting that it is possible the strain is distributed differently in the two layers. With this in mind, we looked at the Raman as a function of strain for vertically grown triangles of MoS2 consisting of 1, 2, 3, 4, and 4+ layers on a single triangle to study the distribution of strain in multilayered 2D materials.

1JRS and MW acknowledge support from School of Emerging Tech., TU.

11:42AM C5.00005 Strain Engineering of 2D Transition Metal Dichalcogenides, AMBER MCCREARY, PENN STATE University, MATIN AMANI, Army Research Lab, Adelphi MD, AVINASH DONGARE, University of Connecticut, TERRANCE O'REGAN, Army Research Lab, Adelphi MD, MAURICIO TERRONES, Pennsylvania State University, RAJU NAM-BURU, MADAN DUBEY, Army Research Lab, Adelphi MD, RUDRESH GHOSH, The University of Texas at Austin — The potential of ultrathin monolayer transition metal dichalcogenides (TMDs) nanomaterials for applications in electronic and optoelectronic devices requires a fundamental understanding of their electronic structure and optical properties. We report the temperature-dependent Raman spectra of the monolayer TMD materials molybdenum disulfide (MoS2) and MoS2. Mechanical overcoating or substitution of either transition metals or the chalcogen. Here we present an experimental and computational study of the electronic and optical properties of doped WS2 monolayers. Re-doped WS2 monolayers have been produced by chemical vapor deposition (CVD). Photoluminescence and Raman spectroscopy studies suggest that rhenium atoms have been successfully incorporated into WS2 lattice. ab initio calculations indicate that substitution of W atoms by Re results in the formation of new states in the vicinity of the Fermi energy that allows tailoring of the electronic band gaps, which also results in different optical properties.


11:54AM C5.00006 Facile Synthesis of MoS2 and MoxW1−xS2 Triangular Monolayers, ZHONG LIN, MICHAEL THEE, ANA ELIAS, SIMIN FENG, CHANJING ZHOU, KAZUNORI FUJISAWA, NESTOR PEREA-LOPEZ, VICTOR CAROZO, Pennsylvania State Univ, HUMBERTO TERRONES, Rensselaer Polytechnic Institute, MAURICIO TERRONES, Pennsylvania State Univ. — Single- and few-layered transition metal dichalcogenides (TMDs) such as MoS2 and WS2 are emerging two dimensional materials exhibiting numerous and unusual physico-chemical properties that could be advantageous in the fabrication of unprecedented optoelectronic devices. Here we report a novel and alternative route to synthesize triangular monocrystals of MoS2 and MoxW1−xS2 by annealing MoS2 and MoS2/WO3 precursors, respectively, in the presence of sulfur vapor. In particular, the MoxW1−xS2 triangular monolayers show gradual concentration profiles of W and Mo whereby Mo concentrates in the islands’ center and W is more abundant on the outskirts of the triangular monocrystals. These observations were confirmed by atomic force microscopy (AFM), and high-resolution transmission electron microscopy (HRTEM), as well as Raman and photoluminescence (PL) spectroscopy. The presence of tunable PL signals depending on the MoxW1−xS2 stoichiometries in 2D monocrystals opens up a wide range of applications in electronics and optoelectronics.

12:06PM C5.00007 Investigating the Work Function of WS\textsubscript{x}Se\textsubscript{2−x} Alloys, JACOB SHEVIRIN, JUNJIE WANG, AN NGUYEN, TOM MALLOUK, JUN ZHU, Pennsylvania State Univ — Two-dimensional layered transition metal dichalcogenides (TMDs), such as WS\textsubscript{2} and WSe\textsubscript{2}, are important classes of materials because of their novel physical and electrical properties. The work function of the material can inform the choice of metal to use when making contacts and can also provide valuable information regarding the band alignment in heterostructures made of dissimilar materials. Here we present work function measurements of multi-layer WS\textsubscript{x}Se\textsubscript{2−x} (x ranges from 0 to 2) sheets exfoliated from bulk alloys using Kelvin Probe Force Microscopy. Using a graphite work function W\textsubscript{C} = 4.5 eV as reference, we find the average work function of WS\textsubscript{x}Se\textsubscript{2−x} to linearly interpolate between W\textsubscript{C} = 4.52 eV for WSe\textsubscript{2} to W\textsubscript{C} = 4.74 eV for WS\textsubscript{2} as x varies from 0 to 2. At every alloy composition, W varies from sheet to sheet in a range of approximately 0.15 eV. Our experimental results provide useful information to the design of transistors and heterostructures of these materials.

12:18PM C5.00008 Center for the Computational Design of Functional Layered Materials: A New Energy Frontier Research Center at Temple University, JOHN P. PERDEW, MARIA IAVARONE, XIFAN WU, ADRIENN RUZSINSZKY, JIANWEI SUN, Temple Univ — With Temple as the lead institution, seven universities (including Drexel, Duke, Pennsylvania, Princeton, and Rice) and one national lab (Brookhaven) have partnered to form a new DOE-supported Energy Frontier Research Center. New or modified materials with desired functionalities play an essential role in the development of clean-energy technologies such as solar cells, batteries, and the generation of hydrogen fuel by water-splitting. Computation of materials properties, based on first-principles theory and modeling, is a promising direction for materials design: quicker and cheaper than experiment, and slower but more reliable than intuition. We aim to design new or defect-modified functional layered materials by theory, modeling, and computation. Candidate materials of special interest will be grown and experimentally characterized in the Center. Detailed experimental and theoretical work will be carried out for catalysis on layered materials, e.g., water splitting. The work of the Center can have important benefits, including new, accurate, and widely useful methods of electronic structure theory, new insights into the materials-by-design problem, and new materials for clean-energy technologies.

Supported by the Department of Energy Office of Basic Energy Sciences

Saturday, October 4, 2014 10:30AM - 12:18PM –

Session C6 Phase Transitions/Thin Films Life Sciences Building 011 - Xuemei May Cheng, Bryn Mawr College

10:30AM C6.00001 Pressure-driven magnetic and structural transitions in the 122-pnictides, MICHAEL WIDOM, Carnegie Mellon University — Pnictides of the family AFe\textsubscript{2}As\textsubscript{2}, where A is an alkali earth element, exhibit several phase transitions in their structure and magnetic order as functions of applied pressure. We employ density functional theory total energy calculations at T=0K to model these transitions for the entire set of alkali earths (A=Ca, Sr, Ba, Ra) which form the 122 family. Three distinct types of transition occur: an enthalpic transition [1] in which the striped antiferromagnetic orthorhombic (OR-AFM) phase swaps thermodynamic stability with a competing tetragonal phase; a magnetic transition in which the OR-AFM phase loses its magnetism and orthorhombicity; a lattice parameter anomaly in which the tetragonal c-axis collapses. We identify this last transition as a Lifshitz transition [2] caused by a change in Fermi surface topology. Depending on the element A, the tetragonal state exhibiting the Lifshitz transition might be metastable (A=Ca) or stable (A= Sr, Ba and Ra).


In collaboration with Khandker Quader, Kent State University.

10:06AM C6.00002 Geometric Magnetic Frustration in the Double Perovskites Ba2YMoO6, Ba2YRuO6, and Ba2CaOsO6 studied with neutron scattering and muon spin relaxation, J.P. CARLO, Villanova University, J.P. CLANCY, University of Toronto, C.M. THOMPSON, B.D. GAULIN, J.E. GREEDAN, McMaster University — Geometrically frustrated materials, in which the arrangement of ions inhibits the development of magnetic order, have been of substantial interest owing to their rich phase diagrams featuring exotic ground states and emergent properties. Typically associated with triangular or tetrahedral coordination of antiferromagnetically (AF) coupled moments, frustration manifests in a variety of lattices, including spinel, garnet, pyrochlore and Kagome systems. The double perovskites (DPs) A\textsubscript{2}B\textsuperscript{5+}O\textsubscript{6}\textsuperscript{−y}, where A is an alkaline earth element, are an important class of materials because of their novel physical and magnetic properties. They exhibit several phase transitions in their structure and magnetic order as functions of applied pressure. We employ density functional theory total energy calculations at T=0K to model these transitions for the entire set of alkali earths (A=Ca, Sr, Ba, Ra) which form the 122 family. Three distinct types of transition occur: an enthalpic transition [1] in which the striped antiferromagnetic orthorhombic (OR-AFM) phase swaps thermodynamic stability with a competing tetragonal phase; a magnetic transition in which the OR-AFM phase loses its magnetism and orthorhombicity; a lattice parameter anomaly in which the tetragonal c-axis collapses. We identify this last transition as a Lifshitz transition [2] caused by a change in Fermi surface topology. Depending on the element A, the tetragonal state exhibiting the Lifshitz transition might be metastable (A=Ca) or stable (A= Sr, Ba and Ra).


1In collaboration with Khandker Quader, Kent State University.

10:18AM C6.00003 Effects of Particle Size on the Magnetic Properties of Maghemite Nanoparticles, KELLY L. PISANE, MOHINDAR S. SEEHRA, Department of Physics and Astronomy, West Virginia University — The effects of particle size on the magnetic properties of oleic-acid-coated maghemite (γ-Fe\textsubscript{2}O\textsubscript{3}) nanoparticles (NPs) with average diameters of 3.2 nm and 7.0 nm are reported. These samples were prepared by identical procedures and characterized by x-ray diffraction, transmission electron microscopy, FTIR spectroscopy and temperature-dependent ac and dc magnetometry. The zero field-cooled and field-cooled magnetization M vs. T data under H = 100 Oe yield the blocking temperature T\textsubscript{B} \approx 21 K (35 K) for the 3.2 nm (7.0 nm) NPs. Changes in T\textsubscript{B} with changes in the measuring frequency f\textsubscript{m} (10 Hz to 10 kHz) are used to determine the Neel-Brown relaxation time and the strength of inter-particle interaction. Above T\textsubscript{B}, the data of M vs. H up to H = 90 kOe are used to determine magnetic moment per particle and to understand the effects of size distribution on the measured properties. Below T\textsubscript{B}, the plots of M vs. H show surprisingly negligible hysteresis with coercivity H\textsubscript{C} \approx 20 Oe for both NPs. Interpretation of these results will be presented along with comparison with results obtained from bulk maghemite.

1Supported in part by NSF IGERT Grant DGE-1144676.
11:30AM C6.00004 Thermoelectric properties of amorphous ZnO-based materials using Ab initio methods, ANINDYA ROY, YU-TING CHENG, MICHAEL FALK, Johns Hopkins Univ — We use a combination of computational methods - viz., molecular dynamics and density functional theory, to predict thermoelectric properties of amorphous ZnO-based materials. We use BoltzTraP [1] to calculate properties such as Seebeck coefficient and electrical conductivity within semiclassical Boltzman transport theory, and compare with available experimental results. Additionally, we investigate the change in the thermoelectric parameters caused by alloying amorphous ZnO with tin and other elements. Our preliminary calculations suggest that the thermoelectric performance of amorphous ZnO is on par with the crystalline counterpart. This is encouraging - since amorphous materials are yet to be studied in depth for their potential as thermoelectric materials, and they could see much improvement with sustained effort. Also, while ab initio methods are routinely used to predict properties of crystalline systems, their application in amorphous systems is a less-explored area. The present work reports exciting advance in the latter direction.


11:42AM C6.00005 Control of the interfacial chemical coupling between organic adsorbates and semiconductor surfaces revealed with Raman spectroscopy1, FLOYD HILTY, Bowling Green State University, ANDREW KULHMAN, University of Konstanz, ALEXEY ZAYAK, Bowling Green State University — In the search for methods of studying chemical properties of surfaces and heterogeneous interfaces we focus on Raman scattering, aiming to reveal physical and chemical processes that vary on the scale of a few chemical bonds, with information not only about a particular chemical species, but also about its immediate chemical environment. While the so-called “chemical enhancement” on metallic surfaces has been previously investigated in the context of SERS, in this work we use first-principles calculations to reveal general trends of the chemical modification of Raman spectra of organic species after being chemically absorbed on semiconductor surfaces. We examine the binding of a trans-1,2-two(4-pyridyl) ethylene molecule to various crystallographic facets of a PbSe, showing that Raman spectra of adsorbed species vary significantly on different crystallographic facets of PbSe, which is correlated with the electronic structure of each type of semiconductor surface. Based on that picture, we demonstrate the possibility of tuning the interfacial coupling by applying an external electric potential, achieving not only chemical tunability of the interface, but also a direct method of studying surface chemistry with Raman.

1We acknowledge “Building strength” grant from BGSU and XSEDE project TG-DMR130080.

11:54AM C6.00006 Detecting the Presence of Quartz-Dissolution Precursors with DFT-based Molecular Dynamics1, MARK DELLOSTRITTO, JORGE SOFO, Department of Physics, The Pennsylvania State University, State College, PA, JAMES KUBICKI, Department of Geosciences and the Earth and Environmental Systems Institute, The Pennsylvania State University, State College, PA — The study of water/oxide interfaces presents challenges as a result of the low symmetry of the system, the highly structured nature of water, and the difficulty of accurately modelling H-bond interactions. An example is the quartz-water interface, where adding ions to solution increases the dissolution rate by an order of magnitude, but without any change in the activation energy. This suggests that the ions alter the interfacial structure such that the dissolution reaction configuration becomes more accessible to the reactants, thereby decreasing the entropic barrier and increasing the rate of reaction. As the interfacial structure and dissolution reaction are dominated by H-bonding and proton transfer, DFT calculations are useful for simulating the interfacial configuration. We use DFT molecular dynamics simulations of the quartz-water interface with statistical measures of the interfacial structure and vibrational analysis to test whether or not ion-induced stable configurations increase the population of dissolution precursor states. We find that intrasurface proton transfer is likely to be a common precursor when an ion is near the surface, and that both direct proton transfer to the surface and nucleophilic attack of Si by H$_2$O are unlikely to be reaction precursors.

1Work supported by U.S. Department of Energy. Computation supported by Research Computing and Cyberinfrastructure of Penn State.

12:06PM C6.00007 LEED Study of the Structure of $Si(111) - (2\sqrt{3} \times 2\sqrt{3}) R30^\circ - 4B + 14Sn$ Phase , YING-TZU HUANG, RENEE DIEHL, Department of Physics, Penn State University, WEISONG TU, DANIEL MULUGETA, Department of Physics and Astronomy, University of Tennessee, PAUL SNIJERS, PAUL KENT, Oak Ridge National Laboratory, HANNO WEITERING, Department of Physics and Astronomy, University of Tennessee — While doping of bulk materials to control their properties has been hugely successful, doping of inherently low-dimensional surface-based electronic structures remains a challenge: dopant atoms not only affect the electronic carrier density but also significantly disrupt the surface atomic structure, and often lead to localized changes of atomic and electronic properties. We developed a modulation doping approach to dope surface structures with the dopants that are located below the surface of a two-layer thick Sn film on Si(111). The doped Sn film exhibits a temperature dependent structural and electronic phase transition that is absent in the undoped structure. In this study, we have used low-energy electron diffraction (LEED) to determine the surface structure. The LEED experiment was performed at 90 K. The energy range was 40-500 eV, for a total of 7126 eV from 20 independent beams. The structure models considered include those based on the scanning tunneling microscopy (STM) images and density functional theory (DFT) calculations. The best agreement obtained was proposed in a recent DFT study produces a Pendry R-factor of 0.36. However, the level of agreement is not yet convincing and many more structure models are being tested.

Saturday, October 4, 2014 10:30AM - 12:42PM – Session C7 Atomic, Molecular and Optical Physics I

10:30AM C7.00001 Engineering Strongly Correlated States with Ultracold Atoms, VITO SCAROLA, Virginia Tech — Optical lattices containing ultracold alkali atoms represent nearly ideal manifestations of Hubbard models. As a result, they are being used to study poorly understood quantum states of matter. Some of the work in my group uses numerical modeling to help guide experiments in these searches. I will review our recent work that compares with ongoing optical lattice experiments trying to emulate the Fermi-Hubbard model in particular. The Fermi-Hubbard model is thought to capture some of the essential features of high temperature superconductors. I will discuss recent progress in using optical lattices to probe the controversial phase diagram of the Fermi-Hubbard model. I will also discuss a proposal to generalize current experimental setups beyond conventional Hubbard models to engineer exotic quantum states. We find that optical lattice experiments can use synthetics gauge fields to realize fractionalized collective excitations.
11:06AM C7.00002 Controlling the Interactions of Ultracold Atoms Using Anharmonic Optical Potentials. JESSIE HIRTenSTEIN, American University — Ultracold atoms, when trapped by laser light, interact with each other differently according to the geometry of the potential well in which they are held. We are studying how the shape of a confining potential made of light affects the quantized energy levels of a pair of atoms. We have developed a numerical code that runs on American University’s high-performance computing system and found the energies of two atoms by constructing and diagonalizing the Hamiltonian matrix. The simulations allow us to study how the energies change as a function of the trap shape and atom-atom coupling parameter. Our results should find application to laboratory experiments on ultracold atoms, bringing us a step closer to controlling the quantum world.

11:18AM C7.00003 Tuning and Locking a Diode Laser for a Magneto-Optical Trap. RACHEL LIVINGSTON, MATTHEW GIFT, JOHN HUCKANS, JU XIN, Bloomsburg Univ — The purpose of a MOT is to utilize the atomic structure of rubidium-87 to manipulate a sample into an ultra-cold atom cloud in a vacuum sealed environment via a laser array. The extended cavity diode lasers used in this experiment must be tuned using an absorption spectroscopy system which utilizes the Doppler effect of light through a rubidium cell as the extended cavity of the diode laser is scanned across the rubidium absorption peaks with a piezo stack. The laser is then locked with a lock-in amplifier to ensure the frequency remains stable. When the lasers are locked they will be ready for use in the creation of a MOT. The light will be red-detuned so as to excite atoms moving towards each beam. When an atom absorbs the photon it will lose momentum along the photon’s axis of motion, then spontaneously emit a photon of the observed frequency in a random direction. The isotropic nature of the emitted photons creates a randomly-directed recoil momentum in the affected atoms and reduces the average energy of the sample as a whole. With the orthogonal laser set-up and in conjunction with an anti-Helmholtz magnetic field this will create a point where the least energetic atoms will form an ultra-cold cloud with a temperature on the order of 200 microkelvins.

11:30AM C7.00004 Coherent individual addressing of neutral atom qubits in a 3D optical lattice. YANG WANG, XIANLI ZHANG, THEODORE A. CORCOVILOS, AISHWARYA KUMAR, DAVID S. WEISS, Physics Department, The Pennsylvania State University, 104 Davey Lab, University Park, PA, 16802, USA — A collection of neutral atoms in a 3D optical lattice is a candidate quantum computer. We have recently demonstrated the ability to perform arbitrary single qubit rotations on target atoms in a 5x5x5 array, without affecting quantum information stored in other atoms. This is an important step in the demonstration of scalability in neutral atom quantum computers.

1 Current address: Department of Physics, Duquesne University, 600 Forbes Ave., 317 Fisher Hall, Pittsburgh, PA 15282, USA.

11:42AM C7.00005 Momentum-dependent 3-body loss in out-of-equilibrium 1D Bose gases. LAURA ZUNDEL, LIN XIA, JEAN-FELIX RIOU, DAVID WEISS, Penn State University — We measure the 3-body loss rates for out-of-equilibrium one-dimensional Bose gases of varying average energies and infer that the three body collision cross section depends strongly on the momentum distributions. We present a loss model based on momentum dependent correlations and show that it describes the data well. Calculating correlations in out-of-equilibrium many-body systems remains a theoretical challenge. These experiments provide insight into how these correlations evolve.

11:54AM C7.00006 Classical Study of Atomic Bound State Dynamics in Circularly Polarized Ultrastron Fields. SIUY LUO, PATRICK GRUGAN, BARRY WALKER, University of Delaware — We investigate hydrogen-like atoms in ultrastrong fields up to 1000 a.u. (3 \times 10^{22} W/cm^2). We find the influence of the magnetic component (B_{Laser}) of the external ultrastrong field introduces perturbations for the bound states of the atom. For intensities up to 1 \times 10^{19} W/cm^2 the changes in the trajectory energies and Poincare plots are on the order of a few percent. While small, the changes from B_{Laser} with circular polarized (CP) light can result in a several fold decrease in the ionization probability at the highest intensities for the bound states, where ionization approaches 50%. For these highest intensities, we find the Lorentz force from B_{Laser} exerts a force on the bound electron perpendicular to the rotating plane of the CP light. Since these trajectories are then aligned away from the minimum in the potential barrier it is stabilized against tunneling ionization. The results provide a classical understanding for ionization in ultrastrong fields and indicate relativistic effects in ultrastrong field ionization may most easily seen with CP field.

12:06PM C7.00007 Experimental Resolution of 100 keV to MeV Photoionization from Ultrahigh Intensity Ionization of Atoms. BARRY WALKER, PATRICK GRUGAN, SIUY LUO, SUI LUO, University of Delaware — Recent work on the ionization of atoms by ultrahigh intensities (2 \times 10^{19} W/cm^2) has shown that photoelectrons are strongly forward scattered and atomic shell structure plays a significant role in the energy resolved photoelectron spectrum and angular distribution [1]. The energy and angular resolutions for these previous experiments were 30% and 4°, respectively. The experiments were unable to determine the yield of photoelectrons beyond 2 MeV or observe potential dynamics due to excitation from photoelectron rescattering with the parent ion in the ultrastrong field. We will discuss the recent results and a new magnetic spectrometer, currently under construction, that will allow for better angular and energy resolution of the 100 keV to MeV photoelectrons. Additional benefits of the new system include the ability to resolve photoelectrons above 4 MeV, an order of magnitude improvement in the signal to noise, and an increased sample density at the laser focus creating the ultra-high intensity.


12:18PM C7.00008 The linear stability of the principle relative equilibria in the Coulomb (n + 1) body problem. CHARLES JAFFE, Department of Chemistry, West Virginia University, JOHN E. MARTIN, III, Department of Mathematics, West Virginia University — The linear stability of the principle relative equilibria of the Coulomb (n + 1)-body problem is studied. The n particles are the electrons having a charge of -1 and the (n + 1)th particle is the nucleus having a positive charge Z equal to the atomic number. The mass of the nucleus is over three orders of magnitude greater than that of the electrons. Treating the n electrons as identical particles allows the introduction of symmetry variables. This block diagonalizes the Jacobian matrix and consequently factors the characteristic polynomial.
12:30PM C7.00009 Polarization Studies of Highly Oriented Carbon Dioxide Super Rotors, MATTHEW J. MURRAY, Department of Chemical Physics, University of Maryland, College Park, HANNAH M. OGDEN, CARLOS TORO, QINGNAN LIU, AMY S. MULLIN, Department of Chemistry and Biochemistry, University of Maryland, College Park — Controlling molecular motion could enable manipulation of energy flow between molecules. We have used a high power optical centrifuge IR spectrometer to investigate energy transfer between molecular super rotors with oriented angular momenta. The polarizable electron cloud of the molecules interacts with the electric field of linearly polarized light that angularly accelerates over the time of the optical pulse. This process drives molecules into high angular momentum states that are oriented with the optical field and have energies far from equilibrium. High resolution transient IR spectroscopy reveals the dynamics of collisional energy transfer for these super excited rotors. We make time-dependent measurements of individual rotational states of carbon dioxide ranging from J=0 to J=100. Polarization-dependent studies show that the initial angular momentum orientation persists even after thousands of collisions, indicating that molecules in an optical centrifuge behave as quantum gyroscopes.

Saturday, October 4, 2014 2:30PM - 3:06PM –
Session D1 Plenary Session III Thomas Building 101 - Murat Gunaydin, Pennsylvania State University

2:30PM D1.00001 The Very Early Universe: Origin of Space, Time and the Large Scale Structure, ABHAY ASHTEKAR, Pennsylvania State University — Modern cosmology began almost a hundred years ago, with the advent of general relativity. Yet, for decades there was a great deal of controversy on basic questions such as the origin of space, time and of the large scale structure of the universe. Thanks to the spectacular observational advances since the 1990s, a ‘standard model’ of the early universe has now emerged. However, since it is based on quantum field theory in curved space-times, it is not applicable in the Planck era. Using techniques from loop quantum gravity, recently the theory was extended over the 12 orders of magnitude in density and curvature from the onset of inflation all the way back to the Planck regime. The new framework sharpens conceptual issues and has interesting lessons for both theory and observations. In the tradition of APS plenary talks, the talk will be addressed to non-experts.

