Annual Meeting of the Four Corners Section of the APS
Denver, Colorado
http://www.aps.org/meetings/meeting.cfm?name=4CF13
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The shallow entry angle led to an extended, near-horizontal, linear explosion. The blast was distributed over a large area, and was much weaker than it would be for a steep entry. The orientation also led to different phenomena than expected for a more vertical entry. There was no ballistic plume as calculated for Tunguska (~35 deg). Instead, buoyant instabilities grew into mushroom clouds and bifurcated the trail into two contra-rotating vortices. This event also suggests that the risk from airbursts is greater than previously thought.

Friday, October 18, 2013 9:00AM - 9:30AM — Session A1 Opening Session 248 - Davor Balzar, University of Denver

9:00AM A1.00001 OPENING SESSION —

Friday, October 18, 2013 9:30AM - 10:40AM — Session B1 Plenary I 248 - Jonathan Ormes, University of Denver

9:30AM B1.00001 Precision Cosmology: Past Successes and Future Prospects JOHN MATHER, NASA’s Goddard Space Flight Center — We now have a Standard Model of cosmology, with all the well-earned pride and possible hubris that entails. We have measured the main cosmological parameters to accuracies of a few percent, and we have even tested inflation theories. But there are some pesky mysteries: dark matter and dark energy, and an apparent deficit of spatial fluctuations on the largest angular scales. And the great current challenge is testing whether gravitational waves were important in the early universe. Then, what happened to produce the galaxies, the black holes, and the remarkable complexity of astrophysics? Combining new measurements and new simulations, we have great hopes to understand a little better, and with luck, to aid in the search for the Theory of Everything, if it exists. I will sketch the history and predict the future.

Friday, October 18, 2013 9:00AM - 9:30AM — Session A1 Opening Session

10:05AM B1.00002 The Chelyabinsk Airburst: Observations and Models MARK BOSLOUGH, Sandia Natl Labs — On Feb. 15, 2013, an asteroid exploded about 40 km SSW of the Russian city of Chelyabinsk. It caused many injuries and widespread blast damage, but also yielded a plethora of data from security and dashboard cameras. Combined with seismic, infrasound, and satellite records, this serendipitous source provides a means to determine the projectile size and entry parameters and develop a self-consistent model. Analysis of video with subsequent on-site stellar calibrations enabled precise estimates of entry velocity (19 km/s), angle (17 deg) and altitude of peak brightness (29 km). The inferred pre-entry diameter was ~20 m with a mass of ~1200 tonnes. Satellite sensors recorded a radiated energy consistent with a total energy of ~450 kilotons. The shallow entry angle led to an extended, near-horizontal, linear explosion. The blast was distributed over a large area, and was much weaker than it would be for a steep entry. The orientation also led to different phenomena than expected for a more vertical entry. There was no ballistic plume as calculated for Tunguska (~35 deg). Instead, buoyant instabilities grew into mushroom clouds and bifurcated the trail into two contra-rotating vortices. This event also suggests that the risk from airbursts is greater than previously thought.

Friday, October 18, 2013 11:00AM - 12:24PM — Session C1 AMOI: Atomic Clocks and Frequency Combs

11:00AM C1.00001 Frequency combs for optical clocks and low-noise oscillators

SCOTT DIDDAMS, National Institute of Standards and Technology — The optical frequency comb from a femtosecond mode-locked laser has become an indispensable tool for high-precision optical frequency metrology and as the clockwork for optical atomic clocks. Beyond precision timing applications, optical frequency combs are also used for ultraviolet and infrared spectroscopy, optical waveform generation, and the calibration of astronomical spectrographs. The wide utility of the frequency comb stems from the fact that it forms a phase-coherent link between optical and microwave domains in a simple, compact, and robust manner. When stabilized to an optical frequency reference, the various frequencies of the frequency comb can be used individually as ultrastable optical references, or they can be combined to synthesize pure tones or even waveforms with low phase noise in the microwave domain. This talk will focus on the description of experiments at NIST in which frequency combs are used to count the petahertz oscillations of optical clocks, as well as to generate the lowest noise microwave timing signals ever produced. A new generation of chip-scale frequency combs based on nonlinear parametric oscillation in high-Q micro-resonators will also be described.

In collaboration with Tara Fortier, Scott Papp, and Franklyn Quinlan, National Institute of Standards and Technology.

11:24AM C1.00002 Nested Frequency Combs

JEAN CLAUDE DIELS, University of New Mexico — Simple etalons inserted in a laser cavity are used to tune the wavelength of a laser. Inserting that element inside a mode-locked laser leads to a frequency comb with counter-intuitive features. Instead of a decaying sequence of pulses, the etalon produces a symmetric bunch of pulses, at a repetition rate in the GHz range, that can be fine tuned with the laser cavity length. The wavelength of the laser—as in the cw case—can be tuned with the angle of the etalon. However, the high and low frequency components of the repetition rate are both modified with the angle of incidence. Insertion of the Fabry-Perot results in a much larger modification of the laser cavity round-trip time than would be expected from the modification in optical path. Finally, the repetition rate of the laser has a much stronger dependence on the pump pulse power after insertion of the Fabry-Perot. The application of this research is in repetition rate spectroscopy (tuning the repetition rate of a laser to hit a vibrational resonance). There are applications in metrology, communications and astronomy where very high, tunable, repetition rates are desirable.