Saturday, October 4, 2014 3:30PM - 4:18PM –
Session E2 Theoretical Physics Life Sciences Building 004 - Michael Widom, Carnegie-Mellon University

3:30PM E2.00001 Supersymmetry and Lie Algebras, PATRICK MOYLAN, Pennsylvania State Univ — Construction of of quotients, or localization as it is called in mathematics, provides a powerful tool to relate different physical structures which share some underlying similarities. We require the Gelfand-Kirillov conjecture which assert that the quotient field of the universal enveloping algebra of a Lie algebra is isomorphic to some skew field extension of a Weyl algebra. Another example is the isomorphism between certain skew field extensions of the universal enveloping algebras of the Poincare Lie algebra and the Lie algebra of the de Sitter group established by P. Bozek, M. Hlavicek and O. Navratil (cf. M. Hlavicek, P. Moylan (1993), J. Math. Phys., 34 (11) 5320-5332). Working in a quantum group setting, we extend the ideas of supersymmetry. In addition, it is possible to describe the realizations of such algebras in terms enveloping algebras of Lie algebras by localizations and extensions of them. At least for certain low rank simple superalgebras our results lead to new representations. In particular, we obtain new representations of the standard q deformation of the orthosymplectic Lie super algebra osp(1|2). References: 1) P. Moylan (2014) J. Phys. Conf. Ser., (512) 012026; 2) S. Clark, W. Wang (2013) Let. Math. Phys. (103) 207-231.

3:42PM E2.00002 Equivalence Between Geodesic and Lagrangian Formulations of Pendulum Systems on Manifolds, JARED BLAND, The Richard Stockton College of New Jersey — The pendulum system may be described in terms of the Lagrangian related to the system. This Lagrangian is defined on a manifold (higher-dimensional surface) in the configuration space, which is determined from the constraints of the system. Alternatively, if a proper manifold is chosen, then the shortest paths, or geodesics, will trace out the motion of the system. This provides another method to formulate mechanics. Rather than creating constraints as in the Lagrangian approach, we find these geodesics. Basic methods are rooted in solving variation problems. A basic case is presented: A two-pendulum system without gravity or coupling. Since there is no gravity the angular velocity is constant, and the answer is intuitively obvious. We also suggest related open problems, such as incorporating a surface gravity of g and coupling between the pendulums. Coupled pendula are well studied using Lagrangian mechanics for small oscillations, but not without the small oscillation assumption. We hope that the method may extend to provide insights into this and similar problems.

3:54PM E2.00003 Towards a Conceptual Model of Quantum Mechanics, CARL FREDERICK, Central Research Group — With the decline of the Copenhagen interpretation of quantum mechanics and the recent experiments indicating that quantum mechanics does actually embody ‘objective reality’, we propose a ‘mechanical’, conceptual model for quantum mechanics. We note that space-time vacuum energy fluctuations imply curvature fluctuations. And those fluctuations are indicated by fluctuations of the metric tensor. The metric tensor fluctuations can ‘explain’ the uncertainty relations and non-commuting properties of conjugate variables. It also argues that the probability density $\Psi \ast \Psi$ is proportional to the square root of minus the determinant of the metric tensor (the differential volume element) $|g_{\mu\nu}|. We further argue that the metric elements are actually not stochastic but are torsionally oscillating at a sufficiently high frequency that measured values of same appear stochastic. This is required to allow that the position probability density be a non-stochastic variable. An oscillating metric yields, among other things, a model of superposition, photon polarization, and entanglement, and all within the confines of a 4-dimensional space-time. The proposed model is one of ‘objective reality’ but, of course, as required by Bell’s theorem, at the expense of temporal locality.

4:06PM E2.00004 A Singularity Handling Approach for the Rayleigh-Plesset Equation, ASISH BALU, MICHAEL KINZEL, SCOTT MILLER, The Pennsylvania State University - Applied Research Laboratory, COMPULATIONAL MECHANICS TEAM — Cavitation dynamics of a nuclei are largely governed by the Rayleigh-Plesset Equation. The research focuses on improving the numerical efficiency of integrating the Rayleigh-Plesset equation with the use of “singularity handling” to enable stable integration at much larger time steps, which greatly reduces the computational time while maintaining solution accuracy. In order to maintain constant time step size while maintaining solution quality, the Rayleigh Plesset equation is solved reverse to ensure the solution recovers symmetry across the collapse event. The results indicate that an error of 7% can be maintained while performing over 980% faster than the traditional constant time step Euler method. In addition, the backtrace method had the lowest percent deviation from the actual solution (-0.22%). This increase in efficiency and accuracy allows the program to provide useful solutions in the field of fluids engineering, particularly in the study of shock tube gas explosions.
Various results in polarized unique way to probe the proton spin structure using very well established processes in high-energy physics, both experimentally and theoretically. In particular, we focus on the effects of the parameter $\epsilon_{\mu\tau}$ on muon neutrino survival probability and the number of muons measured in IceCube’s DeepCore detector. These effects are found to be sign asymmetric and an analytic model is presented that predicts points of maximum sign asymmetry. Furthermore, we discuss the implications these sign asymmetric effects have on mass hierarchy determination.

Intermediate states must have taken place during the $s$-process. Since the rates at which these transitions occur are temperature dependent, various polarized deep-inelastic scattering measurements have shown that the spins of all quarks and antiquarks combined account the creation of abundant gluons and quark-antiquark pairs (QCD sea). These “silent partners” make the dominant contribution to the mass of nearly massless quarks (building blocks) and massless gluons (force carriers). The strong force that confines quarks inside the proton leads to phenomena related to both low momentum partons in the target nucleus and the high momentum partons in the projectile nucleus. Run-15 collisions will be a proton and heavy ion collision. The MPC-EX will help distinguish between the direct photons, that result when a valence quark in the projectile scatters off a gluon in the target nucleus, and decay photons that result from $\pi^0$ decay. The measurements at momentum fraction of $10^{-3}$ order of magnitude will provide high statistics data that can be used to understand the gluon saturation at low momentum in the nuclei. The test beam data from the Stanford Linear Accelerator Center test shows that the MPC-EX causes an EM shower prior to reaching the MPC. The data also demonstrates the MPC-EX’s ability to distinguish between double and single EM showers, allowing for $\pi^0$ reconstruction.

The extension consists of eight alternating layers of Si minipad sensors and W absorbers. The Si-W layers allow the identification and reconstruction of the $\pi^0$ meson out to energies greater than 80 GeV. The MPC-EX will uniquely enable us to measure phenomena related to both low momentum partons in the target nucleus and the high momentum partons in the projectile nucleus. Run-15 collision will be a proton and heavy ion collision. The MPC-EX will help distinguish between the direct photons, that result when a valence quark in the projectile scatters off a gluon in the target nucleus, and decay photons that result from $\pi^0$ decay. The measurements at momentum fraction of $10^{-3}$ order of magnitude will provide high statistics data that can be used to understand the gluon saturation at low momentum in the nuclei. The test beam data from the Stanford Linear Accelerator Center test shows that the MPC-EX causes an EM shower prior to reaching the MPC. The data also demonstrates the MPC-EX’s ability to distinguish between double and single EM showers, allowing for $\pi^0$ reconstruction.

The PHENIX Muon Piston Calorimeter Extension (MPC-EX) at RHIC, DHRUV DIXIT, FERNANDO TORALES-ACOSTA, Drexel University, CHRI CHIARA, US Army Research Laboratory, TRISTAN WINICK, Drexel University, JEFF CARROLL, US Army Research Laboratory — The ground state of $^{176}$Lu has a very long half-life of approximately 37 billion years and primarily $\beta^-$ decays ($>99.9\%$) to $^{176}$Hf. However, $^{176}$Lu possesses an isomer ($J^+ = 7^−$) 123 keV above the ground state ($J^+ = 1^−$) that also $\beta^+$ decays to $^{176}$Hf but with a much shorter half-life of about 3.6 hours. The study of this isomer could lead to new findings regarding astrophysical nucleosynthesis. A disparity between the predicted abundance of $^{176}$Lu due to nucleosynthesis and the actual measured abundance implies that transitions from the isomer to the ground state via intermediate states must have taken place during the s-process. Since the rates at which these transitions occur are temperature dependent, $^{176}$Lu could be used as an s-process “thermometer.” A photoactivation experiment was performed on $^{176}$Lu at the Stuttgart DYNAMITRON using bremsstrahlung with varying endpoints between 0.7 and 2.2 MeV to determine the intermediate state energies and integral cross sections for the transitions that lead to the isomer. We present the results of the analysis of the data as well as preliminary values for the intermediate state energies and their cross sections.

Photoactivation of $^{176}$Lu via Bremsstrahlung at the Stuttgart DYNAMITRON, BRIAN GODDARD, Drexel University, TOM HENRY, University of Surrey, TREVOR BALINT, Youngstown State University, HEINZ-HERMANN PITZ, FRANCISSA DILE, ULRICH KNEISSL, University of Stuttgart, JEREMY GAISON, Drexel University, CHRI CHIARA, US Army Research Laboratory, TRISTAN WINICK, Drexel University, JEFF CARROLL, US Army Research Laboratory — The ground state of $^{176}$Lu has a very long half-life of approximately 37 billion years and primarily $\beta^-$ decays ($>99.9\%$) to $^{176}$Hf. However, $^{176}$Lu possesses an isomer ($J^+ = 7^−$) 123 keV above the ground state ($J^+ = 1^−$) that also $\beta^+$ decays to $^{176}$Hf but with a much shorter half-life of about 3.6 hours. The study of this isomer could lead to new findings regarding astrophysical nucleosynthesis. A disparity between the predicted abundance of $^{176}$Lu due to nucleosynthesis and the actual measured abundance implies that transitions from the isomer to the ground state via intermediate states must have taken place during the s-process. Since the rates at which these transitions occur are temperature dependent, $^{176}$Lu could be used as an s-process “thermometer.” A photoactivation experiment was performed on $^{176}$Lu at the Stuttgart DYNAMITRON using bremsstrahlung with varying endpoints between 0.7 and 2.2 MeV to determine the intermediate state energies and integral cross sections for the transitions that lead to the isomer. We present the results of the analysis of the data as well as preliminary values for the intermediate state energies and their cross sections.

Fundamental measurements of the proton’s sub-structure using high-energy polarized proton-proton collisions, BERNRD SURROW, Temple University, STAR COLLABORATION — Understanding the structure of matter in terms of its underlying constituents has a long tradition in science. A key question is how we can understand the properties of the proton, such as its mass, charge, and spin (intrinsic angular momentum) in terms of its underlying constituents: nearly massless quarks (building blocks) and massless gluons (force carriers). The strong force that confines quarks inside the proton leads to the creation of abundant gluons and quark-antiquark pairs (QCD sea). These “silent partners” make the dominant contribution to the mass of the proton. Various polarized deep-inelastic scattering measurements have shown that the spins of all quarks and antiquarks combined account for only 25% of the proton spin. New experimental techniques are required to deepen our understanding on the role of gluons and the QCD sea to the proton spin. High energy polarized proton-proton ($p+p$) collisions at RHIC at Brookhaven National Laboratory provide a new and unique way to probe the proton spin structure using very well established processes in high-energy physics, both experimentally and theoretically. Various results in polarized $p+p$ collisions will be presented.
mechanics of a novel dynamical system, the Rotating Space Elevator (RSE). The RSE is a spinning strings

STEVEN KNUDSEN, LEONARDO GOLUBOVIC, West Virginia University — We explore classical and statistical

tator circuit

predictions for and extensions to the Kuramoto model.

described with coefficients for five harmonics and a noise amplitude. We hope this will lead to easy-to-build experimental tests of a number of

oscillator description. In this talk, we will introduce the Wien bridge design that we chose for our oscillators. A single auto-oscillator can be

described with coefficients for five harmonics and a noise amplitude. We hope this will lead to easy-to-build experimental tests of a number of

predictions for and extensions to the Kuramoto model.

1This work was supported by USDOE Contract No. DE-AC02-09CH11466.

3:42PM E4.00002 A simple experimental spontaneously synchronizing phase oscillator circuiti 1 ZHUWEI ZENG, DAVID MERTENS, Dickinson College — Spontaneous synchronization appears in many natural and laboratory settings, from the synchronous beating of pacemaker cells in the heart to optically coherent arrays of coupled lasers. The toy model for synchronization is the Kuramoto model, a model of nonlinear coupled phase oscillators notable for its phase transition to collective

synchronization. Unfortunately, the Kuramoto model is too simple to accurately characterize the dynamics of any experimental collection of

oscillators. We endeavored, therefore, to build a set of simple electronic auto-oscillators and to model them with a minimal but accurate phase oscillator description. In this talk, we will introduce the Wien bridge design that we chose for our oscillators. A single auto-oscillator can be described with coefficients for five harmonics and a noise amplitude. We hope this will lead to easy-to-build experimental tests of a number of

predictions for and extensions to the Kuramoto model.

1This work was funded by a Dickinson College Student Faculty Research Grant.

3:54PM E4.00003 Rotating space elevators: Nonlinear dynamics of celestial scale spinning strings 1 STEVEN KNUDSEN, LEONARDO GOLUBOVIC, West Virginia University — We explore classical and statistical mechanics of a novel dynamical system, the Rotating Space Elevator (RSE). The RSE is a double rotating floppy string reaching extraterrestrial

locations. Objects sliding along the RSE string (climbers) do not require internal engines or propulsion to be transported far away from the

Earth’s surface. The RSE thus solves a major problem in space elevator science which is how to supply energy to the climbers moving along

space elevator strings. The RSE can be made in various shapes that are stabilized by an approximate equilibrium between the gravitational and inertial forces acting in a double rotating frame associated with the RSE. This dynamical equilibrium is achieved by a special (“magical”) form of the RSE mass line density. The RSE exhibits a variety of interesting dynamical phenomena. Thanks to its special design, the RSE exhibits everlasting double rotating motion. Under some conditions however, we find that the RSE may undergo a morphological transition to a chaotic state reminiscent of fluctuating directed polymers in the realm of the statistical physics of strings and membranes.

4:06PM E4.00004 The impact of resolution upon the complexity, information, thermodynamics, and transferability of coarse-grained models1, THOMAS FOLEY 2, The Pennsylvania State University, M. SCOTT SHELL 3, University of California, Santa Barbara, WILLIAM NOID 4, The Pennsylvania State University — By eliminating atomic degrees of freedom, coarse-grained (CG) models allow highly efficient simulations of complex phenomena. However, as a consequence of changing the model resolution, the coarse-graining procedure alters the apparent thermodynamic properties and model transferability. The present work analyzes the effects of model resolution upon the exact many-body potential of mean force (PMF), W, and, in particular, its entropic component, S_W. We demonstrate that S_W quantifies the loss of information from the atomistic model and impacts the complexity, thermodynamics, and transferability of the CG model. In order to investigate these formal results, we analytically calculate the exact PMF for the popular Gaussian Network Model of proteins and quantify both the energy-entropy balance as well as the entropic contribution to

intramolecular interactions as a function of resolution. Interestingly, seven diverse proteins demonstrate strikingly similar shifts in energy-entropy balance with decreasing model resolution. We expect that these results may provide general insight into both the thermodynamic properties and transferability of coarse-grained models for soft materials.

1We acknowledge support from the NSF, Alfred P. Sloan Foundation, and KITP.
2Department of Physics
3Department of Chemical Engineering
4Department of Chemistry

Saturday, October 4, 2014 3:30PM - 4:30PM –

Session E5 Gravitation and Cosmology II Life Sciences Building 009 - Marc Geiller, Pennsylvania State University

3:30PM E5.00001 Covariant Loop Quantum Gravity 1 WOLFGANG WIELAND, The Pennsylvania State University – Institute for Gravitation and the Cosmos — This talk gives a brief overview over recent developments in covariant loop quantum gravity. I will report on the semi-classical limit of the theory, and comment on the prominent role that spinors have for the theory.

3:42PM E5.00002 Canonical Effective Methods for Quantum Systems 1 SUDDHASATTWA BRAHMA, MARTIN BOJOWALD, Pennsylvania State University — Canonical effective equations are a powerful method of describing quantum systems. Using this formulation, we not only recover the results known from standard field theory, but also extend them, for instance, by allowing for a non-gaussian state as the expansion basis (useful for cosmology), and accommodating a deformed version of general covariance. Several interesting applications of these methods (like Coleman-Weinberg type potentials and higher derivative corrections) shall be discussed in this talk.
3:54PM E5.00003 Entanglement entropy production in gravitational collapse. EUGENIO BIANCHI, Penn State University — After 40 years of active research the question of the fate of information that falls into a black hole is still open. In this talk I discuss recent results that allow us to compute the entanglement entropy production in gravitational collapse. For a solvable model of black hole formation I show that the entanglement entropy of the radiation emitted by the black hole reproduces all the standard thermodynamic results on Hawking radiation. In the second part of the talk I apply these new methods to models of gravitational collapse in which quantum gravity effect avoid the formation of a singularity. In these black hole models there is a trapping horizon but no event horizon: the radiation coming out from the black hole at late times is expected to purify the early radiation so that no information is lost. I discuss some unexpected features of this “purifying” radiation and put new bounds on the time need for the recovery of information that fell into the black hole.

4:06PM E5.00004 Black hole fireworks: quantum-gravity effects outside the horizon spark black to white hole tunneling1, HAL HAGGARD, Physics Program, Bard College, CARLO ROVELLI, Centre de Physique Theorique, Aix-Marseille University — We show that there is a classical metric satisfying the Einstein equations outside a finite spacetime region where matter collapses into a black hole and then emerges from a white hole. We compute this metric explicitly. We show how quantum theory determines the time for the process to happen. A black hole can thus quantum-tunnel into a white hole. For this to happen, quantum gravity should affect the metric also in a small region outside the horizon: we show that contrary to what is commonly assumed, this is not forbidden by causality or by the semiclassical approximation, because quantum effects can pile up over a long time. This scenario alters radically the discussion on the black hole information puzzle.

1HMH acknowledges support from the National Science Foundation (NSF) International Research Fellowship Program (IRFP) under Grant No. OISE-1159218.

4:18PM E5.00005 Numerical aspects of loop quantum cosmology. BRAJESH GUPT, Penn State University, University Park — A key feature of the singularity resolution in loop quantum cosmology (LQC) is the occurrence of the quantum bounce when the spacetime curvature becomes comparable to the Planck scale. The presence of quantum bounce greatly modifies the dynamics of the early universe and can have important implications for the observational signatures. Although the quantum bounce has been previously studied via numerical methods for initial conditions that correspond to large macroscopic universes at late times, a detailed study of the robustness of the quantum bounce for a generic class of initial condition has so far been missing due to severe computational challenges. I will talk about the numerical scheme, Chimera, which we have developed to tackle these computational challenges and some important results pertaining to the observable consequences of the loop quantum geometry.

Saturday, October 4, 2014 3:30PM - 4:30PM –
Session E6 Condensed Matter Physics  Life Sciences Building 011 - Anthony Richardella, Pennsylvania State University

3:30PM E6.00001 Electric field tuning of anisotropic magneto-transport properties of two-dimensional electron gas at the surface of SrTiO3. LUDI MIAO, RENZHONG DU, YUEWEI YIN, QI LI, Department of Physics, The Pennsylvania State University — Two-dimensional electron gases (2DEGs) at transition metal oxide surfaces and interfaces have attracted much attention due to their fascinating exotic properties such as superconductivity, large magneto-resistance and ferromagnetism. We have created a 2DEG at the (001) surface of SrTiO3 by Ar+ irradiation and measured its anisotropic magneto-resistance (AMR). The 2DEG exhibits a fully metallic behavior with a low temperature mobility as large as 5500 cm2V-1s-1. At low temperatures, a mixture of a four-fold component which reflects the four-fold symmetry of the SrTiO3 Fermi surface and only appears in a two-dimensional system as well as a two-fold component which is due to the Lorentz force effect are observed in the AMR. These components can be separated by Fourier analysis. Moreover, the four-fold component can be modulated by electric field applied by a back gate. The electric field induced redistribution of oxygen deficiencies which are created at the SrTiO3 surface during Ar+ irradiation and hence the tuning of dimensionality of the system are responsible for the modulation on AMR.

3:42PM E6.00002 Ferroelectric phase transition in EBTO thin films using second harmonic generation. GUERAU CARRERA, SAM MATHERS, West Virginia University. WEIWEI LI, HAO YANG, Soochow University China, MIKEL HOLCOMB, West Virginia University — Europium Barium Titanate (Eu0.5Ba0.5TiO3) or EBTO in bulk form is a novel single-phase multiferroic material that exhibits ferroelectric (Curie temp ~ 213K) and G-type antiferromagnetic (Neel temp ~ 1.9K) properties. Oxygen vacancies have been shown to play a role in room temperature ferromagnetism (HfO2, ZnO, TiO2) and have been reported to increase the Curie temperature of EuO films. EBTO films were grown on SrTiO3 (STO) substrates by pulsed laser deposition (PLD). We performed a temperature dependence study using second harmonic generation (SHG) and found the SHG signal to change as a function of temperature indicating a phase transition from paraelectric to ferroelectric in these EBTO films.

3:54PM E6.00003 Enhancement of tunneling electroresistance in multiferroic tunnel junctions by ferroelectric driven phase transition. Y.W. YIN, Penn State, J.D. BURTON, University of Nebraska, Y-M. KIM, A.Y. BORISEVICH, S.J. PENNYCOOK, Oak Ridge National Laboratory, S.M. YANG, T.W. NOH, Seoul National University, A. GRAUERMAN, University of Nebraska, X.G. LI, University of Science and Technology of China, E.Y. TSYMBAL, University of Nebraska, QI LI, Penn State — A multiferroic tunnel junction (MFTJ), employing a ferroelectric (FE) barrier sandwiched between two ferromagnetic (FM) electrodes has become a promising multifunctional device for practical use. Large resistance difference between states is critical for utilizing MFTJ as resistance switch. To increase the tunneling electroresistance (TER) effect, we have designed a La0.75Sr0.3MnO3(LSMO)/BaTiO3(BTO)/La0.5Ca0.5MnO3(LCMO)/LMO MFTJ in which a FM metallic to antiferromagnetic (AFM) insulating phase transition in LCMO due to interfacial charge doping occurs when the FE polarization of BTO is pointing opposite to LCMO. The metal to insulator transition of LCMO will increase the tunneling barrier width which was verified by transport fitting. While the FE to AFM transition of LCMO will reduce the transmission probability of spin polarized tunneling electrons, which also suppresses tunneling magneto-resistance effect. This is supported by high magnetic field measurement demonstrating that the suppressed AFM order leads to the TER reduction. Both the barrier width increase and transmission probability reduction will significantly increase the resistance difference between two polarization states, and an increase of TER from 30% to 10,000% was obtained.
Proposed method of optical spin read-out in a quantum dot using the AC Stark effect. EDWARD FLAGG, GARY LANDER, CABOT ZABRISKIE, West Virginia Univ. We propose a method to read-out the spin-state of a single electron trapped in a quantum dot via a cycling transition induced by the AC Stark effect. Optical spin initialization and manipulation are allowed by a magnetic field in the Voigt configuration, which modifies the polarization selection rules of the transitions. The lack of a cycling transition in the Voigt configuration, however, makes read-out of the spin-state very difficult. We show that cycling transitions can be made possible by a red-detuned, circularly-polarized laser, which modifies the spin eigenstates and polarization selection rules via the AC Stark effect.

Fractional angular momentum in cold atom systems. YUHE ZHANG, Department of Physics, 104 Davey Lab, Pennsylvania State University, University Park, PA 16802, USA, CANESH JAYA SREEJITH, NORDITA, Roslagstullsbacken 23, 10691 Stockholm, Sweden, NATHAN D. GEMELKE, JAINENDRA K. JAIN, Department of Physics, 104 Davey Lab, Pennsylvania State University, University Park, PA 16802, USA. The statistics of bosons or fermions are manifest through even or odd relative angular momentum of a pair. We show theoretically that a pair of “impurity atoms” immersed in a fractional quantum Hall state possesses, effectively, a fractional relative angular momentum, which can be interpreted in terms of fractional braid statistics. We propose that the fractionalization of the angular momentum can be detected directly through the measurement of the pair correlation function in rotating ultracold atomic systems in the fractional quantum Hall regime. Such a measurement will also provide direct evidence for the effective magnetic field, resulting from Berry phases arising from attached vortices, and of excitations with fractional particle number, analogous to fractional charge in condensed matter systems.

Single photon detection with an actively quenched light emitting diode. DAVID STARLING, BLAKE BURGER, EDWARD MILLER, JOSEPH ZOLNOWSKI, JOSEPH RANALLI, Penn State University. Light emitting diodes (LEDs) have applications in many industries for illumination. However, the LED is not limited only to the generation of light. In this presentation, we demonstrate and analyze the LED for use as a single photon detector and make comparisons to its more costly relative, the avalanche photodiode. We show that LEDs can operate in reverse bias for single photon detection and can even be actively quenched to improve maximum count rates. However, typical LEDs suffer from a few notable drawbacks including long reset times and poor efficiency. Despite these drawbacks, the LED provides a low cost alternative to the avalanche photodiode for use in an advanced lab setting or for photon counting experiments.

Indigo – A biodegradable, low-cost organic semiconductor for device applications. ZHENGJUN WANG, Department of Physics and Astronomy, West Virginia University, Konstantinos Sierrros, Department of Mechanical & Aerospace Engineering, West Virginia University, Dimitris Korakakis, Lane Department of Computer Science and Electrical Engineering, West Virginia University, Mohindar S. Seehra, Department of Physics and Astronomy, West Virginia University. In recent years, the use of organic semiconductors for device applications has attracted considerable attention. In this paper, recent results on indigo-based devices will be reviewed. Indigo is a biodegradable and a low-cost semiconductor with band gap of 1.7 eV and its use in field effect transistors and circuits has been recently reported [1]. In our work, we have recently developed indigo-based write-once-read-many-times (WORM) memory device [2]. Details of the results and their interpretation in terms of interfacial dipoles will be presented.

The physical principle of Fog and haze formation. YONGQUAN HAN, 15611860790. The fog and haze formation is the result of natural, science and technology, human activity. The reason of the fog and haze are: combustion, vehicle exhaust, dust, but the the second outbreak of PM2.5 reasons are complex, including some chemical reaction. In fact, the reason is: 1. The accumulation of the fog and haze, namely the results of combustion, automobile exhaust, dust effects. 2. The fog and haze particles upward momentum – hot air upward movement, wireless communication, the electromagnetic wave net sports. 3. no sustained wind. Three conditions have erupted persistent cause the fog and haze weather, indispensable, the second outbreaks of PM2.5 are above these three conditions together of the results.

Rectenna with broadband operation from near-infrared to visible. RAYMOND WAMBOLD, JAMES CHEN, MICHAEL PHILLIPS, ZACHARY SINISI, GARY WEISEL, DARIN ZIMMERMAN, Penn State Altoona, BRIAN WILLIS, University of Connecticut, PAUL CUTLER, NICHOLAS MISKOVSKY, Scretech Associates, LLC. We describe a rectifying antenna (rectenna) for the efficient collection and conversion of solar radiation into electricity. Engineered for broadband absorption, an array of rectennas employs geometrical asymmetry, resulting in a self-biased junction that enables a rectified DC tunneling current. To achieve junction gaps within the tunneling regime, we use selective atomic-layer deposition (ALD) applied to devices created using standard electron-beam lithography. We demonstrate the tunability of the optical extinction response in these devices and show that the resonance peak is progressively red-shifted with increasing cycles of ALD, consistent with optical antenna theory. We compare our optical extinction measurements to simulation results and describe electro-optical experiments that are planned for the near future.

Saturday, October 4, 2014 3:30PM - 4:30PM – Session E8 Atomic, Molecular and Optical Physics II Life Sciences Building 013 - Charles Jaffe, West Virginia University
3:30PM E8.00001 Optical beam imaging studies on high power lasers

JULIA YANG, Carnegie Mellon University — SLAC National Accelerator Laboratory hosts the unique Linac Coherent Light Source, a free electron x-ray laser (FEL) with high peak brightness, tunability, and narrow bandwidth. Matter in Extreme Conditions (MEC) end station at SLAC investigates the behavior of states in extreme environments of high pressure (several megabars) and temperatures (millions of Kelvin) produced by powerful class 4 lasers using the FEL to probe transient states. Recent experiments in warm dense matter at MEC have required relativistic laser intensities greater than $10^{19}$ W/cm² to create hot electrons. The aim of this study is to characterize the beam spot per pulse to establish high intensity values within 10% accuracy. This will indicate if enough peak intensity has impacted the sample. A numerical code in MATLAB is developed to find spatial and intensity jitter, spot size measurements for four profiles, average peak intensity, and error propagation. This procedure automates previous methods done with imaging software for characterizing beam profile. The implemented code leads to faster and more accurate beam size characterization to eventually enable live pulse-by-pulse measurement, a valuable capability yet to be achieved in laser studies.

1Work supported by the Science Undergraduate Laboratory Internships and Fusion Energy Sciences under DOE Office of Science

2This work was done under mentorship of Hae Ja Lee, SLAC National Accelerator Laboratory. However, all results and data presented are my own.

3:42PM E8.00002 Transmission Spectra for 1D Disordered Photonic Crystals

DONALD PRIOUR, Youngstown State University — With a recursive technique which accounts for disorder in a rigorous fashion without a need for averaging over multiple configurations of disorder, we calculate transmission spectra (for normal and oblique incidence in the optical range) for disordered nanoscale photonic crystals comprised of layers of alternating composition (i.e. Zinc Oxide and Chromium). Our theoretical results are in accord with recent experimental data obtained for a ZnO/Cr system. For the latter, we discuss the unusually high transmitted intensity of the photonic crystals, with theoretical predictions (calculated using the bulk attenuation coefficient for Chromium) several orders of magnitude lower. Nevertheless, by using a modified and considerably reduced attenuation coefficient for the nanoscale chromium layers, we obtain excellent agreement with the experimental data.

3:54PM E8.00003 Coherent spectroscopy of excitons in strained bulk GaAs

BRIAN WILMER, West Virginia University, ASHLEY BATESOLE, Ohio Northern University, DANIEL WEBBER, KIMBERLY HALL, Dalhousie University, WILMER, West Virginia University, ASHLEY BATESOLE, Ohio Northern University — Two-dimensional Fourier transform spectroscopy is used to measure bulk excitons in GaAs. The degeneracy of heavy and light hole excitons is lifted due to biaxial strain. This allows for observation of coherent coupling features between exciton resonances in rephasing spectra. This system differs from quantum wells, due to lack of inhomogeneity, and is a model system for isolating many-body interactions without quantum confinement. Low power and low temperature excitation reveals excitation-induced dephasing in the real-part of spectra. Excitation dependence shows an increase in spectral linewidths due to increasing excitation induced dephasing. Increasing temperature also increases dephasing, but reduces signal strength, due to increased interactions with the phonon bath. At low temperature there is also asymmetry in the strength of the off-diagonal coupling features, with down-hill energy transfer being favored. The degree of asymmetry indicates that there are the same number of quantum pathways transferring spectral weight from the uphill coherence to the lower energy eigenstate and the higher energy eigenstate to the down-hill coherence. At higher excitation density there is a swap in the strength of the coherences possibly due to saturation of the lower energy feature.

4:06PM E8.00004 Structure and Symmetry in Coherent Perfect Polarization Rotation

MICHAEL CRESCIMANNO, CHUANHONG ZHOU, JAMES ANDREWS, MICHAEL BAKER, Dept. of Physics, Youngstown State University — Theoretical investigation of different routes to coherent perfect polarization rotation illustrates its phenomenological connection with coherent perfect absorption, a.k.a. The anti-laser. Analysis of the effects of parity breaking, layering, combining Faraday rotation and optical activity, and a rotator-loaded optical cavity serve to sharpen the contrast between these phenomena. These comparisons may be useful in suggesting new approaches to common optical devices and identifying promising routes to their miniaturization.

4:18PM E8.00005 Near-analytic solutions to the PMD equations in Periodically Spun Fiber using Differential Transform Method

VINOD MISHRA, No Company Provided — Periodically spun optical fibers have been found to reduce Polarization Mode Dispersion (PMD) in propagating optical modes [1]. The resulting coupled ordinary differential equations are usually solved numerically. To gain better physical understanding and dependence of PMD on relevant parameters, analytical solutions are to be preferred. The current work uses Differential Transform Method to derive analytical solutions to the original equations as a series and investigates their properties.


5:00PM - 5:00PM
Session F1 Poster Session
Days Inn Atrium - Stephane Coutu, Pennsylvania State University

F1.00001 Partial Trace of Hypergraph States

DANIEL UPCHURCH, Lebanon Valley College — Hypergraph states are generalizations of graph states, which are known resources for models of quantum computation and error correction. We have shown that partial tracing over single qubit subsystems of hypergraph states results in the equal mixture of smaller hypergraph states, that is, of their density matrices. We have also described all possible hypergraphs that could share the same reduced density matrices that are smaller by one qubit. Comparing reduced density matrices of different quantum systems can show if they share entanglement properties.

F1.00002 Experimental Approach for Circuit Analysis

FRANK MALATINO, MATTHEW WIDJAJA, JASON SHULMAN, Richard Stockton College of New Jersey — For complex circuits, implementation of Kirchoff’s Laws can be tedious and time consuming. Here, we present an alternative procedure, which is based on a methodology designed to control complex networks. It is an experimental, rather than analytical, approach to analyzing circuits. From this, one can generate equations that describe the behavior of a circuit. These are the same equations that would be obtained through more traditional means.

1Professor
Kingdom. Our study constrains the companion mass to $m_2 = \text{result}$ by analyzing pulsar timing data from four different radio telescopes: the Effelsberg 100m radio telescope in Germany, the Westerbork telescope in the Netherlands, the Nancay radio telescope in France, and the Lovell radio telescope at Jodrell Bank in the United Kingdom. Continued monitoring should therefore allow further improvements to this mass measurement.

The formation of star clusters is a complex process that involves the coalescence of multiple stars. As the system evolves, we observe that heavier stars sink towards the center of the cluster. In both investigations, we modify the following parameters and analyze the effects they have on the resulting physical effect we study is the degree of mass segregation in the final star cluster. As the system evolves, we observe that heavier stars sink towards the center of the cluster. Continued monitoring should therefore allow further improvements to this mass measurement.

In this paper, capacitance of the parallel-plate capacitor filled with multiple dielectric slabs was measured and compared with the first-principles data. Partition of the internal energy of the nascent H2 molecule into translational, vibrational, rotational, and graphene phonons will be studied and compared with the first-principles data. 

Ultra-light carbon nanotube sponge as an efficient electromagnetic shielding material in the GHz range. MARIA CRESPO, Pennsylvania State Univ; Universidad Carlos III, MARIA GONZALEZ GONZALEZ, Universidad Carlos III, LAKSHMY PULICKAL RAJUKUMAR, ANA LAURA ELIAS, Pennsylvania State Univ, JUAN BASELGA, Universidad Carlos III, MAURICIO TERRONES, Pennsylvania State Univ, JAVIER POZUELO, Universidad Carlos III. A CVD-synthesized CNT flexible sponge, with density lower than 0.02 g cm$^{-3}$, has been found to serve as high performance EMI shielding material without the aid of any polymer infiltration or impregnation. Due to its extreme lightweight, the specific SE of the CNT-sponge was found to be as high as 1100 dB cm$^3$ g$^{-1}$, having a total SE above 20 dB in the whole 1–18 GHz range, and being able to shield by absorption. The material is the best of our knowledge this specific SE value appears to be the highest reported hitherto. Improved EM absorbers should fulfill the synergic requirements of being low reflective and highly absorptive. In our CNT-sponges this condition is not satisfied because, although their net absorption ability is strongly remarkable, their high electrical conductivity favors the wave to be reflected at the input interface. Therefore, this sponge material would have a great potential for microwave-frequency applications that need negligible reflection and great absorption when combined in a multilayered structure that could prevent the wave to be reflected at the input interface.

Energetic of formation of molecular hydrogen on graphene using Eley-Rideal (ER) and Langmuir-Hinshelwood mechanisms. MAJID KARIMI, Indiana University of PA, SEAN MORGAN, IUP, JUSTIN PETUCCI, University of Denver, CARL LEBLOND, Indiana University of PA, RAZI HASSAN, Alabama A&M University, GIANFRANCO VIDALI, Syracuse University. The second generation AIREBO potential for hydrocarbons is modified to accurately reproduce features of the chemical interactions and reaction of H atoms on graphene surface. The adapted potential reproduces many features of the adsorption potential of hydrogen on graphene in close agreement with the corresponding data from DFT. The modified potential is employed to study formation of H2 on graphene using ER and LH processes. This study will be carried out using classical molecular dynamics (LAMMPS) and nudged elastic band (NEB) for the calculation of barriers. Partition of the internal energy of the nascent H2 molecule into translational, vibrational, rotational, and graphene phonons will be studied and compared with the first-principles data.

Shapiro Delay of Pulsar J1640+2224. NATASHA L. McMANN, West Virginia University. JORIS VERBIEST, Universität Bielefeld. Pulsar J1640+2224 is a binary millisecond pulsar with a white dwarf companion and is being used in pulsar timing arrays being used in experiments to detect gravitational waves. A previous study of the system’s Shapiro Delay by Löhmer et al., 2005 constrained the companion mass to $m_2 = 0.15 \pm 0.06 -0.05$ Msolar which would imply an unprecedentedly low pulsar mass. We improved their result by analyzing pulsar timing data from four different radio telescopes: the Effelsberg 100m radio telescope in Germany, the Westerbork Synthesis Radio Telescope in the Netherlands, the Nancay radio telescope in France, and the Lovell radio telescope at Jodrell Bank in the United Kingdom. Our study constrains the companion mass to $m_2 = 0.28 \pm 0.35 -0.03$ Msolar and the pulsar mass to $m_1 = 1.51 \pm 3.30 -0.22$ Msolar. The relatively wide orbit in which this pulsar resides (period \( \approx 6 \) months) complicates this analysis as it introduces covariances with the Earth’s motion. Continued monitoring should therefore allow further improvements to this mass measurement.
We find that bright LAEs in the redshift range $1.9 < z < 2.5$ fit the individual spectral energy distributions (SEDs) of 67 bright Ly-alpha emitting galaxies (LAEs) discovered in the HETDEX Pilot Survey.

ZEIMANN, Pennsylvania State University, HETDEX TEAM — We use photometry spanning from the rest-frame UV to the rest-frame NIR to isolate galaxies as hosts. For galaxies which are isolated, 20 percent have a single host, and 10 percent have multiple possible hosts and most likely lie within a dense region.

We find that roughly 82 percent of all void dwarf galaxies are isolated, 14 percent have a single host, and 4 percent have multiple possible hosts and most likely lie within a dense region. In contrast, only 70 percent of wall dwarf galaxies are isolated, 20 percent have a single host, and 10 percent have multiple possible hosts and most likely lie within a dense region.

F1.00012 Exploring HETDEX Pilot Survey Lyman-alpha Emitters with Spectral Energy Distribution Fitting . ALEX HAGEN, ROBIN CIARDULLO, CARYL GRONWALL, JOANNA BRIDGE, GREGORY ZEIMANN, Pennsylvania State University, HETDEX TEAM — We use photometry spanning from the rest-frame UV to the rest-frame NIR to fit the individual spectral energy distributions (SEDs) of 67 bright Ly-alpha emitting galaxies (LAEs) discovered in the HETDEX Pilot Survey. We find that bright LAEs in the redshift range $1.9 < z < 3.5$ are quite heterogeneous. Our LAE masses span more than three orders of magnitude and are distributed in a manner that suggests that the objects are drawn in an almost uniform manner from the underlying galaxy mass function. This diversity is also reflected in the LAEs' dust content: while most of our objects are dust poor, some of the more massive LAEs are dust-rich, with differential extinctions as large as $E$(B-V) $\sim 1.2$. We find no significant correlation between half-light radius and stellar mass but we show that the Ly-alpha escape fraction does depend on mass, with low-mass systems being more efficient Ly-alpha emitters. Finally, we present evidence which suggests that there is an upper limit to the mass-specific star formation rates of Ly-alpha emitting galaxies.

F1.00013 Searching for Protostars using MYStIX . GREGORY ROMINE, ERIC FEIGELSON, Penn State — The MYStIX data set synthesizes photometric data in the Xray, nearIR, and farIR for 20 star forming regions in the nearby galaxy with rich OBdominated clusters. Data are obtained from NASA’s Chandra Xray Observatory, the UKIRT telescope in Hawaii, and NASA’s Spitzer Space Telescope. This project attempts to utilize the MYStIX data sets and ESA’s Herschel mission farIR cloud maps to find protostellar candidates within dense cloud cores of the star forming regions. Within the data set are stars with strong infrared excesses indicative of dusty protoplanetary disks at the Class I stage of protostellar evolution. In addition, Xray sources with very high extinction are present that may represent obfuscated protostars. The study will describe the selection process for candidate protostars, reducing contamination from extraneous Galactic and extragalactic objects. Candidates are then compared to known protostars in the regions, and we provide an atlas and catalog of the resulting candidate protostars.

F1.00014 Physical and Morphological Properties of [O II] Emitting Galaxies in the HETDEX Pilot Survey . JOANNA BRIDGE, CARYL GRONWALL, ROBIN CIARDULLO, ALEX HAGEN, GREG ZEIMANN, Penn State — The Hobby-Eberly Dark Energy Experiment pilot survey identified 284 [O II] 3727 emitting galaxies in a 169 square-arcminute field of sky in the redshift range $0 < z < 0.5$. This line flux limited sample provides a bridge between studies in the local universe and higher-redshift [O II] surveys. We present an analysis of the star formation rates (SFRs) of these galaxies as a function of stellar mass as determined via spectral energy distribution fitting. The [O II] emitters fall on the “main sequence” of star-forming galaxies with SFR decreasing at lower masses and redshifts. However, the slope of our relation is flatter than that found for most other samples, a result of the metallicity dependence of the [O II] star formation rate indicator. The mass specific SFR is higher for lower mass objects, supporting the idea that massive galaxies formed more quickly and efficiently than their lower mass counterparts. This is confirmed by the fact that the equivalent widths of the [O II] emission lines trend smaller with larger stellar mass. Examination of the morphologies of the [O II] emitters reveals that their star formation is not a result of mergers, and the galaxies' half-light radii do not indicate evolution of physical sizes.

F1.00015 First Results from the Swift/UVOT Near-Ultraviolet Survey of the SMC . LEA HAGEN, MIKE SIGEL, CARYL GRONWALL, Pennsylvania State Univ, ERIK HOVERSTEN, University of North Carolina at Chapel Hill, STEFAN IMMELER, Goddard Space Flight Center — The Swift Ultraviolet/Optical Telescope (UVOT) has recently completed the first wide-field multi-color NUV survey of the Small Magellanic Cloud. The resulting imaging covers nearly four square degrees and includes over 250,000 NUV sources. We present early analysis of this outstanding data set, looking at the recent star formation history of the SMC, the distribution of young stellar populations over the face of the SMC, the location of rare stellar types such as Post-Asymptotic Giant Branch stars, and the SMC dust extinction law.

F1.00016 R-mode frequencies for slowly rotating neutron stars with realistic equations of state . ASHIKUZZAMAN IDRISY, BENJAMIN OWEN, Institute for Gravitation and the Cosmos, Center for Gravitational Wave Physics, Department of Physics, The Pennsylvania State University, DAVID JONES, Mathematical Sciences, University of Southampton — The frequency of $r$-mode oscillations of rotating neutron stars is of interest when carrying out gravitational wave and electromagnetic observations. The $r$-mode frequency in the slow rotation limit of Newtonian stars is well known, but will be subject to several corrections. We make simple estimates of the importance of several sorts of correction, and conclude that relativistic corrections are likely to be the most important. For this reason we extend the formalism of Lockitch et al. [1], who consider relativistic polytropes, to the case of realistic equations of state. The perturbation equations resulting from this formulation are solved using a spectral method. We find that for stars with realistic equations of state, the $r$-mode frequency $\Omega_{\text{r}}$ ranges from 1.390 to 1.561 (where $\Omega$ is the rotation rate of the star), when the relativistic compactness parameter $M/R$ is varied over the astrophysically-motivated interval from 0.11 to 0.31. The results presented here are relevant to the design of gravitational wave and electromagnetic $r$-mode searches, and will help in constraining the compactness parameter following a successful $r$-mode detection, which is itself related to the high density equation of state.
F1.00017 Characteristics of a 2-D Magneto-Optical-Trap, CHRISTIANE EBONGUE, ERIC MAGNAN, PABLO SOLANO, JEFFREY GROVER, LUÍS ORÓZCO, Univ of Maryland-College Park — The 2D Magneto-Optical-Trap (MOT) produces a cold collimated Rubidium (Rb) atomic beam in a compact set up. The 2D MOT is in a stainless steel vacuum system, and requires a gradient of magnetic field as well as two different laser frequencies, one for cooling through a cycling transition and one for repumping atoms that fall into the wrong state. The vacuum system has four vacuum windows to allow retroreflection of the cooling beams, a dispenser that generates a vapor of Rb atoms. The lowest pressure attained is about $10^{-10}$ mbar. We have produced the quadrupole field using first small permanent rare earth magnets, and then coils. Finally, the red-detuned cooling beam has a frequency offset a few MHz from transition frequency of $^8$Rb, with circular polarization. The optics arrangement is compact using fiber optics. We present here advances and results of the 2D MOT.

F1.00018 Construction of Zeeman Slower and Ultra High Vacuum for Use in Laser Cooling and Trapping, JOSHUA HALBFOERSTER, NICHOLAS HITCHO, JOHN HUCKANS, Bloomsburg Univ — Laser cooling and trapping involves slowing vaporized rubidium-87 (Rb) atoms in a vacuum using red-detuned laser light to observe atomic behavior in a microkelvin environment. Rb atoms are first vaporized in a 135$^\circ$ oven, sent through a collimating apparatus down a Zeeman slower toward a counterpropagating laser beam that slows them down to millikelvin temperatures. Subsequent techniques further cool the atoms to microkelvin temperatures. A Zeeman slower consists of a one-meter solenoid of precisely wound copper wire, creating a spatially-varying magnetic field that compensates for the spatially-changing Doppler shift of the $^8$Rb ground state transition due to the fact that the atoms are decelerating relative to the counterpropagating laser beam. Our experiment occurs in an ultra-high vacuum (UHV) environment ($\leq 10^{-7}$ Pa). We achieve this level of vacuum using tools and methods such as sonication, baking, turbomolecular, ion and titanium sublimation pumps.

F1.00019 Tuning and Locking a Diode Laser for a Magneto-Optical Trap, MATTHEW GIFT, RACHEL LIVINGSTON, JU XIN, JOHN HUCKANS, Bloomsburg Univ — The purpose of a magneto-optical trap (MOT) is to use the atomic structure of rubidium-87 to manipulate a sample into an ultra-cold atom cloud in a vacuum sealed environment via a laser array. The extended cavity diode lasers used in this experiment must be tuned using an absorption spectroscopy system which utilizes the Doppler effect of light through a rubidium cell as the extended cavity of the diode laser is scanned across the rubidium absorption peaks with a piezo stack. The laser is then locked with a lock-in amplifier to ensure the frequency remains stable. When the lasers are locked they will be ready for use in the creation of a MOT. The light will be red-detuned so as to excite atoms moving towards each beam. When an atom absorbs the photon it will lose momentum along the photon’s axis of motion, then spontaneously emit a photon of the observed frequency in a random direction. The isotropic nature of the emitted photons creates a randomly-directed recoil momentum in the affected atoms and reduces the average energy of the sample as a whole. With the orthogonal laser set-up and in conjunction with an anti-Helmholtz magnetic field this will create a point where the least energetic atoms will form an ultra-cold cloud with a temperature on the order of 200 microkelvins.

F1.00020 Rotationally inelastic collisions of He and Ar with NaK: Theory and Experiment, T.J. PRICE, K. RICHTER, J. JONES, C. FAUST, A.P. HICKMAN, J. HUENNEKENS, Lehigh University, R.F. MALENDA, Moravian College, A.J. ROSS, P. CROZET, ILM Université Lyon 1 — Rotationally inelastic collisions of NaK ($^1$Σ$^+$) molecules with He and Ar are studied in this work. Using a 2D MOT, we are able to cool and trap NaK atoms in the ground state and observe the inelastic collisions with He and Ar. The collisions are studied using a pump-probe scheme where the probe is scanned over the ro-vibrational levels of NaK. The ratios of satellite to direct lines intensities in LIF and PL yield information about population and orientation transfer. A strong propensity for $\Delta J = 1$ transitions is observed for both He and Ar perturbers. In the FT fluorescence experiment we also observe $\nu$ changing collisions.

F1.00021 Biophysical Aspects of Blood Flow in the Cardiac Valve, AYOUNG CHO, SUNG HONG, MATTHEW SEH, CRG (Choice Research Group) — Blood flow through cardiac valve occurs by the pressure gradient in the cardiovascular system. Assuming the incompressibility of the blood in the cardiovascular system, this paper applied a numerical method to find the blood flow rate and biofluid parameters in the mitral valve. Also biomechanical analysis was performed on a disk-type prosthetic mitral valve in heart. For the purpose of computational and mathematical modeling, the valve was assumed to be immersed in fluid and symmetric about the midline plane. Incompressible laminar steady flow with constant viscosity was assumed. The flow is considered during the greater part of systole when the valve is fully open. Stress, displacement distributions are computed at every grid point. And two-dimensional velocity profiles across anterior mitral valve are presented. In this study, computational and numerical method were attempted to analyze the mitral valve quantitatively by using finite element analysis. A finite element model of the mitral valve showed that the maximum pressure occurs at the early diastolic period. Also, high velocity flow through the mitral valve was observed due to pressure buildup during initial filling.