In collaboration with Ladan Arissian and Koji Masuda, University of New Mexico.

1Keck foundation, NSF ECS 0925526

11:48AM C1.00003 A New Record in Atomic Clock Performance

TRAVIS NICHOLSON, BENJAMIN BLOOM, JASON WILLIAMS, SARA CAMPBELL, MICHAEL BISHOF, XIBO ZHANG, WEI ZHANG, SARAH BROMLEY, JUN YE, JILA, University of Colorado — The exquisite control exhibited over quantum states of individual particles has revolutionized the field of precision measurement, as exemplified by highly accurate atomic clocks. Two classes of clocks have outperformed the Cs primary standard in both accuracy and precision: single-ion clocks and many-atom lattice clocks. Historically single-ion clocks have been at least 20 times more accurate than lattice clocks, and the two systems have demonstrated comparable precision. In this presentation we announce the first lattice clock that has surpassed single-ion clocks in both precision and accuracy. With the best reported accuracy and precision, lattice clocks are now a strong candidate as a primary frequency standard. This work paves the way for a better realization of SI units, the development of more sophisticated quantum sensors, and precision tests of the fundamental laws of nature.

1Present address: Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
12:00PM C1.00004 A “Nearly-Lightless” Laser . KEVIN COX, JUSTIN BOHNET, JOSHUA WEINER, MATTHEW NORCIA, ZILONG CHEN, JAMES THOMPSON, JILA, University of Colorado at Boulder — Bad-cavity (superradiant) lasers using highly forbidden atomic transitions are predicted to achieve coherence lengths on the order of the earth-sun distance, potentially improving optical atomic clocks and other precision measurements. We have realized a proof-of-principle cold-atom Raman laser operating deep into the superradiant regime, where the atomic linewidth is much narrower than the cavity linewidth. Here we present experiments using a superradiant laser including active and passive sensing of external fields, laser stability to external perturbations, and studies of phase synchronization between two sub-ensembles.

12:12PM C1.00005 Scheme for locking cooling and slowing lasers for a silicon magneto-optical trap . SAM RONALD, JONATHAN GILBERT, WILLIAM FAIRBANK, SIU AU LEE, Colorado State University — An attractive design for scalable quantum computer architectures has been proposed by Bruce Kane using single dopants in a crystal lattice. We are working on a magneto-optical trap (MOT) for single silicon atoms as a source for precise single ion implantation. Our laser systems operate at 221.74 nm utilizing frequency quadrupling of a Ti:Sapphire ring laser. The Zeeman slowing laser for cooling atoms in a silicon atomic beam has been locked to a molecular tellurium reference line for long term frequency stability. A portion of the second harmonic beam from the Zeeman slowing laser is acousto-optically shifted and used to lock the laser to a weak molecular tellurium absorption line. A portion of the unshifted second harmonic beam is overlapped with a portion of the second harmonic output of our main trapping laser system for the MOT to create a heterodyne beat note that is used to set our trapping laser detuning. In this talk I will discuss the setup for laser locking and present saturation spectra of molecular tellurium as referenced to the 221.74 nm transition in silicon, observed in the silicon beam and in a hollow cathode discharge.

Friday, October 18, 2013 11:00AM - 12:24PM –
Session C2 Astrophysics | 254 - Pearl Sandick, University of Utah

11:00AM C2.00001 New Views of Stellar Explosions: The Supernova Spectropolarimetry Project1, JENNIFER L. HOFFMAN, University of Denver — Nearly all supernovae possess spectropolarimetric signatures that indicate the presence of aspherical morphologies. These asphercities may include, for example, global asymmetries in the ejecta’s shape or velocity structure, clumpy distributions of ejected material, or interactions between the supernova and surrounding inhomogeneous circumstellar material. Interpreting spectropolarimetric signatures and their variations over time can give rise to unprecedentedly detailed information about the explosion mechanism, the physical processes that shape the ejecta, and the properties of the progenitor star. The Supernova Spectropolarimetry Project (SNPOL) is a recently formed collaboration between observers and theorists that focuses on understanding the complex, time-dependent spectropolarimetric behavior of supernovae of all types. Using the CCD Imaging/Spectropolarimeter (SPOL) at the 61” Kuiper, the 90” BoK, and the 6.5-m MMT telescopes, we have obtained multi-epoch observations of 21 supernovae of various types. I will present early observational results from this project and discuss ongoing modeling efforts. Initial analysis reveals strong, time-variable line polarization signatures that probe the distributions of different chemical species and thereby trace the detailed structure of the ejecta as these supernovae evolve. Our continuing observations will form the most comprehensive survey to date of supernovae in polarized light, allowing us to illuminate previously obscured relationships among subtypes and build a more well-rounded picture of the supernova population as a whole.