F1.00022 Analysis of the Biophysical Factors Affecting Cardiovascular Disease, SHEILLIN HYEAM, RICHARD KYUNG, CRG — The object of this research is to find the biomechanical effects of aortic valve stenosis on the heart disease using biophysical and computational analysis. Observations are carried out for significant factors, such as blood pressure changes, aortic valve area changes, and possible correlations with blood velocity and other fluid dynamic-related properties. The Gorlin equation is expressed as a formula that directly links cardiovascular and geometric properties to the purpose of establishing a malicious link between pressure and aortic valve stenosis. Based on Bernoulli’s principle, Gorlin Equation differs only in that it is an application of the principle to cardiovascular analysis and combines cardiovascular properties to determine heart valve area. To determine the area of the aortic valve, hemodynamic parameters are set: heart rate is set at 80 beats/minute, systolic ejection period at 0.33 seconds, cardiac output at 6400 mL/minute, and the “standard Gorlin constant” at 44.3. Additionally, computer program MATLAB is used to support and help with the calculation of results respectively.
same material parameters, under stress, the structures behave very differently due to varying levels of porosity, causing the material response to
to the failure mechanics of the skull. Upon completion of the simulations, we found that although each sample was initially provided with the
were analyzed using finite element simulations, subjected to quasi-static compression. The output models allowed for a detailed understanding
three-dimensional surface geometry meshes of various locations throughout the skull, from which volume meshes were developed. All samples
 loading, thirty finite element models of small sections of a porcine skull were created. MicroCT scans of the skull were used to generate
growth, propagation and coalescence. To gain a better understanding of the microstructure and the mechanics of bone fracture under impact
chanics Group — Fracture and damage of the skull remains one of the largest and most detrimental injuries in combat. Although skull fracture
research continues, the aim is to develop model accuracy and resolution at micro- and macroscale levels for a thorough understanding of injury
investigations into the effect of trabecular structure and material interaction on patterns of stress propagation and potential fracture paths. As
parameters are determined using a large collection of experimental animal models. The results show that the five ossification centers that form
surrounds the brain, eventually forming mineralized bone. Signaling pathways for the cell differentiation start from some actions of
of this pathway is the communication between photoreceptors and large monopolar cells (LMCs). Photoreceptors transmit information to an
Univ of Maryland-College Park, ROB DE RUYTER, Indiana University — The blowfly visual information pathway is a well-studied system,
F1.00023 Dynamics of the Blowingly Photoreceptor-LMC Synapse1, CHRISTOPHER BOUGHTER, Univ of Maryland-College Park, ROB DE RUYTER, Indiana University — The blowingly visual information pathway is a well-studied system, from the initial absorption of a photon by a photoreceptor to the corresponding reaction by the fly. One particularly interesting component of this pathway is the communication between photoreceptors and large monopolar cells (LMCs). Photoreceptors transmit information to an LMC through the release of vesicles containing histamine. The dynamics of vesicle release is usually modeled as an inhomogeneous Poisson process with a rate driven by the presynaptic voltage. Preliminary experimental evidence suggests that this release may have a more complex temporal structure consistent with a population of driven oscillators. To determine the validity of this model, in-vivo measurements were made on both photoreceptor cells and LMCs. The response of these cells to high frequency light pulses was recorded in an attempt to entrain the putative oscillators. In the LMC we observe transient oscillatory behavior after cessation of stimulation at 125 Hz. This behavior is not observed in eye photoreceptors, and there is some published evidence that postsynaptic mechanisms are not responsible for these oscillations. These observations are consistent with our hypothesis, but future work is needed to determine the validity of the idea.

1Acknowledgement of support from: Indiana University and the National Science Foundation Research Experience for Undergraduates

F1.00024 Microstructural Analysis of Porcine Skull Bone Subjected to Impact Loading , ALLISON RANSLOW, Penn State Computational Biomechanics Group, KIMBERLY THOMPSON, SIKHANDA SATAPATHY, U.S. Army Research Lab, RAUL RADOVITSKY, MIT Department of Aeronautics and Astronautics, REUBEN KRAFT, Penn State Computational Biomechanics Group — Fracture and damage of the skull remains one of the largest and most detrimental injuries in combat. Although skull fracture is a common injury, its mechanics are still unknown due to bone’s complex structure, which spans the molecular level and macroscopic dimensions. Using finite element analysis of the microscopic architecture allows for a controlled evaluation of stress wave interactions, micro-crack growth, propagation and coalescence. To gain a better understanding of the microstructure and the mechanics of bone fracture under impact loading, thirty finite element models of small sections of a porcine skull were created. MicroCT scans of the skull were used to generate three-dimensional surface geometry meshes of various locations throughout the skull, from which volume meshes were developed. All samples were analyzed using finite element simulations, subjected to quasi-static compression. The output models allowed for a detailed understanding of the mechanics of the skull. Upon completion of the simulations, we found that although each sample was initially provided with the same material parameters, under stress, the structures behave very differently due to varying levels of porosity, causing the material response to change drastically with load.

F1.00025 A Computational Analysis of Bone Formation in the Cranial Vault, CHANY-OUNG LEE, Department of Mechanical and Nuclear Engineering, The Pennsylvania State University, JOAN T. RICHTSMEIER, Department of Anthropology, The Pennsylvania State University, REUBEN H. KRAFT, Department of Mechanical and Nuclear Engineering, The Pennsylvania State University — Bones of the cranial vault are formed by the differentiation of mesenchymal cells in osteoblast cells on a surface that surrounds the brain, eventually forming mineralized bone. Signaling pathways for the cell differentiation start from some actions of extracellular proteins driven by information from genes. We assume that the interaction of cells and extracellular molecules which are associated with cell differentiation can be modeled using Turing’s reaction-diffusion model, which is a mathematical model for pattern formation controlled by two interacting molecules (activator and inhibitor). In this study we hypothesize that regions of high concentration of an activator develop into regions of ossification, therefore, bone. In the pattern formation model described above, the concentration of an activator associated with bone growth. These mathematical models were solved using the finite element method. The computational domain and model parameters are determined using a large collection of experimental animal models. The results show that the five ossification centers that form in our model occur at the same position as those identified in experimental data. As bones grow from these ossification centers, sutures form between the bones.

F1.00026 Cell fate Affected by Carbon Nanotubes during C17.2 Neural Stem Cell Differentiation , MASSOOMA PIRBHAI, SABRINA JEDLICKA, SLAVA V. ROTKIN, Lehigh Univ — Delivery of materials, such as drug compounds or imaging agents for treatment or diagnosis of disease still presents a biomedical challenge. Nanotechnological advances have presented biomedicine with a number of agents that possess the appropriate size and chemistry to pass the blood brain barrier. Functionalized carbon nanotubes are one such agent. Functionalized carbon nanotubes, shown to penetrate the blood brain barrier can potentially aid in drug and gene delivery to the central nervous system. In addition, carbon nanotubes have already been applied in several areas of nerve tissue engineering to probe and augment cell behavior, to label and track subcellular components, and to study the growth and organization of neural networks. Although the production of engineered carbon nanotubes has escalated in recent years, knowledge of cellular changes associated with exposure to these materials remains unclear. In this study, we employed multipotent C17.2 neural stem cells to probe how individual single-wall carbon nanotubes functionalized with synthetic ssDNA or RNA affect cellular processes of adhesion, proliferation, and differentiation. The research has shown that while toxicity might not be an issue at low concentration of the carbon nanotubes, irregular behavior is nonetheless observed in terms of the fate of cells after differentiation and is worth considering when developing strategies to deliver components to the central nervous system.

F1.00027 Simulation of the Effects of Flanking Sequences on Polyglutamine Aggregation1, JASON HAAGA, Lehigh University Department of Physics, SIDDIQUE KHAN, University of Pennsylvania Department of Medical Physics, JAMES GUNTHER, Lehigh University Department of Physics — Huntington’s disease is one of a set of nine progressive neurodegenerative diseases caused by the expansion of CAG sequence repeats. This results in affected proteins with abnormally long polyglutamine (polyQ) tracts, which beyond a pathological threshold length form toxic aggregates. Recent experimental studies suggest the sequences flanking the polyQ tract have a profound impact on the aggregation rates and morphologies. The 17 residues N terminus to the polyQ insert in the huntingtin protein (Htt) have been shown to accelerate aggregation, particularly the formation of insoluble fibrils. The proline-rich C terminal region has demonstrated to slow the rate of aggregation. We propose a coarse-grain model of the polyQ tract, with and without its N and C terminal regions, and utilize Brownian dynamics simulation to examine the kinetics of aggregation.

1This work is supported by a grant from the G. Harold and Leila Y. Mathers Foundation.

F1.00028 Finite Element Modeling of Impact and Injury to the Lower Extremity , REBECCA FIELDING, REUBEN KRAFT, Pennsylvania State University, ANDRZEJ PRZEWALSKI, X.G. TAN, Computational Fluid Dynamics Research Corporation — An underbody blast (ubb) is the detonation an explosive device under a military vehicle. Such incidents can lead to severe injuries in the lower extremities. Research has been conducted at a variety of anatomical levels to better understand the mechanisms that lead to injury in the lower extremity. A finite element model of the lower leg was validated against experimental data for vertical loading at 5 m/s. This model was used as a basis for full leg simulations and preliminary fracture modeling. In UBB events, the foot and ankle, particularly the understudied calcaneus, may sustain significant damage. A cadaveric calcaneus was scanned to a resolution of 55 microns using an industrial microCT scanner. This data was used to generate a 2D finite element mesh of the calcaneus that included marrow, trabecular bone, and cortical bone. Loading conditions for the calcaneus were based on results of the lower leg simulations. The calcaneus model was used for exploratory investigations into the effect of trabecular structure and material interaction on patterns of stress propagation and potential fracture paths. As research continues, the aim is to develop model accuracy and resolution at micro- and macroscale levels for a thorough understanding of injury mechanisms.
The MRI process produces large amounts of data, not all of which is necessary to produce the required image. This image can be reconstructed by mathematical and computational transformations. Since the frequency data of the brain with Alzheimer's disease was used to determine the frequency domain, which can be used to study the self-assembly of these polypeptide chains, in order to understand the formation of hydrogels. The primary purpose of this research is to develop a better algorithm that would enhance the quality of the final MRI image, decrease the amount of time required to produce it, and generate the image with less ringing artifact.

In this poster we present preliminary Monte Carlo simulation results which shows that the structure of MAX1 is: VKVKVKVKV-VDPPTKVKVKVKV-NH2. Therefore, the general structure of MAX1 is a random coil shape. We will also present the experimental data for the conformational variations at the polymer chain level. In addition, we also propose a coarse-grained model that we will use to study the self-assembly of these polypeptide chains, in order to understand the formation of hydrogels.

Acknowledgements: We thank NSF (CREST grant 1242067), NASA (URC 5 grant NNX09AU90A) and NIH (Delaware INBRE Pilot Project) for the generous funding of this project.

**F1.00029** Steady-state fluorescence anisotropy and lifetime measurements of fluorophores and fluorescent-dye-loaded microspheres. JACOB A. COLE, SAM V. MIGIRDITCH, TYLER W. FOLEY, BROOKE C. HESTER, Appalachian State University — We perform steady-state fluorescence anisotropy and lifetime measurements via illumination of fluorophores with a continuous intensity beam of light. In steady-state fluorescence anisotropy, fluorophore molecules are excited when the polarization of the incoming excitation light is parallel to the excitation axis of the fluorophore. Following a delay known as the fluorophore lifetime, a molecule will return to its rest state by emitting photons polarized along the instantaneous orientation of the molecule. The steady-state anisotropy, , is defined as the average change in orientation of the sample weighted by the average intensity of each polarization axis. Experimental results are used to determine the anisotropy, , and the lifetime, , of the samples: freely diffusing rhodamine as well as yellow-green fluorescent-dye-loaded microspheres with sizes ranging from 0.51 μm to 6.2 μm. Experimental outcomes confirm that the custom-made steady-state fluorescence anisotropy optical system and analysis software are properly engineered and optimized. These outcomes include the fluorescence lifetime, , for each fluorophore type, the fluorescence lifetime, , for each fluorescent bead size, and the anisotropy, , at various temperatures.

**F1.00030** A Fluorometrical Study of the Impact of Gold Nanoparticles on the Fluidity DMPC Liposomes1, LANCÉ EDWARDS, Department of Biological Sciences, Delaware State University, DILLON BADMAN, Department of Physics and Engineering, Delaware State University, PATIMA EDWARDS, Polytech High School, QI LU, Department of Physics and Engineering, Delaware State University — Liposomes are model membrane systems composed of phospholipid bilayers that are the major constituent of cellular membranes. In this study, we aim to understand how nanoparticles affect the integrity of cell membranes by examining the interactions between liposomes and gold nanoparticles (AuNPs). The liposomes were prepared by sonication 1,2-dimyristoyl-sn-glycero-3-phosphocholine (DMPC) in PBS partitioned with Laurdan (6-lauryl, 1,2-dimethylamino naphtalene), a hydrophobic fluorescent dye. AuNPs in four different sizes (5, 10, 20 and 30 nm) at various concentrations were introduced to extruded or non-extruded liposomes. The extrusion process allowed for a size uniformity of the liposomes below 100 nm in diameter, confirmed with an IX-71 fluorescence microscope. The emission spectra of Laurdan-labeled liposomes upon AuNP interactions were collected with a K2 spectrophotometer. The emission peaks at 440 and 490 nm were then used to derive the generalized polarization (GP) functions, which reveal the change of fluidity in the lipid bilayers induced by AuNPs. These changes may lead to new insights on how AuNPs may be used to control the metabolic pathways of lipid membranes in the process of cancer cell adhesion.

1Acknowledgements: We thank NSF (CREST grant 1242067), NASA (URC 5 grant NNX09AU90A) and NIH (Delaware INBRE Pilot Project) for the generous funding of this project.

**F1.00031** Reinforced composite based modeling of axonal injury - A physics based approach. HARSÁRA GARIMELLA, REUBEN KRAFT, Penn State Univ — Sports related concussion/brain injury is a major health problem in the United States that is particularly common in contact sports like American football, hockey etc. Despite the significance and growing concerns about the potential long term consequences of concussion, their biomechanical mechanisms are not fully understood. Since 1970s computational modeling proved to be an efficient tool for biomechanical modeling of human brain. Computational modeling coupled with recent advancements in brain imaging technology would provide us with a robust method in developing accurate constitutive models for computational analysis. This paper presents a physics based finite element modeling of human brain with axonal fibers using the concept of embedded finite element method and composite based modeling. Axonal strains, which play a major role in neurotrauma, can be obtained with much less complexity using this method. This model will be further developed to include the physics areas like diffusion (spread of disease), electromagnetism(EEG) etc.

**F1.00032** A simulation study of a polypeptide model of a hydrogel. SONGUL KUTLU, Lehigh Physics Department, SIDDIQUE KHAN, U Penn Department of Medical Physics, JASON HAAGA, JAMES GUNTON, Lehigh Physics Department — Hydrogels are water insoluble, cross linked polymers that are capable of swelling substantially in aqueous conditions. The crosslinked nature of a hydrogel makes it strong mechanically. Hydrogels has many applications such as in drug delivery, tissue engineering, contact lenses and wound dressing. The preparation of hydrogels through molecular self-assembly gives microscopic information about the material properties. Some of the hydrogels are environmentally responsive to pH and temperature. MAX1 is a chemically synthesized responsive hydrogel which is the chain of valine and lysine aminoacids flanking a tetrapeptide VDPPT. Therefore, the general structure of MAX1 is: VKVKVKVK-VDPPTKVKVKVKV-NH2. In this poster we present preliminary Monte Carlo simulation results which shows that the structure of a single MAX1 peptide is a random coil shape. We will also present preliminary Monte Carlo simulation results for the MAX1 peptide chains in order to study the conformational variations at dimer level. In addition, we also propose a coarse-grained model that we will use to study the self-assembly of these polypeptide chains, in order to understand the formation of hydrogels.

**F1.00033** Enhanced Imaging of Dental Structure Using MRI Physics. JULIA KIM, NAYEOUN KIM, BOSUL LEE, CRG(Choice Research Group) — Magnetic Resonance Imaging is a common medical imaging technique that uses magnetism and computers to determine the anatomy and physiology of intended subjects in multiple areas. The technique is prevalently used in medical and dental diagnosis. In this paper, human tooth and jaw image data are first transmitted into a spatial frequency (k-space) domain through the Fourier Transformation and physical coordinate transformations. This study compares the resolution of an original MRI image with image data obtained using filtered data of a human tooth and jaw. The main purpose of this research is to develop a better algorithm that would enhance the quality of the final MRI image, decrease the amount of time required to produce it, and generate the image with less ringing artifact.

**F1.00034** Analysis of Alzheimer’s Disease Using Computational Neuroimaging. SOO HWAN PARK, SHEAMIN KHYEAM, HA YOUNG KYUNG, CRG(Choice Research Group) — As Alzheimer’s is becoming more common in our population, it is important to develop adequate medical technology that will help physicians better examine patients with Alzheimer’s disease. Alzheimer’s disease is a progressive neurodegenerative disorder characterized by the gradual onset of other disease such as dementia. Neuroimaging has mainly studied for the diagnosis of dementia and the causes of neurodegenerative disorders of the brain. Structural imaging based on magnetic resonance is an integral part of the clinical assessment of patients with suspected Alzheimer dementia. In this paper, MRI image of the brain affected with Alzheimer’s disease was used to determine the frequency domain, which can be used to reconstruct the image by mathematical and computational transformations. Since the frequency data of the brain with Alzheimer’s disease produced through the MRI process is in a large magnitude, not all of the data is necessary in producing the required image.
F1.00035 Reconfigurable Tunable Hyperbolic Metamaterial . THOMAS GRESOCK, BRADLEY YOST, DAVID LAHNEMAN, VÉRA SMOLYANINOVA, Towson University, IGOR SMOLYANINOV, University of Maryland — Hyperbolic metamaterials are artificially created materials that have unique properties for light transmitted in different polarization directions. For one polarization direction the material will behave as a metal, while for the other polarization direction the material behaves like a dielectric. This behavior allows hyperbolic metamaterials to manipulate light on the sub microscopic level, which has applications that range from cloaking to creating a perfect lens. We used a cobalt based ferrofluid in an applied magnetic field to attempt to recreate the effects of hyperbolic metamaterials. Ferrofluids selfassemble in nanocolumns in applied magnetic field. By measuring the polarization dependence of the light in the visible and infrared spectrum, we demonstrate that the ferrofluid exhibits hyperbolic metamaterial behavior. This study found a novel polarization property of the ferrofluid, which blocks the light polarized in one direction for a very narrow range of polarization angles. These novel properties have potential applications in efficient chemical and biological sensing. Supported by NSF Grant DMR-1104676

F1.00036 Computational studies of the boron carbide structure , SANXI YAO, Carnegie Mellon Univ — Boron carbide is a structure that exhibits a broad composition range, implying a degree of intrinsic substitutional disorder. While the observed symmetry is rhombohedral, the enthalpy minimizing structure has lower, monoclinic, symmetry. We apply compressive sensing to fit a pair interaction model to a database of structural energies. Utilizing histogram methods to analyze Monte Carlo simulations of this model, we investigate the symmetry-restoring phase transition that explains the observed rhombohedral symmetry at high temperatures.

F1.00037 Growth pattern and emergence of bulk-like structures in Aluminum Hydride (AlH$_3$) nanoclusters , GEORGIA MONTONE1, ANIL KANDALAM, WILLIAM SAWYER, West Chester University, DEPARTMENT OF PHYSICS TEAM — Complex aluminum hydrides, because of their light weight and being hydrogen-rich, have attracted considerable attention as a potential hydrogen storage materials and propellants. In this poster, we will present our computational results exploring the structural evolution and stabilities of neutral and anionic (AlH$_3$)$_n$ (n = 2-8) nanoclusters. Using density functional theory based calculations of neutral (AlH$_3$)$_n$ (n=2-8) clusters, we identified a new prototype, based on the unit cell of γ-AlH$_3$, that forms a template for the growth pattern of higher alanes, n >6. Structures containing hexa-coordinated Al atoms dominate this growth pattern. These findings contradict previous studies which predict ring or polymer-like chain structures for AlH$_3$ nanoclusters. For anionic (AlH$_3$)$_n$, clusters, the preference for structures containing hexa-coordinated Al atoms was observed for clusters n >4. The stabilities of these clusters against fragmentation will also be presented and discussed.

1Undergraduate presenter

F1.00038 The Role of Donor Acceptor Pairs (DAP) and Influence of Gallium Nitride Co-Doping on Excitation Efficiency , NATALIE HERNANDEZ, BRANDON MITCHELL, Lehigh University, YASAFUMI FUJIIWARA, Osaka University, DONGWHA LEE, Lawrence Livermore National Laboratory — Europium doped Gallium Nitride (GaN:Eu) has been identified as a candidate for the active layer in nitride-based light emitting diodes. In order to understand and improve the critical excitation energy transfer from the excited GaN host to the Eu ion, we performed an extensive study of a wide variety of GaN:Eu and GaN:Eu,Mg samples, which were grown under various growth and temperature conditions. In these studies, we focused on the different incorporation sites of the Eu ions and the role of intentionally doped and unintentional defects on the optical properties and excitation efficiencies. We found that Eu centers for which the ions is close to a donor acceptor pair exhibit the most efficient luminescence. We further discovered temperature and sample dependent structural changes of some defect complexes and studied their influence on the excitation efficiency.

F1.00039 Photon statistics of quantum dot resonance fluorescence , DISHENG CHEN, GARY LANDER, CABOT ZABRISKIE, EDWARD FLAGG, West Virginia Univ — We study the blinking behavior of a self-assembled InAs quantum dot in a planar cavity formed by AlGaAs/GaAs distributed Bragg reflectors. The quantum dot is resonantly excited through the waveguide mode of the sample while being simultaneously illuminated by a second laser with photon energy above the GaAs band gap. We characterize the fluorescence blinking behavior as a function of the above-band laser power via second-order correlation measurements and extract the local intrinsic charge density.

F1.00040 Prediction of New Crystal Structures of Bi-Sb Compounds using Minima Hopping Structural Search Method , SOBHIT SINGH, IRAIS VALENCIA-JAIME, Department of Physics and Astronomy, West Virginia University, Morgantown, WV-26506, USA, ANDRES GARCIA-CASTRO, Cinvestav-Unidad Queretaro, Queretaro-76230, Mexico, ALDO ROMERO, Department of Physics and Astronomy, West Virginia University, Morgantown, WV-26506, USA — In the last few years, semi-conducting alloy Bi$_{1-x}$Sb$_x$ has emerged as a potential candidate for topological insulators [1]. In this work, we present systematic study of the low-enthalpy phases of Bi$_{1-x}$Sb$_x$ alloys at zero pressure by using the ab-initio minima hopping structural prediction method [2]. Even though, Bi and Sb crystalize in the same 16B space group, our calculations indicate that the Bi$_{1-x}$Sb$_x$ alloys can have several other thermodynamically stable crystal structures. Additionally to the configurations on the convex hull, we also find a large number of metastable structures which are dynamically and elastically stable. Band structure calculations of the stable phases reveal the presence of strong spin-orbit interaction leading to the Rashba spin splitting of the bands which is of great interest for spintronics applications.

1J. C. Y. Teo, L. Fu and C. L. Kane; Phys. Rev. B 78, 045426 (2008)

F1.00041 Construction of a dual-filament 3D printer , M. CRAIG, G. TCHERNIATINSKY, J. OBIEFULE, R. EDELMAN, R.D. DIEHL, Pennsylvania State University — 3D printers are a new form of technology that can create 3-dimensional solid objects from a digital file. My project is to design and construct a new 3D printer that prints using two different plastics, ABS plastic and PLA plastic, in two different colors. The plastic material is heated and squeezed through the extruder of the printer and is then deposited onto a heated plate in layers to create a 3-dimensional object. My objective is to print models of C-60 molecules as a conceptual tool for our research group. To do this, the new printer will use a dual extruder that can print multicolored plastic objects. This new printer’s exterior was completely laser cut out of acrylic while the inside of the printer itself was created using our old 3D printer.
F1.00042 Bidimensional hybrid materials based graphene oxide. CYNTHIA GUERRERO-BERMA, Pennsylvania State Univ, Universidad Autonoma de Nuevo Leon, SELENE SEPELVEDA-GUZMAN, Universidad Autonoma de Nuevo Leon, RODOLFO CRUZ-SILVA, Shishu University, MAURICIO TERRONES, Pennsylvania State Univ — Two-dimensional materials (2D) have historically been studied, and the large number of unusual physical phenomena that occur when the charge and heat transport are limited to a plane. Some materials with properties dominated by two-dimensional structure are derived from carbon, transition metal chalcogenides (TMS), and other hexagonal materials, exhibiting great electronics phenomena and a high-temperature superconductivity. In this talk, we will focus on graphene and MoS2 by intercalation and chemical techniques that have been achieved, including the characterization of the resulting materials by SÉM and TEM, having good exfoliation to few-layer. The microstructure was also studied by using UV-Vis spectroscopy, FTIR spectroscopy and XRD. In order to produce hybrid functional materials besides of 2D materials with good quality, and for applications in nanoelectronic devices, a casting method was used to produce a paper based of graphene oxide and molybdenum disulfide. The resultant paper has excellent flexibility, and apparently has a good charge transport. Characterization by SEM, XRD, FTIR, and DSC were achieved.