1This project is supported by NSF AAG award AST-1210372.

11:24AM C2.00002 Finding the First Cosmic Explosions: Hypernovae and Pair-Instability Supernovae1, BRANDON WIGGINS, Brigham Young University — The cosmic Dark Ages ended with the formation of the first stars at z ≈ 20, or ≈ 200 Myr after the Big Bang. Because they literally lie at the edge of the observable universe Pop III stars will be beyond the reach of even next generation observatories like JWST and the Thirty-Meter Telescope. But primordial supernovae could soon directly probe the properties of the first stars because they can be observed at high redshifts and their masses can be inferred from their light curves. I will present results from numerical simulations of Pop III hypernovae and pair-instability supernovae and their light curves computed with the Los Alamos National Laboratory’s RAGE and SPECTRUM codes. We find that these two types of explosions will be visible at z ≈ 10 – 15, revealing the positions of ancient dim galaxies on the sky and tracing their star formation rates.

1Special thanks is due to my collaborators Daniel Whalen, Joe Smidt and Wesley Even at Los Alamos National Laboratory.

11:36AM C2.00003 Cross Section Measurements for 34S(α,γ)24Si . PATRICK O’MALLEY, DEVIN CONNOLLY, ULRIKE HAGER, UWE GRIEFE, SERGEY ILYUSHIN, FRED SARAZIN, Colorado School of Mines, CHARLES AKERS, University of York, ALAN CHEN, McMaster University, GREG CHRISTIAN, JENNIFER FALLIS, TRIUMF, BRIAN FULTON, University of York, DAVE HUTCHIEON, TRIUMF, ALISON LAIRD, University of York, CHRIS RUIZ, TRIUMF, KIANA SETOOODEHnia, McMaster University, BARRY DAVIDS, TRIUMF — Some massive stars will go through a stage of explosive oxygen burning which commences with conversion of 16O and 24Mg to 28Si. When the 24Mg becomes exhausted, a network of reactions ranging from 28Si to 40Ca is initiated. Final abundances of most of the neutron-rich nuclides in this mass region depend in varying amounts on the cross sections of reactions involving 24Mg and 40Ca, particularly those of α-capture. Astrophysical reaction rates are dominated by the isolated resonances within the Gamow windows. Often statistical modeling is used instead for reaction rate calculations though there is typically a large discrepancy between these calculations and experimental determinations. For α-capture onto 34S there are discrepancies between experimental measurements that have never been resolved. Also, unstudied states exist around the Gamow window that could be resonances for alpha capture. A recent measurement was done using DRAGON at TRIUMF to resolve these discrepancies and to search for new resonances. Experimental data will be shown and preliminary results discussed.

11:48AM C2.00004 Convective Origins of Active Longitudes on Solar-like Stars, MARIA WEBER, Colorado State Univ, YUHONG FAN, MARK MIESCH, High Altitude Observatory — Using a thin flux tube model in a rotating spherical shell of turbulent, solar-like convective flows, we find that the distribution of emerging flux tubes in our simulation is inhomogeneous in longitude, with properties similar to those of active regions on the Sun and other solar-like stars. The large-scale pattern of flux emergence that our simulations produce exhibits preferred longitudinal modes of low order, drift with respect to a fixed reference system, and alignment across the equator at low latitudes. We suggest that these active-longitude-like emergence patterns are the result of columnar, rotationally aligned giant cells present in our convection simulation at low latitudes. If giant convecting cells exist in the bulk of solar and stellar convection zones, this phenomenon, along with differential rotation, could in part provide an explanation for the behavior of active longitudes.
12:00PM C3.00005 Chromospheric activity and stellar winds in supergiant stars . KATHLEEN GEISE, University of Denver — Emission lines in the ultraviolet (UV), such as the doublet lines of Mg II, and in the visible part of the spectrum, such as Ca H & K, may be good indicators of chromospheric activity in supergiant stars. Some of these lines may also be used to infer the presence of stellar winds, especially when blue-shifted absorption is present in the line profile. Stellar winds are an important mechanism for mass loss in supergiant stars. We seek to show that mass loss from slow winds may be common in F supergiant stars and that variability in spectral lines such as H alpha may be used as an indicator of stellar wind. We compared archival UV and visible spectra of type F supergiant stars in order to distinguish between chromospheric activity and stellar winds in these stars. Variable or asymmetric H alpha lines were found in spectra of supergiant stars that also exhibited wind or chromospheric signatures in UV Mg II lines.