F1.00043 Three dimensional Porous Architectures from Carbon Nanomaterials Based Hydrogels. ARCHI DASGUPTA, The Pennsylvania State University, BUNSHI FUGETSU, Hokkaido Univ, LAKSHMY-PULLICKEL RAJKUMAR, NESTOR PERERA-LOPEZ, ANA LAURA ELIAS, MAURICIO TERRONES, The Pennsylvania State University — Carbon nanotube (CNT) and graphene oxide (GO) based macroscopic solids with a light weight, high porosity and large surface area are of great importance for applications such as in energy, as electrodes in batteries, in medicine, as scaffolds for tissue regeneration and in environment for absorption and filtration materials. However, establishing 3-Dimensional interconnected Carbon nanomaterial structures with controlled porosity and functionality is still in its infancy. Here we report reproducible and inexpensive methods to obtain macroscopic 3D solids consisting of CNT and graphene oxide, with or without polymers as backbones. The hydrogels are formed by simply mixing graphene oxide dispersed in water, carbon nanotubes and polymers. The hydrogels are then subjected to freeze-drying that results in ultralight, macroporous and stable solid. The porosity of the 3D solid can be controlled by the freezing protocol. When using a thermal gradient during freezing (unidirectional freezing), homogenous pore alignment within the solid is achieved. Field emission scanning electron microscopy (FESEM) and thermogravimetric analysis (TGA) are employed for characterizing the materials. Processing of similar solids with nitrogen-doped CNTs and functionalized CNTs will also be presented.

F1.00044 Structural and Electrical Properties of Electron-doped CaMnO3 Thin Films1, ZOEY WARECKI, CACIE HART, GRACE YONG, PRAKASH SHARMA, CHRIS STUMPF, DAVID SCHAEEF, RAJESWARI KOLAGANI, Towson University, University of Maryland, College Park — Perovskite metal oxides are a class of materials that are predicted to play a big role in future electronic technologies as silicon does in today’s semiconductor based electronic technologies. Research in thin films of manganites in the past has largely been focused on the hole-doped compositions that exhibit the phenomenon of colossal magnetoresistance. We are currently investigating the properties of thin films of electron-doped calcium manganese oxide. We use the technique of pulsed laser deposition to grow these thin films. The films are grown epitaxially on LaAlO3 substrates, whose lattice parameters are larger than that of CaMnO3, thus causing the films to be under tensile stress. By decreasing the film thickness we can increase the tensile strain. We have studied structural and electrical properties of CaMnO3 films under tensile strain, by means of X-ray diffraction and temperature dependent resistivity measurements. Our results suggest that tensile strain causes CaMnO3 to be more susceptible to the formation of oxygen vacancies, thus reducing electrical resistivity.

1 NSF Grant ECCS 112856

F1.00045 Adsorption of gases on graphene1, SIDI MAIGA2, TABIA MUHAMMAD3, ALOZIE PAT-EKEJI4, Howard University, BIBIANA VALDES, Prince George Community College, SILVINA GATICA5, Howard University — We have studied the adsorption of several gases (Ar, Kr, Xe, NO) on graphene. We run Monte Carlo simulations to characterize the equilibrium properties of the monolayer film adsorbed on graphene. We were able to construct the phase diagrams of Ar and Kr showing commensurate and incommensurate 2D-solid phases. By analyzing the adsorption isotherms and structure functions of the films, we obtain the L-V, L-S and V-S coexistence lines. We also compared the Langmuir-model isotherms to the results of the Monte Carlo simulations, finding strong disagreement even at low coverage. A modified Langmuir model is proposed and tested.

1Supported by CIQM-NSF, PRDM-NSF and REU-NSF
2Department of Physics and Astronomy
3Department of Physics and Astronomy
4Department of Electrical Engineering
5Department of Physics and Astronomy

F1.00046 Mode Coupling for Primordial Nonlocal Non-Gaussianity. BEKIR BAYTAS, ARUNA KESAVAN, ELLIOT NELSON, SOHYUN PARK, SARAH SHANDERA, Institute for Gravitation and the Cosmos, The Pennsylvania State University, University Park, PA 16802, USA — The purpose of this study is to build the statistical formalism of a nonlocal functional of a Gaussian random field and to identify the relationship between non-Gaussian statistics in a large volume (the entire universe beyond our Hubble volume) and the statistics measured in a smaller subvolume (the observable universe). We set the rules and the constraints on the coefficients of the each nonlocal contribution term, which are derived under the known behavior of power spectrum and bispectrum, to generate the possible subset of cubic terms which can reproduce the quadratic terms under the long-short wavelength split. Under this split, one can write the possible coverage. A modified Langmuir model is proposed and tested.

F1.00047 When you dance, you dance with the universe. KIELAN WILCOMB1, JAMES OVERDUN, Towson University — As she spins, a dancer’s hands are acted on by non-inertial forces such as the centrifugal and Coriolis force. After briefly summarizing the standard treatment of these forces, we ask whether the dancer would still experience them if, instead, she stood still while the rest of the universe spun around her. Within Newtonian physics, the answer is no, since the dancer is in an inertial frame. Within Einstein’s general relativity, however, theoretical calculations show that a rotating mass distribution of cosmological dimensions pulls the inertial frame of an observer around with it, by a process known as frame dragging. The existence of frame dragging has recently been experimentally confirmed using gyroscopes in orbit around the spinning Earth. If the extrapolation to cosmology is valid, as we argue here, then a dancer experiences the same forces, whether or not she spins clockwise or the universe spins counter-clockwise around her. Her arms are, in a real sense, pulled out and around by the stars. The facts we present are not new, but they imply a radical reinterpretation of non-inertial motion on the conceptual level, one that we argue deserves to be brought into the standard undergraduate physics curriculum.

1Undergraduate student
F1.00048 Higher moments of primordial non-Gaussianity and constraints from X-ray clusters, SAROJ ADHIKARI, SARAH SHANDERA, Institute for Gravitation and the Cosmos, The Pennsylvania State University, University Park, PA, USA, NEAL DALAL, Department of Astronomy, University of Illinois, 1002 W. Green St., Urbana, IL, USA — We perform cosmological N-body simulations of dark matter structure formation using non-Gaussian initial conditions, with two different scaling of higher order moments (skewness, kurtosis etc). The scalings determine the relative strength of the total non-Gaussianity for a given value of skewness. We show that a current analytic prescription to compute the non-Gaussian mass function (number density of dark matter halos as a function of the halo mass) can describe the simulation results, after some calibration, in a useful parameter space when the strength of non-Gaussianity is small. We use our simulation results to produce semi-analytic fitting functions for the non-Gaussian mass function relative to the Gaussian mass function. These mass function results have already been used to generate constraints on the primordial non-Gaussianity parameter $f_{NL}$ using X-ray cluster measurements. The constraints are consistent with Gaussian initial conditions, and demonstrate the potential of cluster mass function in constraining primordial non-Gaussianity.

F1.00049 Non-Gaussianities from Long Wavelength Modes, ANNE-SYLVIE DEUTSCH, BÉATRICE BONGA, SUDDHASATTWA BRAHMA, SARAH SHANDERA, Penn State University — We consider a two field model; a light inflaton $\phi$ coupled to a heavy field in the hidden sector $\sigma$ which has a cubic self-interaction. At low energies, the heavy field can be integrated out to get an effective description of the theory. With this effective Lagrangian, we derive correlation functions such as the powerspectrum and the bispectrum to look at non-Gaussianities. However, we only have access to a portion of the universe, and some very long wavelength modes ($\lambda > H$, nearly constant across our Hubble volume) can be unobservable to us, but still affect the correlation functions and generate non-Gaussianities in CMB data. We therefore derive the adjusted form for the observed correlation functions. It allows us to study with more accuracy the origin of the non-Gaussianities. This may have direct implications for renormalisation in cosmology, and affect the constraints that the detection of non-Gaussianities can have on inflation models.

F1.00050 Mining the Sky for Very High Energy Gamma Rays, HARRIS BERNSTEIN, JOHN PRETZ, MIGUEL MOSTAFA, Pennsylvania State Univ — Gamma rays with energies above 100 GeV are detected by the High Altitude Water Cherenkov (HAWC) Observatory. The HAWC Observatory is an array of 300 water Cherenkov detectors. Each detector has four photomultiplier tubes (PMTs) that are used to pinpoint the incoming directions of large air showers originating from the interaction of gamma rays with the Earth’s atmosphere. We analyze the impact of parameters that affect the reconstruction of the arrival directions. We vary the calibration parameters and the number of the PMTs used in the reconstruction. We also examine the impact of timing and signal noise. Results show that large changes to the calibrations do not impact significantly the distribution of arrival directions, while changes in the reconstruction parameters may inhibit our ability to identify point sources of very high energy gamma rays. We discuss the results in detail and their implications for further research.

F1.00051 Neutron detection using far ultraviolet radiation from noble-gas excimers, JACOB C. MCCOMB, TASC, Inc., ERIC MILLER, CHRISTOPHER M. LAVELLE, Johns Hopkins University Applied Physics Laboratory, ALAN K. THOMPSON, National Institute of Standards and Technology, MICHAEL A. COPLAN, University of Maryland, ROBERT E. VEST, National Institute of Standards and Technology, MOHAMAD I. AL-SHEIKHLY, University of Maryland, CHARLES W. CLARK, Joint Quantum Institute, NEUTRON OBSERVATORY COLLABORATION — When triggered in a noble gas medium at atmospheric pressure, neutron-absorption reactions such as $^4$He($n, p\gamma$) [1] and $^{13}$B($n, a\alpha$)Li [2] can generate tens of thousands of far ultraviolet photons per neutron absorbed. In some cases, up to 30% of the $\sim$ MeV nuclear reaction energy is channeled into far ultraviolet emission. The far ultraviolet photons are produced by noble-gas excimer radiation, to which the noble gas medium is transparent, facilitating efficient optical detection. We report progress in the development of the Neutron Observatory, an absolute neutron detector stationed at the fundamental physics beamline at the NIST Center for Neutron Research. Our reaction initiators consist of arrays of thin films of $^{13}$B [2] and boron-coated vitreous carbon foams [3].


F1.00052 Investigation of Voltage Configuration and Radial Dependence of Transmission Curves in PTOLEMY, HADAR LAZAR, J. SUERFU, C. GENTILE, C. TULLY, None — Princeton Tritium Observatory for Light, Early- Universe, Massive-Neutrino Yrsted (PTOLEMY) aims to directly detect relic neutrinos. This is achieved by measuring the energies of electrons produced from neutrino capture by tritium, which would lie just above the endpoint of tritium beta decay. The Magnetic Adiabatic Collimation combined with an Electrostatic filter (MAC-E filter) is a spectrometer that allows for the transmission and detection of these high-energy signal electrons while filtering the background beta electrons. Characterizing the process by which the MAC-E filter utilizes electric and magnetic fields helps determine the desired properties of the filter’s configuration. The electric field is generated by nine electrode rings of adjustable voltages. A mathematical method incorporating the superposition principle is used as a guide to estimate the voltages that achieve the most favorable transmission curve. Once these values are determined, the different cut-off potentials of electrons due to magnetic field expansion are calculated. By manipulating the voltages on the electron source, the transmission curve for different source radii can be aligned. This overall process approaches the accuracy that the MAC-E filter demands in order to limit the flux of electrons on the calorimeter to those with energies that could indicate a relic neutrino signal.

1Thank you to the Princeton Plasma Physics Laboratory (PPPL) for giving me this opportunity through the Science Undergraduate Laboratory Internships (SULI). Thank you to the DOE for funding it.

F1.00053 Searching for $D^0 \rightarrow K^- \pi^+ \pi^0$ in Belle Data, YASIEL CABRERA, DAVID CINABRO, SUDESHNA GANGULY, Wayne State University, BELLE I COLLABORATION — We describe the reconstruction of the CP- decay mode $D^0 \rightarrow K^- \pi^+ \pi^0$ in the Belle I data set. Using a set of simulated signal and a generic simulated sample equal in size to the Belle I data set, we reconstructed 826 events from an initial sample of 18,900 simulated events for an efficiency of 4.4%. We studied backgrounds in the generic simulated sample, and checked in the real data. We found, in agreement with the simulations, no obvious signal in the Belle I data indicating that further work has to go into suppressing the background.

1National Student Foundation
2at KEKB
F1.00054 Optimization of Preliminary Data Analysis for PINGU

DARIA PANKOVA, Pennsylvania State University, ICECUBE-PINGU COLLABORATION — The IceCube Neutrino Observatory (INO), a 1 km$^3$-sized detector at the South Pole, collects Cherenkov light from neutrino interactions in the ice. The light is detected by Photomultiplier tubes (PMT), which are contained inside the Digital Optical Modules (DOM) along with an FPGA board with an ARM CPU meant to process and analyze the incoming signal. The analysis includes the Waveform detector, which uses a Non-Negative Least Squares algorithm to unfold the signal into a series of separate pulses. The Precision IceCube Next Generation Upgrade (PINGU) is proposed low energy infill extension to the INO, which will require the deployment of many additional DOMs. The new DOMs can be optimized by running a routine like Waveform on the FPGA fabric on the TPU. Because the output of Waveform is much more compact than the original waveforms, the amount of data transmitted from the DOM would be greatly reduced. As it is, Waveform is a complicated procedure that depends on several libraries and requires a lot of processor power to run. It needs to be optimized or substituted by a faster algorithm. The performance of other algorithms for identification of photoelectron pulses (SPE) is evaluated and the received parameters of SPE pulses are compared to those by Waveform.

F1.00055 Characterizing Hardware Requirements for the Digital Optical Modules of PINGU, Using Current Experience from IceCube

FEIFEI HUANG, Department of Physics, The Pennsylvania State University, ICECUBE-PINGU COLLABORATION — The Precision IceCube Next Generation Upgrade (PINGU) is proposed low energy extension to the IceCube Neutrino Observatory, with the primary scientific goal of determining the neutrino mass hierarchy. Neutrinos interacting in the ice will produce secondary charged particles which emit Cherenkov radiation, which is then detected by photomultiplier tubes within the Digital Optical Modules (DOMs) of IceCube. We will present results of our investigations related to the redesign of the IceCube DOMs for deployment in PINGU. First, we investigated the dynamic range of the DOMs by characterizing the signal in the current IceCube data. Second, we studied the impact of two hardware design parameters, the DOM-to-DOM timing difference and the ADC sampling rate, on zenith and neutrino energy resolutions. Thirdly, we investigated the optimal DOM buffer length for PINGU by using the most energetic IceCube neutrino events. These studies will also be used in re-designing the DOMs for the high energy extension of IceCube which has the goal of improving the understanding of the recently discovered astrophysical neutrinos.

F1.00056 A Quality-of-Fit Indicator for Reconstructions of Neutrino Interactions in the IceCube-PINGU Detector

JUSTIN LANFRANCHI, Department of Physics, The Pennsylvania State University — PINGU, a proposed low-energy infill of the IceCube detector, will trigger due to hundreds of thousands of atmospheric neutrinos per year with energies above 3 GeV. PINGU will consist of an array of digital optical modules (DOMs) that detect Cherenkov radiation from charged secondaries due to neutrino interactions in the ice beneath the South Pole. PINGU’s primary scientific goal of resolving the neutrino mass hierarchy (NMH) relies upon accurately reconstructing neutrino-nucleon interactions (events) from data recorded by the DOMs. We reconstruct events using a method which seeks to determine the event vertex, energy, and direction by finding the best points that are most likely to have produced the DOMs’ data. This usually performs well, as assessed using simulated events to verify that reconstructed vertices, energies, and directions are close to their true values. However, there remain inaccurately-reconstructed events that degrade our ability to resolve NMH. We expect our sensitivity to NMH will improve by introducing a quality-of-fit (QoF) indicator, currently under development, that correlates with the accuracy of reconstructions using information from the event’s data, MultiNest’s fitting process, and the reconstructed parameters. We will present the development status of the QoF indicator in our poster.

F1.00057 Reduction of Radiation Damage in Lead-Glass by Thermal Annealing

FERNANDO TORALE - ACOSTA, State Univ. of NY - Stony Brook, BOGDAN WOJTEK HOSKIOWSKI, Thomas Jefferson National Accelerator Facility — The elastic electric field factor (GEF) experiment at Jefferson Lab aims to measure properties that directly relate to the charge and current distributions of the proton. Electrons from the experiment are detected by an electromagnetic (EM) calorimeter based on lead-glass blocks (ECal). Due to its density and transparency, lead-glass is a good material to be used calorimeters. The material, however, suffers from radiation damage and a loss of transparency during operation. The transparency can be recovered through thermal annealing, but the timescale and affect of temperature on the annealing process in lead-glass need further investigation before implementation in future ECal experiments. A transparency measurement was conducted by shining a low power laser through a block of damaged lead-glass as the block is heated and its transmission monitored. Additionally, blocks of lead-glass were placed in an oven as temperature-time profiles as well as the reduction factor of radiation damage and a loss of transparency during operation. The transparency can be recovered through thermal annealing, but the timescale and affect of temperature on the annealing process in lead-glass need further investigation before implementation in future ECal experiments. A transparency measurement was conducted by shining a low power laser through a block of damaged lead-glass as the block is heated and its transmission monitored. Additionally, blocks of lead-glass were placed in an oven as temperature-time profiles as well as the reduction factor of damage were recorded. From these temperature profiles, we were able to obtain an expression for the characteristic annealing time as a function of temperature modeled after the electrical conductivity of glass.

F1.00058 Tourist or Traveler: Student Attitudes Toward the Study of Physics - A Survey of High School Physics Students and its Implications in the Classroom

A. TABOR-MORRIS, T. BRILES, H. NOLAN, Georgian Court University — When students take physics in high school they do so for a variety of reasons, including, in some cases, its usefulness toward their future career goals. Students may engage in different learning strategies toward physics problem solving, for example, desiring step-by-step directions or committing to creating a mental map. Physics education research in the past indicates that the creation of a mental map can generate a sense of learning stability for students studying physics, especially due to the complexity of this learning and its use of multiple intellectual abilities including verbal, graphical, pictorial and mathematical skills. Yet not all students appear to feel compelled to use mental mapping. An analogy is made here that indicates that some students appear to take on attitudes more aligned with visiting tourist observers, while others seem to want to “go native” or even “move in.” A survey of 133 high school physics students was taken which included both students who indicated taking physics because of an interest in future science careers and those who did not. Results of these groups are compared and possible implications in the physics classroom are suggested.

F1.00059 Comparison among Three Charge Models for Dust Grain Transport in an Abrupt Inhomogeneity

JEFFREY WALKER, No Company Provided, MARK KOEPKE, West Virginia University, MICHAEL ZIMMERMAN, Johns Hopkins University, WILLIAM FARRELL, NASA, VLADIMIR DEMIDOV, West Virginia University, Air Force Research Laboratory — The trajectory of a dust grain, radius $a$, is modeled semi-analytically for an abrupt inhomogeneity, and it is shown that the guiding center drift is sensitive to grain charging rate. For an abrupt inhomogeneity, two neighboring regions are characterized by two respective sets of plasma parameters and corresponding in-situ equilibrium charge states. The grain charges or discharges with each gyro-excitation between regions at a characteristic charging time $t_{ch}$. We assess grain transport due to guiding center drift for the Orbit Motion Limited, Patacchini-Hutchinson electron current, and Gatti-Kortshagen ion current charging models for a given set of plasma parameters. The three models yield different guiding center drift magnitudes, demonstrating that charge models can be in principle be discriminated under certain conditions. Neutral drag force, or Epstein drag, is included in our model, and it is assumed that the perpendicular dust grain velocity is small with respect to the thermal speed of neutrals. The application of these theoretical results to dust confinement and model validation in the Auburn Magnetized Dusty Plasma Experiment is assessed through theory and simulation.
**F1.00060 Development of the Spacecraft Environmental Anomalies Expert System (SEAES) at NASA**, DHANESH KRISHNARAO, American University & NASA Goddard Space Flight Center, YIHUA ZHENG, MARLO MADDOX, NASA Goddard Space Flight Center, TYLER SCHIEWE, Linfield College & NASA Goddard Space Flight Center. We develop and implement a post-anomaly analysis and monitoring tool for NASA satellite operators to understand causes for specific spacecraft anomalies and specify thresholds for future watches and warnings. A hazard quotient showing the ratio of instantaneous to mission averaged likelihood of an anomaly is available for four space weather hazards at geosynchronous orbit (GEO): surface charging, internal charging, single-event effects (SEE) from solar energetic particle events (SEP), and total dose to solar arrays. We use the algorithms and rules developed by Ó'Brien (2009) as a guideline and make modifications to improve accuracy and account for more recent satellite data. In conjunction with the Community Coordinated Modeling Center (CCMC) at NASA Goddard Space Flight Center (GSFC), we will provide hazard quotients in the Space Environment Automated Alerts & Anomaly Analysis Assistant (SEA^5), a comprehensive analysis and dissemination system currently under development. In the future, we plan to expand the system to other orbits such as those in Low Earth Orbit (LEO), Middle Earth Orbit (MOE), High Earth Orbit (HEO) and those in the interplanetary space.

**F1.00061 Analysis of Ion Temperatures During a Geomagnetic Storm**, TESSA MAYNARD, AMY KEESEE, West Virginia University — The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite was launched in the Earth’s magnetosphere in 2000 with the Medium Energy Neutral Atom (MENA) instrument attached. MENA is an energetic neutral atom (ENA) imager. ENA data can be used to determine ion energy spectra from which a temperature can be calculated. By doing such, images of ion temperature can be produced with spatial and temporal resolution. The data and images collected by MENA during geomagnetic storms are being analyzed. The data analysis will result in graphs mapping the ion temperature in relation to time and position. This will improve our understanding of ion heating during storms. Geomagnetic storms can be powerful and dangerous, knocking out power grids and satellites. Looking at the storm data will give us a better understanding of the dynamic relationship between the Earth’s magnetosphere and the geomagnetic storms.

**F1.00062 Algebraic Geometry of Tree Tensor Network States**, SHAHRZAD JAMSHIDI, JASON MORTON, Pennsylvania State Univ — Tree tensor networks have been used to model the ground states of Hamiltonians in condensed matter physics and quantum chemistry. Exactly which quantum states can be represented by a tree tensor network with a given topology and given restrictions on the parameter tensors? When the restrictions are algebraic, the set of states is a projective algebraic variety. We describe those varieties, using techniques originally developed for phylogenetics.

**F1.00063 Prediction and Mechanical Characterization of the Al-P compounds by ab-initio Minima Hopping**, O. PALVIC, I. VALENCIA-JAIME, West Virginia University, A.C. GARCIA-CASTRO, CINVESTAV-Queretaro, A.H. ROMERO, West Virginia University — The III-V group compound semiconductors, including GaAs and InP, have led to large technological advances [1]. Of these, AlP has the largest direct band gap (3.56 eV) and is arguably the least understood [2]. Here, we present a study of the AlP phase-diagram by means of first principle minima hopping calculations [3]. We were able to reproduce the previously obtained structure for AlP (cubic, F-43m). Also reported here are a large number of metastable structures and the mechanical properties as a function of the P content. We discuss alternative path for synthesis to stabilize metastable structures. Our results are relevant also for ternary alloys such as AlInP, AlAsP, and AlIPs. Such compounds have applications in quantum wells [4], solar cells [5], and optical equipment [6]. Our research is the initial step for the ternary characterization.