12:12PM C3.00006 Understanding the Relation of Progenitors and Supernovae through the Study of Circumstellar Material (CSM) , MANISHA SHRESTHA, JENNIFER L. HOFFMAN, Univ of Denver, HILDING R. NEILSON, RICHARD IGNACE, East Tennessee State University — Circumstellar material (CSM) around supernovae helps us to uncover the evolutionary connections between these supernovae and their massive progenitor stars. This CSM arises from stellar winds, outflows, or eruptions from the massive star before it explodes and can be detected with polarimetric observations. We use a Monte Carlo-based radiative transfer code (SLIP) to investigate the polarization created by different models for the CSM surrounding Type IIn supernovae. We vary parameters such as the shape, optical depth, temperature, and brightness of the CSM and compare the simulated flux and polarization behavior with observational data. We present results from new simulations that assume bow shock shapes for the CSM. Bow shocks are commonly observed around massive stars; this shape forms when a star moving more quickly than the speed of sound in the local interstellar medium emits a stellar wind that drives a shock wave into the ISM. Since a bow shock projects an aspherical shape onto the sky, light from the central source that scatters in the shock region becomes polarized. We present electron-scattering polarization maps for this geometry and discuss the behavior of observed polarization with viewing angle in the unresolved case.

Friday, October 18, 2013 11:00AM - 12:24PM — Session C3 Biological and Soft Condensed Matter Physics I 287 - Kingshuk Ghosh, University of Denver

11:00AM C3.00001 The ugly truth of enzyme dynamics: coupled chaos and biological function , ELAN EISENMESSE, University of Colorado Denver — One of the most remarkable findings in the field of protein dynamics has been the discovery that functionally important regions of proteins have evolved to be flexible, yet how such dynamics relate to function still remains obscure at best. Specifically, dynamic movements on the micro-millisecond timescale, otherwise referred to as conformational change, are thought to be especially important for enzymes that rely on conformational changes for catalysis. The widely accepted paradigm is that an inherent conformational exchange comprises a highly concerted process that is “fine-tuned” to match the catalytic function. However, our studies on multiple enzymes as well as multiple members within an enzyme family suggest that dynamics may instead be a collection of partially coupled dynamic segments tied to the active site. Our lab has even altered dynamic segments distal to an enzyme active site leading to modulated function, providing a proof-of-principle that dynamic segments may be engineered to modify protein function.

11:24AM C3.00002 Designing Foldable Protein Sequence Through Zipping Contacts1 , SEFIKA OZKAN, Arizona State University — Earlier experiments suggest that the evolutionary information (conservation of amino acids and coevolution between amino acids) encoded in protein sequences is necessary and sufficient to specify the fold of a protein family. However, there is no computational work to quantify the effect of such evolutionary information on the folding process. Here we simulate a repertoire of native and artificial WW domain sequences using a physics-based protein structure search method called ZAM (Zipping and Assembly method), which samples conformational space effectively towards native-like conformations through zipping and assembly search mechanism. We explore the sequence-structure relationship for WW domains and find that the coevolution information has a remarkable influence on local contacts of N-terminal β-turn of WW domains . This turn would not form correctly if lack of such information. Moreover, through maximum likelihood approach, we identify five local contacts that play a critical role in folding. Using the contact probability of those five local contacts at the early stages of folding, a classification model is built. This enables us to predict the foldability of a WW sequence with 81% accuracy. Based on this classification model, we re-design the unfoldable WW domain sequences and make them foldable by introducing a few mutations that leads to stabilization of these critical contacts.

1 NIH 1U54GM094599

11:48AM C3.00003 Role of native-state dynamics in thermophilic adaptation , LUCAS SAWLE, KINGSHUK GHOSH, Univ of Denver — Thermophilic proteins denature at higher temperatures than mesophilic proteins. Among the many hypothesis related to thermophilic adaptation, reduced native state flexibility is one widely believed to be a signature of thermophilic proteins in comparison to their mesophilic homologues. While the majority of existing studies consist of investigating individual proteins, we explore the closed/open conformational transition of the enzyme adenylate kinase by analyzing a sample of trajectories produced by a range of different methods. Hierarchical clustering of pairwise path comparisons can distinguish transitions produced by different sampling methods and also group qualitatively similar trajectories generated by variations of the same method. In summary, we present a method to quantitatively classify macromolecular transition pathways, which may assist in the future in evaluating the accuracy of transition path sampling methods.