**F1.00064 An off axis OH center in ZnO studied by IR spectroscopy**, PHILIP WEISER, ELLEN FARMER, MICHAEL STAVOLA, W. BEALL FOWLER, Lehigh University — Experiments on H in ZnO have revealed several donor species. Two major H vibrational modes were found at 3326 and 3611 cm⁻¹ and assigned to H donors. The IR line at 3611 cm⁻¹ has been associated with an isolated H donor in a bond-centered configuration. The line at 3326 cm⁻¹ has been suggested to be due to H in an antibonding configuration in the vicinity of another defect (a Ca impurity is one such possibility). The band at 3326 cm⁻¹ has a distinctive dependence on temperature. At low temperature, the 3326 cm⁻¹ band appears to consist of three overlapping components. As the temperature is increased, the relative intensities of the components change and additional sidebands appear. This behavior is reminiscent of our previous findings for an OD-Li center in MgO. In this case, the D atom was found to be displaced off axis and added a hindered-rotation structure to the O-D vibrational band. IR absorption experiments and theory are being used to investigate the possible off-axis motion of the 3326 cm⁻¹ center in ZnO.

**F1.00065 Development and Characterization of Dynamic Light Scattering Instrumentation to Determine Nanoparticle Size**, T.J. SEBASTIAN, J. HARDING, T. VOLPE, J.R. SIMPSON, M. SCHULZE, S.M. LEV, Towson Univ — Dynamic Light Scattering (DLS) provides a high-throughput and accurate measurement of particle sizes for monodisperse (MD) spherical nanoparticles (NPs). We report on the development and characterization of homebuilt DLS instrumentation to measure the size of MD NPs of gold, polystyrene, and ZnO. HeNe and Argon-ion laser comprise the excitation sources for the scattering experiment. We have evaluated an avalanche photo-diode detector for the acquisition of scattered light. Time averaging and time-autocorrelation electronic signal detection and analysis provides a measure of the translation diffusion coefficient, which for MD and spherical particles allows for the determination of the NP radius. We have tested our apparatus using commercially-produced gold NPs in the range of 10 nm to 200 nm and synthesized ZnO NPs. DLS measurements were compared to those obtained by Atomic Force Microscopy (AFM). After size characterization, the ZnO NPs will be employed in ongoing toxicity studies.

¹T.f.S and J.H. acknowledge support from Towson University. J.R.S., M.S., and S.M.L. acknowledge support from NSF - CBET #1236083.
F1.00066 OH centers and the conductivity of hydrogen-doped In$_2$O$_3$ single crystals$^1$

WEIKAI YIN, KIRBY SMITHE, PHILIP WEISER, MICHAEL STAVOLA, BEALL FOWLER, Lehigh University, LYNN BOATNER COLLABORATION — Methods for the n-type conductivity of In$_2$O$_3$ have been controversial. Recent experiments suggest that O vacancies are the cause of conductivity$^2$. However, other recent experiments find that the H-doping of thin films gives rise to shallow donors$^3$. Theory also finds that interstitial H and H at an O vacancy are shallow donors in In$_2$O$_3$. We have performed a series of IR absorption experiments to determine the properties of OH and OD centers in In$_2$O$_3$ single crystals. Annealing In$_2$O$_3$ samples in H$_2$ or D$_2$ at temperatures near 450°C (30 min) produces an n-type layer $\approx$0.05 mm thick with an n-type doping of 2x10$^{19}$ cm$^{-3}$. The resulting free-carrier absorption is correlated with an OH center with a vibrational frequency of 3306 cm$^{-1}$ that we associate with interstitial H$_3$.  

$^1$Supported by NSF Grant DMR-1160756.

F1.00067 Osmotic Pressure of E.coli in Suspension , WENXIN HUANG, Lehigh University — The non-equilibrium statistical mechanics of active particles have raised considerable interest over the recent years. Here, we investigate the thermodynamic properties (i.e. osmotic pressure and effective temperature) by dielectrophoresis (DEP) and the single particle behaviors by tracking E. coli’s movements (i.e. mean-square-displacement and diffusivity) in order to characterize the motion activities of E. coli.

F1.00068 Density of Surface States in the Region of the Energy Gap for a-Si/Ge Using a Two Parameter Hamiltonian, ELIEZER RICHMOND, Retired — To rigorously investigate the contribution of surfaces to the density of electronic states of a-Si/Ge and the effect of the topology on the density of surface states (DOSS), a surface for amorphous homopolar tetrahedral solids has been defined$^4$. The effects on the DOSS in the region of the energy gap are investigated using a two parameter Hamiltonian. We address the effects of ring structure, nearest neighbor dangling bonds, multiple dangling bonds per surface atom, and back bonds on the DOSS. In particular, the results here predict a shift of 0.12 eV of the bulk p-like peak at the top of the valence band to higher energies due to the DOSS. Additionally, surface contributions in the lower portion of the conduction band (CB) give rise to a hump in the lower portion of the CB density of states. Lastly, a gap state is found 0.6 eV below the CB edge. These conclusions will be compared to experimental results and are found to be in surprisingly good agreement.

$^4$http://www.tandfonline.com/eprint/dZXIzBKDCsZVENFurTZs/full

F1.00069 Infrared absorption studies of OH centers in the metal-insulator-transition oxide VO$_2$. YING QIN, WEIKAI YIN, MICHAEL STAVOLA, W. BEALL FOWLER, Lehigh University, LYNN BOATNER, Oak Ridge National Laboratory — VO$_2$ is an unusual solid-state material that undergoes a metal-insulator transition at approximately 68 °C that accompanies a structural transition from monoclinic to rutile. The introduction of hydrogen into VO$_2$ has been found to suppress the monoclinic insulating phase, providing a means to tune the metal-insulator-transition temperature. Single crystals of VO$_2$ have been grown recently at the Oak Ridge National Laboratory. We have introduced hydrogen and deuterium into VO$_2$ single crystals for study by low temperature IR spectroscopy. OH and OD vibrational lines (4.2K) have been found at 3289 and 2446 cm$^{-1}$ that provide information about the structure of the OH (and OD) center in VO$_2$. The vibrational frequencies are similar to those found for OH and OD modes in other oxides with the rutile structure, for example SnO$_2$ and TiO$_2$. The frequency ratio, $r = \omega_H/\omega_D$, is $r = 1.345$, consistent with H (and D) being bonded to a light element like oxygen. Furthermore, our experiments determine the polarization of the OH vibrational mode and the thermal stability of H centers in VO$_2$. Supported by NSF Grant DMR-1160756.

F1.00070 Rotational Dynamics in Ionic Liquids, CHRIS RUMBLE, MARK MARONCELLI, PSU — Our group has been investigating rotational dynamics of small molecule solutes in ionic liquids (ILs), a class of salts which are molten below 100 °C using experimental methods and molecular dynamics (MD) simulations. The strong self-association between IL molecules due to Coulombic attractions results in slow dynamics and structural heterogeneity, which reveal themselves in rotations through large angle jump motion, distributed dynamics, and deviations from predictions made using hydrodynamic theory. To explore the effects of solute size and charge distribution on rotations in ILs, we have performed fluorescence anisotropy and NMR T1 relaxation experiments on a series of charged and uncharged solutes of differing sizes in an IL and 1-propanol, as a comparison to a simple glass forming liquid. In conjunction, MD simulations of each solute were performed using our group’s coarse-grained IL model to model the dynamics we observe in experiment. The poster will include a discussion of our experimental and simulation results with comparison to hydrodynamic predictions and comments on the similarity of rotational dynamics in ILs and other systems such as glasses and polymer melts.

F1.00071 Lithium-Silicon crystal structure prediction by minima hopping method, I. VALENCIA-JAIME, West Virginia University, R. SARMIENTO-PÉREZ, S. BOTTI, M.A.L. MARQUES, Institut Lumiere Matiere, A.H. ROMERO, West Virginia University — A thoroughput structural prediction of the lowest energy configurations for Li-Si alloys is presented by means of the Minima Hopping Method [1]. A convex hull is reported and compared with previous calculations and experimental structures. Unit cells with at most sixteen atoms were considered. In particular, we have found eight crystal structures lying on the convex hull. We reproduce the Li$_5$Si$_2$ (R-3m), as foreseen in previous theoretical calculations [2]. Additionally, we predict the thermal and elastic stability of Li$_5$Si$_2$ (C12/m1), Li$_2$Si (C12/m1), Li$_9$Si$_4$ (C12/m1), Li$_3$Si (P12/m1), Li$_7$Si$_2$ (P-3m1), Li$_4$Si (I4/m), Li$_5$Si (P-3m1) and Li$_6$Si (R-3m), structures that have not been previously reported. The potential-composition curve based on those structures is also calculated and compared with previous calculations and experimental measurements.

showed that binary mixtures of actively rotating particles phase separate by spinodal decomposition. Other more exotic types of behaviors such as clustering and swarming depending on the nature of local energy input and the interactions between individual units. e.g. unknown.

robust against strong disorders. The conductance of the nanotube can be characterized by Mott's variable range hopping model in a wide temperature range, indicating the system for Physical Sciences at Microscale, Department of Physics, The Pennsylvania State University, SHIH-YING YU, Department of Materials Science and Engineering, the Pennsylvania State University, JIAN WANG, International Center for Quantum Materials, Peking University, XIAOGUANG LI, Hefei National Laboratory for Physical Sciences at Microscale, Department of Electrical Engineering, The Pennsylvania State University, DUKSOO KIM, Department of Electrical Engineering, the Pennsylvania State University, SUZANNE MOHNEY, Department of Materials Science and Engineering, the Pennsylvania State University, SRIRAM TANDAPARAM, Department of Electrical Engineering, The Pennsylvania State University, NITIN SAMARTH, CHAOXING LIU, JAINENDRA JAIN, MOSES CHAN, QI LI, Department of Physics, The Pennsylvania State University — Topological insulator Bi$_2$Te$_3$ nanotubes have been synthesized and their magnetotransport properties have been studied on single nanotubes. The conductance of the nanotube can be characterized by Mott's variable range hopping model in a wide temperature range, indicating the system is in a strong disorder regime. Magnetoresistance oscillations with h/ε period from the nanotube outer surface were observed, suggesting the presence of surface states due to anomalous Aharonov-Bohm effect. The results show for the first time that the topological surface states are robust against strong disorders.

Lithographic Test Structures — ERIN WOOD, ANGELA HIGHT-WALKER, National Institute of Standards and Technology — Tip-enhanced Raman spectroscopy promises unprecedented spatial resolution and selectivity; however this burgeoning technique is not yet truly robust. Tip size, shape and composition as well as variations in instrumental setup may cause deviation in the resultant spectra, even in the same sample. In order to account for these problems and enable comparability between different instruments, we propose to use a 3-D lithographically-printed, strained silicon standard which will act as both a calibration as well as a benchmark test for instrument robustness. This proposed test structure also will allow for further development and enhancement quantification of TERS instrumentation. Current progress on TERS mapping of the 3-D sample allows us to resolve individual SiGe@Si lines with widths of 32 nm. We also present methodology to allow on TERS mapping of the 3-D sample allows us to resolve individual SiGe@Si lines with widths of 32 nm. We also present methodology to allow for robust TERS-active probes using gold as the plasmonic enhancing materials.

Oxygen-deficient perovskites, in particular, have attracted interest for use in fuel cells and related applications due to high oxygen mobility. We have studied oxygen-deficient perovskites based on SrFeO$_x$ using x-ray diffraction and Mossbauer spectroscopy. While SrFeO$_x$ exhibits cubic Pm-3m symmetry, CaFeO$_x$ has a more distorted structure (orthorhombic Pnma), with gradual reduction in lattice symmetry in doped (Sr,Ca) intermediaries. SrFeO$_x$ exhibits magnetic order below 50K, while CaFeO$_x$ is ordered (with a possible paramagnetic volume fraction) at 300K. Oxygen contents x of the air-annealed samples ranged from 2.3 to 2.65; interestingly, synthesis under 1 atm of flowing O$_2$ did result in a significant change in oxygen content. Somewhat different behavior is observed for the B-site doped series Sr(Fe,Co)O$_x$. In this case, cubic symmetry is maintained down to 10% Fe composition, with a sudden reduction thereafter. While the structure of air-annealed SrCoO$_x$ is consistent with orthorhombic symmetry, it is not consistent with previously reported results; the reason for this discrepancy remains unknown.

We acknowledge support from the Villanova University Department of Physics, and the Villanova Undergraduate Research Fellowship program.

**F1.00073 Anomalous Aharonov-Bohm Oscillations in Bi$_2$Te$_3$ Nanotubes with disorders** — RENZHONG DU, YUEWEI YIN, Department of Physics, The Pennsylvania State University, SINING DONG, Hefei National Laboratory for Physical Sciences at Microscale, Department of Physics, University of Science and Technology of China, WENQING DAI, WEIWEI ZHAO, Department of Physics, The Pennsylvania State University, DUKSOO KIM, Department of Electrical Engineering, The Pennsylvania State University, SHIH-YING YU, Department of Materials Science and Engineering, the Pennsylvania State University, JIAN WANG, International Center for Quantum Materials, Peking University, XIAOGUANG LI, Hefei National Laboratory for Physical Sciences at Microscale, Department of Electrical Engineering, The Pennsylvania State University, SUZANNE MOHNEY, Department of Materials Science and Engineering, the Pennsylvania State University, SRIRAM TANDAPARAM, Department of Electrical Engineering, The Pennsylvania State University, NITIN SAMARTH, CHAOXING LIU, JAINENDRA JAIN, MOSES CHAN, QI LI, Department of Physics, The Pennsylvania State University — Topological insulator Bi$_2$Te$_3$ nanotubes have been synthesized and their magnetotransport properties have been studied on single nanotubes. The conductance of the nanotube can be characterized by Mott’s variable range hopping model in a wide temperature range, indicating the system is in a strong disorder regime. Magnetoresistance oscillations with h/ε period from the nanotube outer surface were observed, suggesting the presence of surface states due to anomalous Aharonov-Bohm effect. The results show for the first time that the topological surface states are robust against strong disorders.

**F1.00074 Enabling Comparability in Back-Scattered TERS instrumentation via Lithographic Test Structures** — ERIN WOOD, ANGELA HIGHT-WALKER, National Institute of Standards and Technology — Tip-enhanced Raman spectroscopy promises unprecedented spatial resolution and selectivity; however this burgeoning technique is not yet truly robust. Tip size, shape and composition as well as variations in instrumental setup may cause deviation in the resultant spectra, even in the same sample. In order to account for these problems and enable comparability between different instruments, we propose to use a 3-D lithographically-printed, strained silicon standard which will act as both a calibration as well as a benchmark test for instrument robustness. This proposed test structure also will allow for further development and enhancement quantification of TERS instrumentation. Current progress on TERS mapping of the 3-D sample allows us to resolve individual SiGe@Si lines with widths of 32 nm. We also present methodology to allow for robust TERS-active probes using gold as the plasmonic enhancing materials.

**F1.00075 Determination of Colloidal Osmotic Equation of State by Dielectrophoresis** — JACOB MAZZA, HAO HUANG, H. DANIEL OU-YANG, Lehigh University — Osmotic equation of state [P(N,T)] of a colloidal suspension, where P is the osmotic pressure, N the particle number density and T the absolute temperature, describes both the mechanical properties and phase behavior of a colloidal suspension or scattering approaches to determine [P(N,T)]. We propose a new approach by dielectrophoresis (DEP). Spatial distributions of the density of fluorescent nanoparticles in a DEP field – imaged by confocal microscopy – can be used to determine the DEP force field at low particle concentration, at which the inter-particle interactions are negligible. Using the known force field and Einstein’s osmotic equilibrium equation, we calculate P(N,T) from the particle density profiles of interacting, charge-stabilized polystyrene latex particles under different salt concentrations.

**F1.00076 Coarsening Dynamics of Actively Rotating Binary Liquids** — SYEDA SABRINA, KYLE J.M. BISHOP, Penn State University — Active matter comprised of many self-driven units (e.g. colloidal swimmers) exhibit emergent behaviors such as clustering and swarming depending on the nature of local energy input and the interactions between individual units. A recent study showed that binary mixtures of actively rotating particles phase separate by spinodal decomposition. Other more exotic types of coarsening dynamics are anticipated in this nonequilibrium system. Here we develop a continuum model of phase separation in actively rotating binary liquids and investigate the role of active rotation, frictional damping and viscous coupling on the system’s macroscopic dynamics. The model combines the convective Cahn-Hilliard equation and the Stokes equation with active rotation governing local composition and velocity field respectively. Besides reproducing previous results under weak rotation ($Pe < 1$), our model predicts a rich phase behavior of the system in different dynamical regimes such as drag dominant ($\beta \gg 1$) and viscous hydrodynamic ($\beta \ll 1$) regimes. Numerical results along with scaling arguments elucidate diverse behaviors under both weak and strong rotation ($Pe > 1$) as well as emergence of active doublet.

**F1.00077 New results from experimental studies of single-crystal quantum structures of spin-triplet superconductor Sr$_2$RuO$_4$** — XINXIN CAI, BRAIN ZAKRZEWSKI, SHAUN MILLS, YIQUN YING, Pennsylvania State Univ, ZONGLI WANG, Zhejiang Univ, LIBIN WEN, SHUN WANG, Shanghai Jiao Tong Univ, DAVID FOBES, TIJIANG LIU, ZHIQIANG MAO, Tulane Univ, YING LIU, Pennsylvania State Univ — Sr$_2$RuO$_4$, the only layered perovskite that becomes superconducting without the presence of Cu, was predicted to be an odd-parity, spin-triplet (possibly chiral p-wave) superconductor shortly after the discovery of its superconductivity. This prediction was supported by intensive work in the past two decades. Our experimental studies of Sr$_2$RuO$_4$ aim at detecting novel topological objects predicted for this superconducting material, including chiral edge currents, domains and domain walls, half-quantum vortices, and others. We established a process to prepare single-crystal quantum structures of Sr$_2$RuO$_4$ starting from mechanically exfoliated thin flakes. We identified Ru-free flakes of Sr$_2$RuO$_4$ showing enhanced superconductivity and demonstrated the link between the local enhancement of $T_c$ and the presence of edge dislocations due to symmetry lowering. We fabricated mesoscopic superconducting rings of Sr$_2$RuO$_4$ and carried out Little-Parks resistance oscillation measurements, finding anomalously large resistance oscillations of full-flux period. With the application of an in-plane field and a large measurement current, the emergence of a second set of resistance oscillations was observed showing enhanced superconductivity and demonstrated the link between the state of flux-locked L-P resistance oscillations. Further experimental issues need to be clarified before the half-flux L-P resistance oscillations are fully established.
F1.00078 First-principles study of monolayer and bilayer TaSe$_2$\textsuperscript{1}, MACK ADRIAN DELA CRUZ, JIA-AN YAN, Department of Physics, Astronomy and Geosciences, Towson University — Two-dimensional atomic crystals of transition metal dichalcogenides (such as Mo$_2$S$_2$, TaSe$_2$, etc.) are currently attracting growing attention due to the broad variety of electronic properties presented in these systems. Here we present a first-principles study of the structural, electronic and vibrational properties of monolayer and bilayer TaSe$_2$, which is a charge-density wave material in the bulk form. The structure of monolayer TaSe$_2$ is determined by performing a series of total energy calculations. For bilayer TaSe$_2$, various stackings of monolayer TaSe$_2$ with the hexagonal (2H) and the trigonal (1T) phases, will be considered. Calculated electronic and phonon properties of the energetically favorable states will be compared with the available experimental data.

\textsuperscript{1}This work is supported by the Faculty Development and Research Committee of Towson University (OSPR # 140269) and also by the FCSM Fisher General Endowment Fund of Towson University.

F1.00079 Morphology-Dependent Properties of Semiconducting SnS Nanomaterials and Evidence for a Structural Distortion at the Nanoscale, ADAM J. BIACCHI, NIST, RAYMOND E. SCHAAK, Penn State, ANGELA R. HIGHT WALKER, NIST — The synthesis of semiconducting nanomaterials with controlled size, structure, and morphology using solution-based methods has emerged as an active field of research due to their excellent properties. Tin(II) sulfide is an intermediate band gap semiconductor that has received markedly less attention than other related compounds despite its non-toxic and earth-abundant constituent elements, as well as its comparably low cost and favorable electronic properties. Here we present a novel route for the solution synthesis of 2D SnS nanosheets as well as monodisperse 0D colloidal SnS nanocubes and spherical nanopolyhedra. The sheets are ∼270 nm squares with an orthorhombic crystal structure matching that of bulk α-SnS. The cubes and spherical polyhedra are ∼10 nm, below the exciton Bohr radius of SnS, allowing them to act as “quantum dots.” An inability to reconcile incongruences in the diffraction patterns of the 0D nanocrystals with the 2D nanosheets leads us to propose that these SnS quantum dots crystallize in a distorted pseudotetragonal structure, which is confirmed by detailed crystallographic characterization and modeling. We interrogate the optoelectronic and photocatalytic properties of these nanomaterials to determine that they are size-, shape-, and structure-dependent.

F1.00080 The effects of initial pH and cobalt concentration on cobalt-doped maghemite, BRIAN RUANE, RAMA BALASUBRAMANIAN, Roanoke College — We investigate the effect of varying cobalt (Co) concentrations and initial pH on the growth of Co-doped iron oxide nanoparticles used for carbon nanotube growth. Co-doped nanoparticles were grown using a coprecipitation method in an acidic medium. Crystal size was estimated using x-ray diffraction and supported with atomic force microscopy. The size of the nanoparticles decreased when cobalt concentrations increased for the unadjusted pH (9.1 nm to 6.5 nm) and the 0.5 pH solutions (10.4 nm to 7.7 nm) but increased for the 1.0 pH solutions (7.9 nm to 9.6 nm). Understanding how the conditions of the coprecipitation reaction affect particle size will allow us to tailor nanoparticles for use as catalysts in carbon nanotube synthesis.

F1.00081 Introduction to the Neutrosophic Statistical Mechanics, FLORENTIN SMARANDACHE, Univ of New Mexico — Neutrosophic Statistical Mechanics is the theory in which, using the neutrosophic statistical behavior of the constituent particles of a macroscopic system, are predicted the approximate properties of this macroscopic system. Neutrosophic Statistics means statistical analysis of population or sample that has indeterminate (imprecise, ambiguous, vague, incomplete, unknown) data. For example, the population or sample size might not be exactly determinate because of some individuals that partially belong to the population or sample, and partially they do not belong, or individuals whose appurtenance is completely unknown. Also, there are population or sample individuals whose data could be indeterminate. (Depending on the type of indeterminacy one can define various types of neutrosophic statistics.) The neutrosophic value of the average energy of one system, for a given period of time, is close to the neutrosophic average instantaneous value of this energy over a large number of systems. Therefore, in principle if one knows the neutrosophic energy levels of its components, one obtains the approximate thermodynamic properties of the system.

F1.00082 Phase Transitions in a Model of Y-Shaped Molecules, DONOVAN RUTH, Lehigh University, RAUL TORAL, University of Balearics Islands, DANIELLE HOLZ, Drew University, JAMES GUNTON, Lehigh University — Increasing attention in statistical mechanics is being given to non-spherical molecules, such as polypeptide chains and protein molecules. One example is provided by immunoglobulin, which has a “Y” shape. In this work, we determine the phase diagram of “Y”-shaped molecules on a triangular lattice through Monte Carlo Grand Canonical ensemble simulation, using histogram reweighting and multicanonical sampling. We show that this system is a member of the Ising universality class through finite size scaling techniques. The molecules interact via the distal tips with the nearest neighbor distal ends of other molecules; There are no center to center interactions, center to tip, or molecule to lattice interactions included in this particular study. For low temperatures, multicanonical sampling was implemented to induce faster phase transitions in the simulation. Studying several system sizes, finite size scaling was used to determine the two phase coexistence curve, bulk critical temperature, and critical chemical potential.

\textsuperscript{1}This work is funded by the G. Harold and Leila Y. Mathers Foundation.

F1.00083 Combining Etching with Laser Ablation to Form Hierarchical Structures in Silicon, Aluminum, and Titanium, ABBIE GANAS, NAHUM ALBA, KURT KOLASINSKI, West Chester Univ — Combining nanoscale with mesoscale features across macroscopic substrates can lead to functional materials. Self-limiting electrochemical etching is well known for making nanostructures\textsuperscript{1}. Chemical etching is capable of making geometrically well-defined structures spanning from the nanoscale to the macroscale\textsuperscript{2}. Both require control over the initiation sites to make hierarchical structures with features ranging over several orders of magnitude. Laser ablation with a nanosecond pulsed Nd:YAG laser produces texture in the form of regular arrays of pillars (with a period of several micrometers) or ripples (with a period of wavelength of light). These substrates are etched electrochemically or chemically to produce combinations of properties such as low reflectivity (black Si, black Ti, black Al) with quantum confinement induced over several orders of magnitude. Laser ablation with a nanosecond pulsed Nd:YAG laser produces texture in the form of regular arrays of pillars (with a period of several micrometers) or ripples (with a period of wavelength of light). These substrates are etched electrochemically or chemically to produce combinations of properties such as low reflectivity (black Si, black Ti, black Al) with quantum confinement induced visible photoluminescence; or membranes composed of micrometer sized pores, the walls of which contain high surface area nanoporous material. Methods and mechanisms of hierarchical structure formation will be discussed.