12:00PM C3.00004 An approach to quantifying macromolecular transition pathways , SEAN SEYLER, AVISHEK KUMAR, MICHAEL THORPE, OLIVER BECKSTEIN, Arizona State Univ — Fast transition path sampling methods can mitigate computational obstacles, though the question of whether they can replicate physical ensembles of transitions remains. We introduce a novel method for quantitatively measuring the similarity of transition paths for addressing a need in the computational biophysics community for techniques that facilitate the comparison of the multiplicity of transition path sampling methods. Using the Hausdorff and Fréchet path metrics, we quantify distances between piecewise-linear curves in protein configuration space. The dependence of these metrics on temperature (fluctuation size) and the number of particles (coarse-graining level) is tested using a toy model. We then apply our method to the closed/open conformational transition of the enzyme adenylate kinase by analyzing a sample of trajectories produced by a range of different methods. Hierarchical clustering of pairwise path comparisons can distinguish transitions produced by different sampling methods and also group qualitatively similar trajectories generated by variations of the same method. In summary, we present a method to quantitatively classify macromolecular transition pathways, which may assist in the future in evaluating the accuracy of transition path sampling methods.
The spin Seebeck effect (SSE) refers to the generation of a spin current with light and a temperature gradient. The voltage amplitude had a linear dependence on light intensity and showed a sinusoidal dependence on temperature. It was found that the voltage varied with time in response to light. We have developed a technique to use scattering of XUV light to determine the surface roughness of thin films. From the scattering data, we calculated the reflectance per unit angle of the different materials. We have developed a technique to use scattering of XUV light to determine the surface roughness of thin films. From the scattering data, we calculated the reflectance per unit angle of the different materials. We have developed a technique to use scattering of XUV light to determine the surface roughness of thin films. From the scattering data, we calculated the reflectance per unit angle of the different materials. We have developed a technique to use scattering of XUV light to determine the surface roughness of thin films. From the scattering data, we calculated the reflectance per unit angle of the different materials.
12:12PM C4.00006 Molecular Dynamics and the Melting Transition: A Computational Modeling Approach for Building Intuition. DEREK OSTREAM, GUS HART, Brigham Young University — Even simple models, like Lennard-Jones particles, can show remarkably realistic physics and exhibit important phenomena. Using a Lennard-Jones model and molecular dynamics simulations using a simple Verlet algorithm for generating dynamics, melting/freezing transitions can be observed, ground state structures can be discovered, and the Maxwell-Boltzmann distribution emerges spontaneously. These simulations can be an intuitive starting point for building intuition and spring-boarding to simulations of more complex representations of real materials.

Friday, October 18, 2013 11:00AM - 12:24PM — Session C5 Materials Physics I 253 - Davor Balzar, University of Denver

11:00AM C5.00001 Metamaterials: What They Are and How They Work. MICHAEL PETRAS, Freescale Semiconductor — Metamaterials are loosely defined as artificial materials engineered to have unusual properties not found in nature. Since these properties predominantly relate to the propagation of waves through the material, metamaterial engineering has a broad range of applications including photonics, acoustics and mechanical vibrations, thermal radiation and heat transfer, and even material transport (fluids). This talk presents a broad overview of these applications, and discusses the underlying physics using microwave photonic crystals as a specific example.

11:24AM C5.00002 Investigation of the cycling stability of an ionically-gated organic thin-film transistor. JACOB FREDELIN, ROBERT MCLEOD, SEAN SHAHEEN, University of Colorado - Boulder — We have fabricated organic thin film transistors (TFTs) using a film of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) as the transistor channel. In its positive oxidation state, PEDOT-PSS is a highly conductive organic semiconductor; however, when it is reduced to its neutral state, its conductivity decreases by many orders of magnitude. We have used this redox switching behavior of PEDOT:PSS as the basis for the modulation of channel current in our (TFTs). When positive ions are driven by a gate voltage into the transistor channel, they interact with the PSS anions, displacing them from the PEDOT, and ultimately reducing the PEDOT to its non-conductive state. Because these devices can operate with gate voltages < 2V and because they utilize ions, they are ideally suited for biological interfacing. In this work, we demonstrate that the redox switching of PEDOT is irreversible in some operational regimes, and we investigate the correlation between device lifetime and the ON/OFF ratio of the channel current. Finally, we explicate the implications of these behaviors on several applications for ionically-gated transistors.

11:36AM C5.00003 Extensions of the Walden-Wintle Model of Charge Transport in Disordered Materials for Charge Injection with Electron Beams1. JR DENNISON, GREG WILSON, Utah State University, ALEC SIM, Irvine Valley College, JODIE CORBRIDGE GILLESPIE, Utah State University — We have extended the Walden-Wintle model for charge transport through highly disordered insulating materials to include charge injection with a charged particle beam. The original model is applicable to charge injection in a dielectric material from a pair of electrodes in a parallel plate geometry. It provides a versatile approach to predict the time-dependent current at a rear grounded electrode, as the injection current density evolves over time with the development of a space charge barrier near the injection electrode. This includes standard Fowler-Nordheim, Schottky injection, space charge limited injection, and various tunneling mechanisms. Our new model modifies the approach to include electrode-less charge injection via a charged particle beam, along with concomitant effects for the injection current, surface voltage, and electron emission as a charge is built up in the insulator. The approach is equally valid for near-surface injection and bulk injection for non-penetrating radiation and for penetrating radiation. The results are based on our dynamic emission model for yields dependant on accumulating charge in both the positive and negative charging regimes.

1Work supported through funds from NASA GSFC and a Senior Fellowship from the National Research Council and AFRL.

12:00PM C5.00005 Influences of small clusters of defects near probe nuclei in cubic structures in perturbed angular correlation models. F. SULLIVAN, M. ADAMS, P. MATHESON, Utah Valley University, W.E. EVENSON, Retired — Evenson, et al. have modeled concentration-dependent inhomogenous broadening (IHBB) in perturbed angular correlation (PAC) spectra for cubic structures by finding a suitable set of coordinates to represent electric field gradients (EFGs) and then characterizing their probability distribution functions (PDFs). For defect concentrations c > 3%, a nonlinear transformation of the EFG components Vzz and Vxx produces two nearly-independent coordinates, W1 and W2. Their PDFs are well characterized by gamma and alpha-stable distributions. These can then be used to reconstruct PAC spectra for arbitrary c > 3%. However for c < 3%, chance occupations by a small number of defects near the probe nucleus can distort the PDFs. For example, a single defect in shell two produces strong secondary peaks in the PDFs. Also, the joint PDF for c < 3% remains skewed, reflecting some influence of the crystal geometry. Parsing the PDFs by contributions from different arrangements of defects in near-probe shells, allows us to investigate the relative contributions of different defect configurations to the PAC spectrum. We report on progress made in modeling low defect concentration PDFs and their PAC spectra in SC, FCC and BCC structures.

12:12PM C6.00006 Pre-breakdown Arcing in Dielectrics under Electric Field Stress

ALLEN ANDERSEN, JR DENNISON, Utah State University — High electric field stress phenomena associated with electrostatic discharge (ESD) were studied for dielectrics, including low density polyethylene, polyimide, and disordered SiO2. ESD is the free flow of current through a dielectric that has broken down due to high electric field stress. The critical field for ESD was determined by increasing the voltage across 25 μm samples in 20V steps, and monitoring the leakage current. A simple parallel-plate capacitor geometry was used, under high vacuum, to reach fields of up to 590MV/m. Prior to destructive ESD breakdown, pre-breakdown current arcs occurred through a dielectric. For polymers, pre-ESD transient current spikes were observed with measurements at 0.25s and 10kHz. The field at which pre-breakdown arcing begins was compared to the critical ESD field for each material studied. Arcing was also observed as part of endurance time measurements, where the sample is held at a fraction of the critical breakdown field and wait time to ESD is measured. These pre-ESD discharge phenomena are explained in terms of breakdown modes and defect generation on a microscopic scale. Pre-breakdown arcs are understood in terms of thermally repairable defects, while ESD requires the creation of defects related to bond breaking in the material.

11:00AM C6.00001 Hunting Asymmetric Top Squark Decays

MICHAEL GRAESSER, Los Alamos — In the irreducible natural supersymmetric spectrum, top squarks have comparable branching fractions to chargino-bottom and neutralino-top final states in the vast bulk of parameter space, provided only that both decay modes are kinematically accessible. The total top squark pair branching fractions into tt + MET (MET = missing transverse energy) can therefore be reduced, thus limiting the reach of traditional top squark searches. A new top squark search targeting the asymmetric final state tb + MET, which can restore sensitivity to natural top squarks in the 7, 8 and 14 TeV LHC runs will be presented. A new variable, topness, will be introduced, which efficiently suppresses the dominant top backgrounds to semileptonic top partner searches. The utility of topness in both the asymmetric search channel and traditional tt + MET searches will be compared and be shown to match or outperform existing variables.

Friday, October 18, 2013 11:00AM - 12:24PM – Session C6 Particle Physics I: Theory
251 - Shufang Su, University of Arizona

11:00AM C6.00001 Hunting Asymmetric Top Squark Decays

MICHAEL GRAESSER, Los Alamos — In the irreducible natural supersymmetric spectrum, top squarks have comparable branching fractions to chargino-bottom and neutralino-top final states in the vast bulk of parameter space, provided only that both decay modes are kinematically accessible. The total top squark pair branching fractions into tt + MET (MET = missing transverse energy) can therefore be reduced, thus limiting the reach of traditional top squark searches. A new top squark search targeting the asymmetric final state tb + MET, which can restore sensitivity to natural top squarks in the 7, 8 and 14 TeV LHC runs will be presented. A new variable, topness, will be introduced, which efficiently suppresses the dominant top backgrounds to semileptonic top partner searches. The utility of topness in both the asymmetric search channel and traditional tt + MET searches will be compared and be shown to match or outperform existing variables.

11:24AM C6.00002 Lattice field theory: QCD and beyond

ETHAN NEIL, University of Colorado, Boulder — Lattice simulation is a numerical technique for the non-perturbative investigation of quantum field theories. It has been very successful in precise studies of the strong nuclear force (quantum chromodynamics, or QCD.) In this talk I will review the basic framework of lattice simulations, and then describe current and future applications in particle physics, including the study of heavy-quark decays and searches for new strongly-coupled physics at the Large Hadron Collider.