F1.00084 Finding Sterile Neutrinos from Nuclear Reactors. JAREDD HAUGHTON, Drexel University, PROSPECT COLLABORATION — A neutrino is a subatomic particle with no electrical charge that only interacts with other particles through the weak force and gravitational force. Neutrinos are produced in nuclear reactions, such as those in nuclear reactors and the sun. Furthermore, neutrinos come in three distinct “flavors” — electron, muon, and tau neutrinos. Neutrinos have been found to oscillate between their different flavor states. Due to differences in the expected number of neutrinos from nuclear reactions and the actual observed count, there is speculation that there is at least one more flavor of neutrino that has not been observed yet. This “sterile” neutrino would not interact via the weak force, and thus would be functionally invisible. This project, PROSPECT, is focused around searching for these sterile neutrinos, using a nuclear reactor as a source. I have calibrated a prototype of a segmented plastic scintillator, which will use light to distinguish between neutrino interactions and other types of interactions in the prototype. The final detector may use this technology to provide evidence of some undetectable “sterile” neutrino.

F1.00085 Automated temperature measurement in an optical tweezers system. ALEXANDER MANDARINO, SAMUEL V. MIGIRITCH, TYLER W. FOLEY, BROOKE HESTER, Appalachian State University — An optical tweezers system uses highly focused laser radiation in order to confine small particles and typically are used to study biological systems or materials. The measurement of the trap stiffness can be completed through various calibration techniques. Many calibration methods require an accurate knowledge of particle size, fluid viscosity, and temperature. We present an automated method for high-frequency power spectral analysis of thermal motion position data to find the temperature of the particle in the optical trap. The implementation of this method of temperature measurement allows for a more accurate determination of trap stiffness in the automation program.

F1.00086 A Comprehensive Analysis of GRB X-ray Afterglows with Deep Chandra Follow-up: Implications for Off-Axis Jets. DAVID BURROWS, Penn State University, BIN-BIN ZHANG, University of Alabama - Huntsville, HENDRIK VAN EERTEN, MPE, GEOFREY RYAN, ANDREW MACFADYEN, New York University, JUDITH RACISIN, NASA / Goddard Space Flight Center, ELEANORA TROJA, NASA / Goddard Space Flight Center, CRESST — We present a sample of 27 GRBs with detailed Swift light curves supplemented by late time Chandra observations. By fitting to empirical mathematical functions, we find a higher fraction of jet-break candidates (56%) than previous studies using Swift-only samples and different analysis techniques (12%). To answer the missing jet-break problem in general, we further develop a numerical simulation-based model which can be directly fit to the data using Monte Carlo methods. Our numerical model takes into account all the factors that can shape a jet break: (i) lateral expansion (ii) edge effects and (iii) off-axis effects. Comparing to the empirical function fit, our results provide improved fits to the light curves and better constraints on physical parameters. More importantly, our results suggest that off-axis effects are important and must be included in interpretations of GRB jet breaks.

F1.00087 Novel 3-dimensional nanocomposite of covalently interconnected multi-walled carbon nanotubes using Silicon as an atomic welder. LAKSHMY PULICKAL RAJUKUMAR, Pennsylvania State University, MANUEL BELMONTE, BENITO ROMAN, Instituto de Ceramica Y Vidrio, CSIC, JOHN SLIMAK, ANA LAURA ELIAS, EDUARDO CRUZ-SILVA, NESTOR PEREA-L ´OPEZ, Pennsylvania State University, AARON MORELOS-G ´OMEZ, Shinshu University, HUMBERTO TERRONES, Rensselaer Polytechnic Institute, PILAR MIRANZO, Instituto de Ceramica Y Vidrio, CSIC, MAURICIO TERRONES, Pennsylvania State University — There is a growing interest in synthesizing three-dimensional (3-D) carbon nanotube structures with multifunctional characteristics. Here, we report the fabrication of a novel composite material consisting of 3-D interconnected multi-walled carbon nanotubes (MWNTs) with Silicon Carbide (SiC). The material was synthesized by a two-step process involving the chemical coating of MWNTs with Silicon oxide, followed by Spark Plasma Sintering (SPS). SPS enables the use of high temperatures and pressures that result in carbothermal reduction of silica and densification of the material into a 3-D composite block. Covalent interconnections of MWNTs are facilitated by a carbon diffusion process resulting in SiC formation during SPS. The presence of SiC in the sintered composite has been confirmed through Raman spectroscopy, which shows the characteristic peak close to 800 cm$^{-1}$ and also EFTEM maps. XRD, SEM, EDX and HRTEM have also been used to characterize the produced material. Interestingly, a high thermal conductivity value (16.72 W/mK) and a 3-D variable range hopping (VRH) electron hopping was observed in the sintered composite.

F1.00088 Renyi Entropies and Generating Invariants of Local Conjugation. JACOB TURNER, JASON MORTON, Penn State University — We investigate the invariant ring of density matrices acted upon by conjugation of a tensor product of Unitary Groups. This is often called Local Conjugation. We find a minimal, algebraically independent set of generators for this ring and see that they are closely related to the Renyi Entropies.

F1.00089 Development of a Syringe-Pump for use in Disposable PSA-Tape Microfluidic Chips. ALAIN M. SCHREMMER, Lehigh University — Disposable, 121/4-mm-thick microfluidic chips were designed and constructed for use in fluorescence microscopy. A syringe pump was also designed and created in order to drive discreet amounts of fluid through microfluidic channels with the highest amount of control. Procedures and images of the setup can be found in the Appendix of this paper to allow further experimentation and improvement. Chip designs were significantly improved although not perfected due to occasional leakage during use. There is vast potential for use of these procedures in future experiments due to the ability to tweak aspects of the setup to accommodate a wide variety of projects including terbium gel formation, neuron cell observation, and CNT behavior in aqueous solution.

Saturday, October 4, 2014 7:00PM - 7:36PM —
Session G1 Plenary Session IV: Your APS: A Dynamic Present and Future Days Inn Banquet Room - Renee Diehl, Pennsylvania State University

7:00PM G1.00001 Your APS: A Dynamic Present and Future, KATE KIRBY, American Physical Society — .

Saturday, October 4, 2014 9:00PM - 9:36PM —
Session G2 Plenary Session V Days Inn Banquet Room - Ken O’Hara, Pennsylvania State University
Majorana fermions in semiconductor nanowires coupled to superconductors,

Sergey Frolov, University of Pittsburgh — Majorana fermions are real solutions to the Dirac equation, meaning they are their own antiparticles. In the condensed matter context, they are quasiparticles that are equal superpositions of electrons and holes. A practical challenge of today is to generate, isolate and study individual Majorana fermions. Theory tells us that they may arise in topological superconductors characterized by spinless p-wave pairing. A particularly feasible approach to realizing this unconventional superconducting state is to realize so-called weak superconducting superlattices with spin-orbit coupling. I will discuss our experiments on semiconductor nanowires that explore this approach, and present the signatures of Majorana fermions obtained by low temperature transport measurements. Interest in Majorana fermions is in part fueled by their predicted but not demonstrated non-Abelian property, which is key to applications in topological quantum computing. I will describe how we can study this in semiconductor-superconductor devices.

Qin Gao, Patrick MenDe, Nishtha Srivastava, Michael Widom, Randall Feenstra, Carnegie Mellon University — Based on density functional theory, we develop a self-consistent description of low-energy electron reflectivity spectra of both free-standing thin films and films on substrates. Our approach includes wavefunctions for a thin light layer together with wavefunctions of bulk substrate, if any. We compare with experimental data for graphene on SiC and various metallic substrates. From our modelling, we find that the minima of reflectivity arise from states with wavefunctions localized between graphene layers, rather than on the layers as previously suggested. The energies of the reflectivity minima are sensitive to the layer spacing between graphene and substrate; thus our method also provides a way to determine the layer spacing by comparing with the experimental reflectivity curve. A simple method is also proposed for inclusion of inelastic effects (electron absorption) in the computed reflectivity spectra, and is applied to graphene and hexagonal boron nitride (h-BN) on various substrates.


10:00AM H2.00004 Tunable band gap in bilayer graphene

J. Li, J. Todd, Department of Physics, Penn State University, University Park, USA, K. Watanabe, T. Taniguchi, National Institute for Material Science, 1-1 Namiki, Tsukuba, Japan, J. Zhu, Department of Physics, Penn State University, University Park, USA — Bernal stacked bilayer graphene is a unique two-dimensional material with a tunable band gap. A perpendicular electric field can break the inversion symmetry of the two graphene layers and open up a field-dependent band gap $\Delta(E)$ up to 0.25 eV. Although $\Delta(E)$ have been measured by optical spectroscopy [1], transport determination is hindered by stronger disorder in oxide- supported samples [2]. By using high-quality dual hexagonal boron nitride grafted samples, we measure the temperature dependence of the charge neutrality point resistance, from which $\Delta(E)$ is determined. We find $\Delta(E)$ to increase approximately linearly with the applied displacement field D and reach $\sim 0.2$ eV at $D = 1.68$ nm. The transport results are close to previous optical measurements but with much higher accuracy. Comparisons to theory and measurements in oxide-supported samples are made. An electric field tunable clean band gap in high quality bilayer graphene can be potentially useful in near and mid-infrared light detection.


10:12AM H2.00005 Screening of substrate charged impurities as mechanism of conductance change in graphene gas sensing

Sang-Zi Liang, Pennsylvania State University, Gugang Chen, Avetik Harutyunyan, Honda Research Institute USA Inc., Jorge Sofo, Pennsylvania State University — In graphene gas sensing, the measured conductance change after the sensor is exposed to target molecules has been traditionally attributed to carrier density change due to charge transfer between the sample and the adsorbed molecule. However, this explanation has many inconsistencies when it is applied to graphene on silica substrate. In this talk, we propose and explore an alternative mechanism. When adsorbed, charged functional groups and polar molecules on the surface of graphene may counteract the effect of charged impurities on the substrate. Because scattering of electrons with charged impurities has been shown to be a limiting factor in graphene conductivity, this leads to significant changes in the transport behavior. A model for the conductivity is established using the random phase approximation dielectric function of graphene and the first-order Born approximation for scattering. The model predicts magnitudes for the charge and dipole moment which has maximal screening effect. The dipole screening is generally weaker than the charge screening although the former becomes more effective with higher gate voltage. With increasing amount of adsorbates, the charge impurities eventually become saturated and additional adsorption always leads to decreasing conductivity.

This research was supported by the Honda Research Institute USA, Inc.
Recent developments in nanomanufacturing have produced molecular “nanocars” that roll on (usually) gold surfaces. Macroscopically, these nanocars are just cars, which are classic examples of nonholonomic systems—mechanical systems subject to non-integrable velocity constraints. Data on the energy required to set the nanocars in motion exists, but no theory of “quantum nonholonomic mechanics” exists. In this talk I will discuss my recent article developing such a theory for particular classes of nonholonomic systems, and my current work on extending that theory to develop a theoretical model for nanocars’ quantum dynamics.
10:12AM H3.00005 Hypernovae and Starbursts as Multimessenger High-Energy Sources, NICHOLAS SENNO, PHILIPP BAERWALD, PETER MESZAROS, The Pennsylvania State University, University Park — Recently the IceCube collaboration reported its first detection of high-energy (30 TeV – 2 PeV) neutrinos that may have been produced in astrophysical events, thus ushering in a new paradigm for the way we view the universe. We investigate the contribution of hypernovae (HNe) in starburst and normal star-forming galaxies to the diffuse flux of PeV cosmic rays, MeV-TeV γ-rays, and TeV neutrinos by numerically solving the Boltzmann transport equation. Cosmic rays produce γ-rays and neutrinos when they interact with ambient matter. Diffusion of the cosmic rays amplifies the amount of γ-rays and neutrinos that are produced in general. We consider cosmic ray propagation and subsequent neutrino production in both the hypernovae host galaxies and intergalactic space.

10:24AM H3.00006 Near Real-Time Compact Binary Merger Gravitational Wave Searches with Advanced LIGO, CODY MESSICK, Penn State University, KIPP CANNON, Canadian Institute for Theoretical Astrophysics, RYAN EVERETT, MIGUEL FERNANDEZ, CHAD JAHNKE, D.J. ROSARIO, S.X. WANG, Y.Q. XU, B. LUO, Pennsylvania State Univ and USTC — We measure the gravitational wave (GW) emission from compact binary mergers with plans to partner with astronomers for rapid follow-up of candidate signals. I will discuss a new low latency analysis pipeline which decreases the latency of compact binary merger detection from O(1) hour to O(1) minute. In addition, the current status of development and prospects for the next few years of time-domain gravitational wave astronomy and astrophysics will be provided.

10:36AM H3.00007 The High Altitude Water Cherenkov Observatory, KELLY MALONE, Pennsylvania State University, HAWC COLLABORATION — The High Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory, located at an altitude of 4100m on the Sierra Negra plateau in Mexico, is a second-generation experiment designed to observe TeV gamma rays and cosmic rays from air showers. It consists of a large array of water Cherenkov detectors, each of which is equipped with 4 PMTs. Data collection began in 2012 with a partially built detector. The full 300-detector array will be deployed by December 2014. HAWC’s large field of view (~ 2 sr) and high duty cycle (>90%) makes it well suited to observe gamma ray bursts, diffuse emission from the galactic plane, AGN, the cosmic ray anisotropy, and other transient and extended sources. I will present the observatory, scientific motivation and current status of the deployment.

10:48AM H3.00008 First Results from the High Altitude Water Cherenkov Observatory, JOHN PRETZ, Pennsylvania State University, HAWC COLLABORATION — The field of TeV astronomy has been rapidly expanding since the first detection of TeV photons from the Crab Nebula by the Whipple Observatory in 1989. There are currently more than 150 known TeV sources including Pulsar Wind Nebulae, Supernova Remnants, Active Galactic Nuclei, Galactic Binaries and Starburst Galaxies. Furthermore, extended emission from the Galactic Plane itself has been observed. The TeV emission from sources illuminates the highest-energy particle populations in these objects, elucidating leptonic and hadronic processes, as well as serving as a probe for new physics. The High Altitude Water Cherenkov Observatory is a new instrument for TeV astronomy. With a wide field of view and continuous observation, the instrument is being used to map the Northern sky at high sensitivity and search for transient emission. I will present results from the first year of operation of the partially-completed observatory.

Sunday, October 5, 2014 9:00AM - 11:00AM — Session H4 Time Domain Astrophysics, Observational Cosmology and Exoplanets Life Sciences Building 007 - David Burrows, Pennsylvania State University

9:00AM H4.00001 Unveiling the Progenitors of Short Duration Gamma-Ray Bursts, BRAD CENKO, Goddard Space Flight Center — While the connection between long duration gamma-ray bursts (GRBs) and massive star core-collapse has been firmly established over the last two decades, the progenitor system of short duration GRBs has proven more difficult to pin down observationally. With the discovery of the first GRBs following the launch of the Swift satellite, we have slowly accumulated evidence supporting a binary neutron star merger origin for these systems. In this talk I will summarize the indirect evidence supporting a link between neutron star mergers and short duration GRBs, as well as ongoing attempts to uncover a direct “smoking gun” signature, either in the form of neutron-rich (r-process) material tidally ejected during the merger (“kilonova” emission) and/or the coincident detection of gravitational waves from the Advanced Ligo/Virgo network.

9:36AM H4.00002 Bridging the gap between theory and observations of galaxies across cosmic time, YUEXING LI, Penn State, LARS HERNQUIST, Harvard, MARK VOGELSBERGER, MIT, VOLKER SPRINGEL, Heidelberg Institute for Theoretical Studies — A major recent milestone in observational cosmology is the detection of a large number of galaxies and quasars across cosmic time through multi-wavelength surveys. In order to interpret the wealth of data and to understand the origin and destination of these objects, a comprehensive model which fully accounts for the formation, evolution and multi-band properties of structures is imperative. However, despite the strong observational push, theoretical modeling in this field has lagged behind. Here, I report the Illustris radiative transfer project, which performs comprehensive radiative transfer calculations on the Illustris Simulation, the largest and most sophisticated cosmological simulation to date, to investigate the multi-band properties of galaxies and quasars from the cosmic dawn to the present day. I will present new results on the cosmic reionization, the origins of extragalactic background lights, and detectability of the first galaxies with the next generation instruments such as JWST and ALMA.

9:48AM H4.00003 Evolution in the Black Hole - Galaxy Scaling Relations and the Duty Cycle of Nuclear Activity in Star-Forming Galaxies, MOUYUAN SUN, J.R. TRUMP, W.N. BRANDT, D. ALEXANDER, K. JAHNKE, D.J. ROSARIO, S.X. WANG, Y.Q. XU, B. LUO, Pennsylvania State Univ and USTC — We measure the location and evolutionary vectors of 70 Herschel-detected broad-line active galactic nuclei (BLAGNs) in the MBH−M∗ relation for our galaxies to evolve most consistently onto the local MBH−MBul relation. Under reasonable assumptions of exponentially declining star formation histories, the data suggest a non-evolving (or weak-evolving) BLAGN duty cycle among star-forming galaxies of ~ 6% (1 sigma range of 0.05 – 30% at z < 1 and 0.6 – 25% at z > 1).

10:12AM H4.00095 Evolution in the Black Hole - Galaxy Scaling Relations and the Duty Cycle of Nuclear Activity in Star-Forming Galaxies, MOUYUAN SUN, J.R. TRUMP, W.N. BRANDT, D. ALEXANDER, K. JAHNKE, D.J. ROSARIO, S.X. WANG, Y.Q. XU, B. LUO, Pennsylvania State Univ and USTC — We measure the location and evolutionary vectors of 70 Herschel-detected broad-line active galactic nuclei (BLAGNs) in the MBH−M∗ relation for our galaxies to evolve most consistently onto the local MBH−MBul relation. Under reasonable assumptions of exponentially declining star formation histories, the data suggest a non-evolving (or weak-evolving) BLAGN duty cycle among star-forming galaxies of ~ 6% (1 sigma range of 0.05 – 30% at z < 1 and 0.6 – 25% at z > 1).
10:00AM H4.00004 Photometric Redshifts in the Hawaii-Hubble Deep Field-North (H-HDF-N) ; GUANG YANG, Chinese Academy of Sciences Hefei and Pennsylvania State Univ., Y.Q. XUE, Chinese Academy of Sciences Hefei, B. LUO, W.N. BRANDT, Pennsylvania State Univ — We derive photometric redshifts (zphot) for sources in the entire (∼ 0.4 deg²) Hawaii-Hubble Deep Field-North (H-HDF-N) field with the EAZY code, based on point spread function-matched photometry of 15 broad bands from the ultraviolet (U band) to mid-infrared (IRAC 4.5 µm). Our catalog consists of a total of 131,678 sources. We evaluate the zphot quality by comparing zphot with spectroscopic redshifts (zspec) when available, and find a value of normalized median absolute deviation (NMAD) of 0.029 and an outlier fraction of 5.5% (outliers are defined as sources having |zphot − zspec|/(1 + zspec) >0.15) for non-X-ray sources. Our zphot quality is comparable to those presented in similar works that derive zphot utilizing broadband photometry. We also classify each object as star or galaxy through template spectral energy distribution fitting, resulting in 4913 stars and 126,765 galaxies. Furthermore, we match our catalog with the 2 Ms Chandra Deep Field-North main X-ray catalog. For the 462 matched non-stellar X-ray sources (281 having zspec), we improve their zphot quality by adding three additional AGN templates, achieving a normalized median absolute deviation (NMAD) of 0.037 and an outlier fraction of 12.8%. We make our catalog publicly available presenting both photometry and zphot, and provide guidance on how to make use of our catalog.

10:12AM H4.00005 Weak Hard X-ray Emission from Broad Absorption Line Quasars Observed with NuSTAR: Evidence for Intrinsic X-ray Weakness ; BIN LUO, NIEL BRANDT, Pennsylvania State Univ, NUSTAR TEAM — We report NuSTAR observations of a sample of six X-ray weak broad absorption line (BAL) quasars. These targets, at z=0.148-1.223, are among the optically brightest and most luminous BAL quasars known at z<1.3. However, their rest-frame 2 keV luminosities are 14 to >330 times weaker than expected for typical quasars. Our results from a pilot NuSTAR study of two low-redshift BAL quasars, a Chandra stacking analysis of a sample of high-redshift BAL quasars, and a NuSTAR spectral analysis of the local BAL quasar Mrk 231 have already suggested the existence of intrinsically X-ray weak BAL quasars, i.e., quasars not emitting X-rays at the level expected from their optical/UV emission. The aim of the current program is to extend the search for such extraordinary objects. Three of the six new targets are weakly detected by NuSTAR with <45 counts in the 3-24 keV band, and the other three are not detected. The hard X-ray (8-24 keV) weakness observed by NuSTAR requires Compton-thick absorption if these objects have nominal underlying X-ray emission. However, a soft stacked effective photon index (Γ = 1.8) for this sample disfavors Compton-thick absorption in general. The uniform hard X-ray weakness observed by NuSTAR for this and the pilot samples selected with <10 keV weakness also suggests that the X-ray weakness is intrinsic in at least some of the targets. We conclude that the NuSTAR observations have likely discovered a significant population (≥33%) of intrinsically X-ray weak objects among the BAL quasars with significantly weak <10 keV emission.

10:24AM H4.00006 New Probes of Quasar Winds: Multi-Year Variability and Red-shifted Troughs ; WILLIAM BRANDT, Pennsylvania State Univ, NURTEN FILIZ AK, Erciyes Univ, PATRICK HALL, York Univ, DONALD SCHNEIDER, Pennsylvania State Univ, SDSS-III QUASAR WINDS TEAM — Winds are key parts of quasar nuclear environments, likely assisting mass accretion and providing feedback into typical massive galaxies. They are most directly observed via prominent absorption in the UV (e.g., Broad Absorption Lines: BALs) and X-ray bands. I will highlight results coming from two new probes of quasar winds: (1) multi-year variability surveys that can now systematically investigate large samples (hundreds-to-thousands of objects), and (2) rare redshifted BAL troughs, which may arise from high-velocity inflows, rotationally dominated outflows, or binary quasars. I will end by describing some key unresolved questions and future prospects.

10:36AM H4.00007 Atmosphere of a Transiting Hot-Jupiter System, Probed in the Lyman-alpha Band ; LOUIS OBERTO, Pennsylvania State Univ, ZHENG ZHENG, University of Utah — A Jupiter-like extrasolar planet (i.e., a hot-Jupiter), close to the host star, can have an atmosphere extending to several times the planet radius, as a result of heating from the star. Such an extended atmosphere is transparent to visible light and hard to be observed in the optical band. However, in the Lyman-alpha band, the extended atmosphere can be detected, because of the interaction of Lyman-alpha photons with the neutral hydrogen atoms in the atmosphere. A fraction of the Lyman-alpha photons emitted from the star are intercepted by the planet, and these photons experience resonant scattering in the planet’s atmosphere and eventually escape the atmosphere. Therefore, in the Lyman-alpha band, the planet appears to be effectively emitting light. We perform a Lyman-alpha radiative transfer study of a model transiting hot-Jupiter system. In the Lyman-alpha band, the transit signal is much stronger (compared to that in the optical band), due to the extended atmosphere. The effective Lyman-alpha emission from the planet also shows a phase variation as the planet orbits around the star. We investigate how the transit and phase-change light curve depends on the distribution of neutral hydrogen in the atmosphere, as well as the velocity of the atmosphere.

10:48AM H4.00008 Status of the LISA Pathfinder Mission ; JACOB SLUTSKY, University of Maryland, Baltimore County, THE LISA PATHFINDER TEAM — LISA Pathfinder is a technology demonstration space mission for the Laser Interferometer Space Antenna (LISA), a space-based observatory for gravitational waves in the milli-Hertz band. Though the formal partnership between NASA and ESA to pursue LISA was dissolved in the Spring of 2011, ESA has recently selected the Gravitational Universe theme for its third Large-class mission (L3), to be fulfilled by a space-borne gravitational wave observatory. Any such mission will take advantage of the significant technology development efforts that have already been made, especially those of the LISA Pathfinder mission, which is being led and built by ESA, with significant NASA contributions. The mission will place two test masses in drag-free flight and measure the relative acceleration between them, in order to validate a number of technologies that are critical to LISA-like gravitational wave instruments. These include the sensing and control of the test masses, drag-free control laws, microNewton thrusters, and piconewton-level laser metrology. With a launch date in the summer of 2015, LISA Pathfinder is currently in the late stages of integration. This talk presents the current status of the LISA Pathfinder mission and associated activities.
9:00AM H5.00001 Multiferroic Tunnel Junctions and ferroelectric control of spins1.
Qi Li, Pennsylvania State University — Multiferroic tunnel junctions, i.e. magnetic tunnel junctions with a ferroelectric barrier, have become one of the very promising approaches for new generation of multifunctional devices and electric control of spins for spintronics. A large tunneling electroresistance (TER) is very desirable for utilizing the devices for signal processing with an on-site magnetic memory. To enhance the TER, we have designed a bilayer tunneling barrier in which one layer is ferroelectric and the other interface layer is close to ferromagnetic metal to act as a spin valve for spin polarized tunneling current. The ferroelectric control of the interface magnetic states have been further confirmed in magnetic field dependence of the TER and magnetic second harmonic generation. Details of the experimental results and the comparison with first principles calculation will be discussed. The results have also shown that the tunneling magnetoresistance can be turned on and off with ferroelectric polarization reversal of the barrier.1 Work done in collaboration with Y. W. Yin, J. D. Burton, Y.-M. Kim, A. Y. Borisevich, S. J. Pennycook, S. M. Yang, T. W. Noh, A. Gruverman, X. G. Li, E. Y. Tsyshbal, H. Zhai, F. Fan, X. Ma, and G. Lüpike and supported by NSF and DOE.