11:48AM C6.00003 Higgs Assisted Stop Search

HUANIAN ZHANG, SHUFANG SU, University of Arizona — The discovery of the Standard Model (SM)-like Higgs boson is a great success of particle physics over the past 50 years. The existence of a light Higgs boson provides strong indications for new physics beyond the SM. In this project, we study the supersymmetric partner of the top quark, namely stop, which is the most relevant supersymmetric particles given its strong coupling to the Higgs sector. We study the pair production of stops at the 14 TeV Large Hadron Collider (LHC): \( pp \rightarrow t\tilde{t} \), followed by the decays: \( t\rightarrow b\tilde{b} \), \( \tilde{t}\rightarrow b\chi_1^0 \), where \( \chi_1^0 \) is the lightest neutralino. The final states include exact one lepton (\( e \) or \( \mu \)), \( \geq 2 \) b-jets, \( \geq 2 \) light flavor jets, and large missing energy. We find that with 100 fb\(^{-1}\) luminosity, a 5 \( \sigma \) reach of the stop mass up to 500 GeV could be obtained.

12:00PM C6.00004 Constraining Type II 2HDM in Light of LHC Higgs Searches

FELIX KLING, BARADHWAJ COLEPAA, SHUFANG SÚ, University of Arizona — The discovery of a resonance at 125 GeV with properties consistent with the Standard Model Higgs boson in both the ATLAS and CMS experiments is undoubtedly the most significant experimental triumph of the LHC to date. Though further data would undoubtedly point us in the right direction, at this point it is useful to explore the implication of the current Higgs search results on models beyond the Standard Model. One of the simplest extensions of the Standard Model is the Two Higgs-Doublet Model which contains an additional Higgs Doublet. We study the impact of the LHC Higgs search results on the Type II Two Higgs-Doublet Model. In particular, we explore the scenarios in which the observed 125 GeV Higgs signal is interpreted as either the light CP-even Higgs \( h^0 \) or the heavy CP-even Higgs \( H^0 \). Imposing both theoretical and experimental constraints, we analyze the surviving parameter regions. We further identify the regions that could accommodate a 125 GeV Higgs with cross sections consistent with the observed Higgs signal. We also investigate the correlation between different discovery channels. \( \gamma \gamma \) and \( VV \) channels are most likely to be highly correlated with \( \gamma \gamma : VV \sim 1 \) for the normalized cross sections.

12:12PM C6.00005 Confinement in a 2 + 1 Dimensional Center Vortex Model of the Yang-Mills Vacuum

DERAR ALTARAWNEH, MICHAEL ENGELHARDT, New Mexico State University — A promising picture of confinement in QCD can be obtained based on a condensate of thick vortices with fluxes in the center of the gauge group (center vortices). We have constructed a concrete realization of this picture. In our model, vortices are represented by closed random lines in 2+1 dimensional space-time. These random lines are modeled as being piece-wise linear and an ensemble is generated by Monte Carlo methods. The physical space on which the vortex lines are defined is a cube with periodic boundary conditions, and we have developed the necessary algorithms which implement those boundary conditions as the vortex lines evolve across the boundaries. When two vortices become close to each other, it is possible that they connect to one another. Also the inverse process, that a vortex separates at a bottleneck, is allowed. Our ensemble therefore will contain not a fixed, but a variable number of closed vortex lines. This is expected to be important for realizing the deconfining phase transition. Using the model, we can investigate both the confinement and the deconfinement phase. We were able to study the potential between quark and anti-quark as a function of vortex density, vortex segment length, and as a function of temperature.

Friday, October 18, 2013 2:00PM - 3:12PM –

Session D1 AMO II: Nonlinear Laser Propagation

151 - Chip Durfee, Colorado School of Mines

2:00PM D1.00001 Nonlinear laser propagation

JERRY MOLONEY, University of Arizona —
Also be used to help constrain Eta Carinae's recent mass-loss history, which is important for determining the current and future states of this fascinating object. By applying differencing techniques to these data cubes, we can compare and measure temporal changes in the interactions between the two massive stars. Data cubes (2D spatial, 1D velocity) have been collected at several phases during Eta Carinae's 5.54-year orbital cycle. The data cubes provide a unique view of the changing interaction between the two stars, which can be used to calculate the mass-loss rate and understand the evolution of the system.

In collaboration with Shermineh Rostami, Brian Kamer, and Jean Claude Diels, University of New Mexico.

1DTRA grant number HDTRA1-11-1-0043 and MURI grant W911NF-11-0297

2:48 PM D1.00003 Broadband shearing interferometer for divergence characterization.