9:36AM H5.00002 ABSTRACT WITHDRAWN

9:48AM H5.00003 Synthesis, characterization and photo-catalytic activity of Au–ZnO heterostructured nano-pyramids, OSHADHA RANASINGHA, Department of Physics, West Virginia University, Morgantown, WV 26506 / NETL, U.S. Department of Energy, Pittsburgh, PA 15236, CHRISTOPHER MATRANGA, NETL, U.S. Department of Energy, Pittsburgh, PA 15236, JAMES P. LEWIS, Department of Physics, West Virginia University, Morgantown, WV 26506 / NETL, U.S. Department of Energy, Pittsburgh, PA 15236 — Pyramid shaped ZnO nano crystals were grown on top of spherical shaped Au nanoparticles. The UV-VIS absorption spectra clearly showed 2 clear absorption peaks which correspond to the 1st exciton peak of the ZnO (359 nm) and surface plasmon resonance of the Au nanoparticles (521 nm). The ZnO was 25.9 nm in size in the pure sample and 20.5 nm in the Au-ZnO heterostructures. The Au nanoparticles are around 5-6 nm in Au-ZnO. XRD patterns confirmed the wurtzite hexagonal structure for the ZnO and cubic structure for the Au. According to the High Resolution TEM (HRTEM) images, single crystal ZnO with ZnO (002) lattice fringes can be observed. But Au can be identified as polycrystalline particles with different Au (111) facets. At the interface, there is a lattice expansion in both ZnO (002) and Au (111) planes. Also, XRD Rietveld analysis confirmed a 3 times higher strain in ZnO particles in Au-ZnO compared to the pure ZnO. Methylene blue dye degradation reactions were performed to evaluate the catalytic activity of the Au-ZnO, which showed a very high catalytic activity compared to the pure ZnO.

10:00AM H5.00004 Atomic Layer-by-layer Growth of Oxide Thin Films by Laser MBE, QINGYU LEI, GUOZHEN LIU, MARYAM GOLALIKHANI, DONGYUE YANG, KE CHEN, ALEXANDER X. GRAY, Department of Physics, Temple University, DARIO ARENA, National Synchrotron Light Source, Brookhaven National Laboratory, ANDREW FARRAR, DMITRI TENNE, Department of Physics, Boise State University, SUILIN SHI, FUQIANG HUANG, CAS Key Laboratory of Materials for Energy Conversion, Shanghai Institute of Institutes, Chinese Academy of Science, XIAOXING XI, Department of Physics, Temple University — We have established a laser MBE-based atomic layer-by-layer thin film growth technique. By in-situ monitoring the reflection high-energy electron diffraction (RHEED) intensity, oxide binary compound targets, such as SrO, TiO2, were ablated sequentially to assemble SrTiO3 in an atomic layer-by-layer manner. Stoichiometry and crystal structures of the films are controlled ex-situ by Rutherford back-scattering spectrometry and x-ray diffraction. UV Raman spectroscopy was used to probe the symmetry breaking due to the cation off-stoichiometry. Highly accurate stoichiometry control as shown by reactive MBE has been demonstrated. Similarly, CaMnO3 films were deposited by ablatting CaO and MnO2 targets separately. The strain states and electronic structure of the CaMnO3 films on various substrates were studied via x-ray diffraction and polarization-dependent x-ray absorption spectroscopy. This atomic layer-by-layer growth technique has applications on the growth of a wide range of perovskite thin films and superlattices.

10:12AM H5.00005 Electronic transition structure and metal-insulator transition in LaNiO3 ultrathin films grown on LaAlO3 substrates from separate oxide targets using laser MBE, MARYAM GOLALIKHANI, QINGYU LEI, DONGYUE YANG, LEILIA KASAEI, Temple University, PASQUALE ORGIANI, UOS Salerno, CNR SPIN, DARIO ARENA, National Synchrotron Light Source, Brookhaven National Laboratory, ALEXANDER GRAY, XIAOXING XI, Temple University — Here we report on a novel approach of growing ultrathin LaNiO3 films on LaAlO3 substrate one atomic layer at a time using laser MBE with La3+ and NiO targets. Reflection high energy electron diffraction (RHEED) spot intensity was used as the main technique to control stoichiometry and growth rate of alternating atomic layers with both LaO and NiO2 surface termination. We studied the change in the thickness-dependent electronic structure of LaNiO3 films across the metal-insulator transition. The techniques used in this study were the combination of temperature-dependent transport measurements, x-ray absorption spectroscopy (XAS) and x-ray linear dichroism (XLD) at the Ni L2,3 and O K absorption edges. We will report on the effect of the growth technique on electronic structure of this material.

10:24AM H5.00006 Magnetic properties of hexagonal HoFeO3 thin films1. ZHUJUN XIAO, XIAO WANG, Department of Physics, Bryn Mawr College, YAOHUA LIU, Argonne National Laboratory, XIAOSHAN XU, University of Nebraska-Lincoln, WENBIN WANG, Fudan University, DAVID KEAVNEY, Argonne National Laboratory, XIAOXING XI, Temple University — HoFeO3 (h-HFO) is a promising candidate for a multiferroics with room temperature ferromagnetism because of the expected enhanced Fe moment due to the exchange interaction between magnetic Ho3+ and Fe3+ ions. We report study of magnetic properties of epitaxial HoFeO3 thin films deposited on SrTiO3 (111) substrates via laser molecular beam epitaxy (LMBE). The X-ray diffraction of h-HFO thin films shows a six-fold symmetry. X-ray magnetic circular dichroism (XMCD) spectra for the Fe L2,3 edges and Ho M2,3 edges were measured with the magnetic field applied parallel to the x-ray propagation direction and 60° away from the film normal. Temperature dependence of the XMCD spectra shows ferromagnetic ordering of Fe3+ ions up to 200 K and paramagnetic behavior for Ho3+ ions above 10 K. The saturation magnetic moment for Fe3+ is determined by the sum rules to be 0.26 µB/Fe cation at 10 K and 0.064 µB/Fe cation at 200 K, which is about 10 times larger than the reported saturation Fe3+ magnetic moment in h-LuFeO3. The SQUID magnetometer results agree with the XMCD results.

10:36AM H5.00007 Electronic properties of silver delafossite materials (AgB$_{1-x}$Fe$_x$O$_2$) using high-throughput calculations. GIHAN PANAPITIYA, JAMES LEWIS, Department of Physics and Astronomy, West Virginia University — Delafossites are promising materials which can be used as photovoltaics or photocatalysts to reduce the CO$_2$ to viable products such as CH$_3$OH and CH$_3$OH. In this work, we present a high-throughput computational study for three delafossite oxides of the form AgB$_{1-x}$Fe$_x$O$_2$ (For B = Al,Ga,In), in search of candidate materials which can harness visible light. We explore the effect on optoelectronic properties of these materials when the B site is alloyed with Fe. A large number of structures are studied by varying the Fe doping percentage(x) from 0 to 0.05 and by choosing the impurity sites randomly. Statistical analysis is carried out to study the relative positions of the substituent atoms (Fe). We will discuss the structural trends and the optoelectronic properties of these materials to determine their viability in potential photoelectrochemical or photovoltaic applications.

Sunday, October 5, 2014 9:00AM - 11:00AM – Session H6 Physics Education Life Sciences Building 011 - Stephen Van Hook, Pennsylvania State University

9:00AM H6.00001 Improving student understanding of physics through research. CHANDRALEKHA SINGH, University of Pittsburgh — Despite our best and most sincere efforts, there is an alarming disconnect between what we teach and what students learn and understand. The goal of physics education research is to help close this gap. I will discuss, using my own research and activities as examples, some important components of physics education research. My own research has emphasized student understanding of introductory and advanced concepts. We are working on developing and evaluating strategies that actively engage students in the learning process. I will summarize some of the findings.

9:36AM H6.00002 ISLE-inspired Pilot Program at Princeton University. KATERINA VISNJIC, CAROLYN SEALFON, EVELYN LAFFEY, CATHERINE RIIHIMAKI, Princeton University — In an effort to enhance the traditional calculus-based introductory physics course at Princeton University, an Investigative Science Learning Environment (ISLE) inspired pilot program is underway. In the first year, two lab sections performed ISLE-inspired labs and activities in class, while the remaining ten sections received traditional instruction. We strove for a random selection of students. To assess the effectiveness of the pilot program, we conducted focus interviews to probe how students felt about the course and how relevant it was in their everyday lives. In this talk, we will describe in more detail the pedagogical approach used in the experimental sections, and the expansion of the pilot to include more sections this year. Using the interviews and more quantitative data, we will compare student learning in the experimental sections and the traditional sections. We will conclude with future plans.

9:48AM H6.00003 Exploring student understanding of the linkage between energy concepts in physics and chemistry. BETH LINDSEY, MEGAN NAGEL, Pennsylvania State Univ - Greater Allegheny — Potential energy is a conceptually rich topic presenting many difficulties for students. One key feature of potential energy is that it is a function of the distance between interacting objects. This concept is relevant to understanding potential energy in both physical and chemical contexts. Data from student responses to written surveys and small-group interviews reveal that students do not spontaneously make connections between ideas they have about energy from physics classes and the understanding of energy that they develop in chemistry. I will describe data that provide insight into students’ in-the-moment reasoning as they are confronted with and struggle to resolve the mismatch between their energy ideas from physics and chemistry. I will also describe the development and implementation of a sequence of questions that appears to aid students in drawing connections between energy concepts across the disciplines.

10:00AM H6.00004 In Through the Out Door - Physics in Introductory Labs. GREGORY PUSKAR, West Virginia University — Students typically regard physics laboratory as a necessary evil. One frequently voiced reason for this dissatisfaction is a perceived lack of relevance. In spite of this, the same experiments with the same methods of presentation persist, hiding the utility of many interesting and broadly useful concepts from most students. Students in the early stages of their academic careers have had little or no exposure to and the utility of physics beyond their classes. How can we help our students find the utility of physics beyond their classes? Direction is needed to help them relate physics to their world. A selection of changes to standard physics laboratories that aim to improve student attitudes and engage them more deeply will be presented.

10:12AM H6.00005 Learn Physics by Programming in Haskell. SCOTT WALCK, Lebanon Valley College — We describe a method for deepening a student’s understanding of basic physics by asking the student to express physical ideas in a functional programming language. The method is implemented in a second-year course in computational physics at Lebanon Valley College. We argue that the structure of Newtonian mechanics is clarified by its expression in a language (Haskell) that supports higher-order functions and types. In electromagnetic theory, the type signatures of functions that calculate electric and magnetic fields clearly express the functional dependency on the charge and current distributions that produce the fields.

10:24AM H6.00006 Animations for Introductory Physics and Astronomy. GALLIS MICHAEL, Penn State Schuylkill — The Animations for Introductory Physics and Astronomy project at Penn State Schuylkill is initiated to help students visualize aspects of 3-dimensional situations where traditional static drawings were seen as inadequate. The animations have been used to portray a wide variety of dynamical systems and processes for physics and astronomy topics typically presented in the advanced high school through introductory college level. Additional applications of the animation technology will be presented, including using more extensive animations for semester mini-themes and “What’s wrong” tasks using artificial video for video analysis. In addition, dissemination of the animations through the project web server at http://phys23p.sl.psu.edu/phys_anim/Phys.anim.htm and through the project YouTube channel at http://www.youtube.com/mrg3 will be discussed.

10:36AM H6.00007 Electrical resistance and connectivity of graphs. MIKHAIL KAGAN, Penn State Abington — One of the basic tasks related to electrical circuits is computing equivalent resistance. In some simple cases, this task can be handled by combining resistors connected either in series or in parallel, until the original circuit reduces to a single element. When this is not possible, one resorts to the “heavy artillery” of Kirchhoff’s rules. What traditionally receives little to no attention in the introductory E&M class is the method of nodal potentials. At the same time, it may often be both mathematically and conceptually simpler. In this talk, I will review the method of nodal potentials and use it to find the unknown currents and voltages in the Wheatstone-Bridge-like circuit. At the end, I will derive - in a closed form - the equivalent resistance of a generic circuit. Given the breadth of physical intuition that we have about electrical circuits, this result can provide a great deal of insight into some important questions of graph theory (e.g. connectivity issues, random walks on graphs etc.), as well as its applications to computer science.
10:48AM H6.00008 The trials and tribulations of building a phase-sensitive detector with an Arduino microcontroller, KEVIN SCHULTZ, Hartwick Coll — In the last few years we have seen a proliferation of relatively inexpensive devices that can be used for data acquisition. In addition to having high resolution and multiple channels, these devices require nothing more than a USB port to communicate with a computer. All of these attributes make these devices perfect for an undergraduate laboratory. Despite their simplicity, they have some costly aspects. Most of these devices, including the popular Arduino series of microcontrollers, do not function easily as signal sources. In this talk, I will describe the challenges I faced making a self-contained, phase-sensitive detector that was cheap, easy to program, and used no external components beyond a few passive components like resistors and capacitors. The pedagogical hope was to use this popular platform, or others like it, to teach undergraduates the important technique of PSD. A two-phase PSD was successfully implemented, but to overcome the technical difficulties inherent in the goals will require the use of advanced programming techniques like “bit-banging,” hardware/software interrupts, and careful memory management.

Sunday, October 5, 2014 9:00AM - 11:12AM –

Session H7 Biological and Medical Physics Life Sciences Building 013 - Colin Campbell, Pennsylvania State University

9:00AM H7.00001 Stochastic expression and epigenetic memory of the HO promoter, LUCY BAI, Pennsylvania State University — Eukaryotic gene regulation usually involves sequence-specific transcription factors and sequence-nonspecific cofactors. Large effort has been made to understand how these factors affect the average gene expression level among a population. How exactly the HO promoter is switched on is still an open question. In this work, we have used the HO gene expression to study how environmental and stochastic factors in the regulation pathway of the yeast HO promoter and probing the corresponding promoter activity in single cells using time-lapse fluorescence microscopy. We show that the HO promoter fires in a stochastic, “on or off” fashion in wild type cells as well as in different genetic backgrounds. Many chromatin-related co-factors that affect the average level of HO expression do not actually affect the firing frequency of the HO promoter; instead they affect the firing frequency among individual cell cycles. With certain mutations, the bimodal expression exhibits short-term epigenetic memory across the mitotic boundary. The memory is propagated in “cis” and caused by enhanced activator binding after a previous “on” cycle. Finally, we proposed a novel model that the short transcriptional memory is a result of slow turnover of the histone acetylation marks.

9:36AM H7.00002 Physics Has Often Been in the Forefront of Fundamental Advances in Biology and Medicine, RONALD AARON, Northeastern University — At a time when the physical structure of a living cell was essentially unknown, and the existence of an enveloping membrane was only a hypothesis, Julius Bernstein (between 1868 and 1912) developed the hypothesis that the cell is composed of an electrolytic interior surrounded by a thin membrane impermeable to ions. Furthermore he basically proposed the sodium-potassium pump! Max Delbruck in the early 1930’s was inspired by new data concerning fruit flies, namely, that when exposed to X-rays and ultraviolet radiation, their mutation was proportional to the concentration of free radicals. Based on this information Delbruck proposed that the gene was a single long-chain molecule and shared a Nobel Prize with Salvador Lurie in 1969. In this presentation we discuss the above, and further such examples, and suggest what is special about the science of physics that produces such remarkable forefront discoveries.

9:48AM H7.00003 Heme electronic structure calculations with band parameters from optical absorption spectra, ARTHUR BRILL, Professor of Physics Emeritus University of Virginia, MARK CARLSOM, Science Faculty, Illinois Mathematics & Science Academy — Central energies, bandwidths, peak absorbivities, oscillator strengths and transition dipole matrix elements are available from bandanalysis of optical absorption spectra both in the visible and near UV regions of the aquo, fluoride and cyanide complexes of horse metmyoglobin (M. L. Carlson and A. S. Brill, paper in preparation). The circular orbit model of porphin structure is applicable to related structures such as heme, and is useful for identifying π − π transitions responsible for the B bands in the Soret and the Q bands in the visible. The other transitions from this bandanalysis are identified as visible n−π (four for the aquo complex, five for both the F− and CN− complexes, six for the NH3− complex) and near ultraviolet beyond the Soret (seven for the aquo, fluoride and cyanide complexes, six for the azide). With the circular orbit model, average inner and outer radii of the structure of the heme chromophore are calculable from the lower and higher pairs of band center energies of π − π transitions. These radial distances are in approximate agreement with structural data from x-ray diffraction.

10:00AM H7.00004 Adaptation in variable action sequences, JASON D. WITTENBACH, DEZHE Z. JIN, Pennsylvania State Univ — Sequential behavior is seen throughout the animal kingdom. Often times the actions that comprise a sequential behavior can be placed in different orders within the sequence, creating a variable action sequence. Examples of variable actions range from the simple grooming patterns of mice to the complex patterns and rules of human speech. Understanding how neural circuits can encode and generate the patterns seen in such variable action sequences is an important step in unraveling how the brain generates complex behavior. One popular model system for studying variable action sequences is the Bengalese finch - a songbird with a complex and variable song. The Bengalese finch song exhibits repetition adaptation: a phenomenon where repeated elements become less likely to continue repeating the longer the repetition continues. We propose a model for the neural circuit that the Bengalese finch uses to produce the patterns of its song. This model reproduces the previously unexplained repetition adaptation. We also present a simplified dynamical system that shows how many systems with slowly changing parameters can exhibit a similar phenomenon.

10:12AM H7.00005 Phase Diagram for a Model of Truncated βB1-Crystallin, THENBAO NGUYEN, JAMES GUNTON, Lehigh University Physics — βB1-Crystallin proteins, found in the eye lens, self assemble into various oligomer sizes that can affect transparency and refractive power of the lens. Knowing the phase diagrams is an important aspect of understanding this self-assembly. There exists an experimental measurement of the effect of truncation of the protein’s N-terminus, which has been associated with aging, on the self-assembly and phase transition properties of the protein solution. By studying the behavior of a native state βB1 and a truncated version, it was found that the protein undergoes two interesting phase transitions. The first transition corresponds to the fluid-solid solubility line, below which is found rod like structures that crystallize over time. Further below the solubility line is the second transition, which is a liquid-liquid phase separation accompanied by gelation of the protein rich phase. We propose a phenomenological coarse-grained model, and use a Monte Carlo method simulation to determine the phase transition with the goal of explaining the solubility line and found self-assembly structures in the experimental work.
10:24AM H7.00006 A Model of Songbird Song Syntax using Bayesian Nonparametrics, SUMITHRA SURENDRALAL, DEZHE Z. JIN, Pennsylvania State Univ — Bird songs are learned sequences of syllables governed by specific rules of arrangement, or syntax. How is syntax encoded in the bird’s brain? How is it accessed to produce variability in the vocalizations? These questions are pertinent not only to birdsong, but also to other kinds of learned sequence generation in animals - motor movements, for example. As a first step in addressing these questions, we can construct a probabilistic model of the song syntax. An earlier study has shown that the song syntax of a Bengalese Finch can be described by a Partially Observable Markov Model (POMM), in which a many-to-one mapping scheme between the syllables and associated hidden states was invoked. However, the construction of this model was largely heuristic. We use a nonparametric Bayesian formulation, the Hierarchical Dirichlet Process - Hidden Markov Model, to develop a more principled method of constructing the POMM for birdsong. Importantly, the use of a nonparametric Bayesian inference technique allows us to automatically estimate the optimal number of hidden states in the model. We also make a case for a correspondence between the abstract states in our model and chain networks of neurons in the avian brain region called the HVC.

10:36AM H7.00007 Physics-based approaches for protein identification, OLEG OBOLEN-SKY, YI-KUO YU, National Center for Biotechnology Information, NIH — In biomedical research it is often necessary to identify proteins present in a sample. Tandem mass spectrometry (MS/MS) techniques are routinely used for this purpose. The protein in question is digested into smaller pieces (peptides) and then these pieces are protonated and further fragmented in mass spectrometers. The obtained mass spectra are analyzed and the peptides (and eventually the original protein) are identified. Currently, mass spectrometry-based peptide identification methods rely solely on statistical analysis of the mass spectra, while information about physics of the peptide fragmentation processes is vastly underutilized. We demonstrate how the physical approaches can be applied to the problem of peptide identification and how they can complement the statistical analysis. In particular, we show that observability of more than 90 per cent of signal peaks in mass spectra of short singly charged peptides can be easily predicted by knowing the dissociation energies in the corresponding fragmentation channels.

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10:48AM H7.00008 Modeling Bengalese finch syllable sequence generation with auditory feedback, SETH HULSEY, DEZHE JIN, Department of Physics, Pennsylvania State University, University Park, Pennsylvania — The song of the Bengalese finch consists of variable sequences of discrete syllables. Auditory feedback is required for normal singing behavior. Disruption of auditory feedback significantly altered syllable sequencing and timing. Deafening led to the emergence of novel transitions and more complex syllable sequences. Here we construct a computational model of variable sequence generation in Bengalese finch that can explain these results. The model is based on the branched chain network of projection neurons in the premotor song nucleus HVC (proper name). Chains of HVC projection neurons are associated with song syllables. Feedback inhibition from inhibitory interneurons ensures that spiking activity propagates along a single chain at a time. Auditory feedback is provided by projections from NIf neurons to HVC neurons. Different sets of NIf neurons respond to different syllables and have distinctive connection patterns to the HVC chains. Auditory feedback in our model provides sequence-dependent feedback inputs to the HVC network that can control syllable transitions. Alteration of auditory feedback temporarily suppresses NIf input, altering syllable sequencing. Deafening leads to random activations of NIf neurons, encouraging novel syllable transitions and randomizing syllable sequences. Our model explains the neural mechanism underlying the effects of altered auditory feedback and deafening on Bengalese finch song sequencing.

11:00AM H7.00009 Identifying and controlling the dynamical repertoire of intracellular networks, JORGE G.T. ZANUDO, RÉKA ALBERT, The Pennsylvania State University — An important challenge when modeling large intracellular networks is to relate the network structure and function to its stable patterns of activity (attractors). Here we present an approach that can be efficiently applied to large networks sizes (up to size 1000 and possibly beyond). Formulated in a discrete dynamic framework, this method is based on a topological criterion to find network motifs that stabilize in a fixed state. Combining these network motifs with network reduction techniques, our method predicts the dynamical repertoire of the network elements (fixed states or oscillations) in the network. Theoretical results are used to model the dynamical repertoire of intracellular network models. Importantly, the use of a nonparametric Bayesian inference technique allows us to automatically estimate the optimal number of hidden states in the model. We also make a case for a correspondence between the abstract states in our model and chain networks of neurons in the avian brain region called the HVC.

Sunday, October 5, 2014 11:30AM - 12:06PM – Session J1 Plenary Session VI

11:30AM J1.00001 NANOGrav: Building a Galactic Scale Gravitational Wave Observatory, MAURA MCLAUGHLIN, West Virginia University — Gravitational waves, or ripples in spacetime, are a key prediction of Einstein’s theory of General Relativity. A massive worldwide effort is underway to detect these waves using a variety of techniques. The NANOGrav (North American Nanohertz Observatory for Gravitational Waves) collaboration aims to detect and characterize these waves at low frequencies through ultra-precise timing of an array of millisecond pulsars. The primary expected sources are supermassive black hole binaries, which could be detectable as a stochastic background or as individual sources. I will give an overview of the observational strategies and detection algorithms used for various source classes. I will describe the dramatic gains in sensitivity that are expected from discoveries of additional millisecond pulsars, more sensitive instrumentation, improved detection algorithms, and international collaboration. Finally, I will discuss the likely time to gravitational wave detection using pulsar timing under various scenarios.

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2On behalf of the NANOGrav Collaboration (http://nanograv.org)