AMANDA MEIER, CHARLES DURFEE, Colorado School of Mines, Golden, CO — Collimation testing for ultrafast pulses is important for grating compressor alignment, astigmatism correction and for the new technique of simultaneous spatial and temporal focusing (SSTF). Traditional techniques for checking collimation include knife-edge and camera scans, as well as shearing plate interferometry. The latter approach does not work well for broadband pulses because intrinsic relative time delays are larger than the coherence time. We have developed a novel polarized Sagnac shearing interferometer which combines spatial and spectral interference. We use birefringence to introduce a relative time delay to give reference spectral fringes. Divergence and spatial shear results in a local angle between the beams. The combination gives fringes in the spatial-spectral domain that rotate with divergence. We will present our experimental setup and fringe analysis techniques, along with estimates of the sensitivity of our measurement. In addition to collimation and astigmatism testing, we propose an extension to characterize angular spatial chirp.

3:00 PM D1.00004 In situ characterization of SSTF beams yielding phase and M2.

MICHAEL GRECO, AMANDA MEIER, ERICA BLOCK, JEFF SQUIRE, CHARLES DURFEE, Colorado Sch of Mines — Simultaneously spatial and temporal focusing (SSTF) of large bandwidth, femtosecond pulses has been demonstrated as a useful way to deliver high energy, ultrafast pulses to a focal plane without incurring second order effects that would damage material or distort the beam as it propagates. Though the optical components used to create these beams are common, the alignment of them (gratings and focusing optics in particular) is difficult. By combining information from a knife edge scan and a dispersion scan we can correct for misalignment in a grating compressor. Similar techniques for determining phase information of a conventionally focused ultrafast laser pulse involve spatial light modulators (SLM) to impart spectral phase[1]. An SSTF beam will experience a change in second order phase away from the focal plane along the axis of propagation. This may be used in lieu of an SLM for the purpose of observing higher order phase with a dispersion scan.

Friday, October 18, 2013 2:00PM - 3:24PM –

Session D2 Astrophysics II 254 - Shane Larson, Northwestern University

2:24 PM D2.00001 Invited talk - Astrophysics.

CHIP KOBULNICKY, University of Wyoming —

Massive stars play a key role in the evolution of their host galaxies, but their formation remains not well understood. Two main competitive theories try to explain it: the turbulent core model, which is an extension of the low-mass star formation model, and models involving competitive accretion or stellar collisions. The study of the massive star-forming region IRAS 20126+4104 with combined data can help us to characterize the population of that cluster (age and mass of the stars) and be used to discriminate between theories. This region was observed with the X-ray space telescope CHANDRA. We detected 150 sources, and a spectroscopic analysis of each source was performed. To determine the cluster characteristics, X-ray data were combined with radio observations done with the JVLA, infrared counterparts from the survey 2MASS, and optical counterparts from the TYCHO catalog. A stellar population simulation was done to determine the expected foreground and background population in the cluster (contamination). This study shows that most of the stars are in the WTT stage and all stars except the main source are low-mass protostars. I will discuss implications of those results and the future work planned for the cluster.

2:36 PM D2.00002 How do massive stars form?

VIRGINIE MONTES, PETER HOFNER, New Mexico Tech — Massive stars play a key role in the evolution of their host galaxies, but their formation remains not well understood. Two main competitive theories try to explain it: the turbulent core model, which is an extension of the low-mass star formation model, and models involving competitive accretion or stellar collisions. The study of the massive star-forming region IRAS 20126+4104 with combined data can help us to characterize the population of that cluster (age and mass of the stars) and be used to discriminate between theories. This region was observed with the X-ray space telescope CHANDRA. We detected 150 sources, and a spectroscopic analysis of each source was performed. To determine the cluster characteristics, X-ray data were combined with radio observations done with the JVLA, infrared counterparts from the survey 2MASS, and optical counterparts from the TYCHO catalog. A stellar population simulation was done to determine the expected foreground and background population in the cluster (contamination). This study shows that most of the stars are in the WTT stage and all stars except the main source are low-mass protostars. I will discuss implications of those results and the future work planned for the cluster.

2:48 PM D2.00003 Observing the Variations of Interacting Solar Winds in a Massive Binary Star System.

DARREN MCKINNON, Utah State Univ, THEODORE GULL, Goddard Space Flight Center, Astrophysics Science Division, Code 667 — Eta Carinae, a massive, highly-eccentric binary star system with enormous colliding solar winds, boasts an astronomical laboratory of great interest. It is an exceptional example of a pre-supernova environment, having survived a non-terminal stellar explosion in the 1800’s that left behind the incredible bipolar Homunculus nebula. The central interacting stellar winds are resolvable using the Space Telescope Imaging Spectrograph (STIS) aboard the Hubble Space Telescope (HST). Using HST/STIS, several three-dimensional (3D) data cubes (2D spatial, 1D velocity) have been collected at several phases during Eta Carinae’s 5.54-year orbital cycle. The data cubes were collected by mapping with a spatially-resolvable long slit, while focusing on selected spectral lines that form in the colliding wind regions. By applying differencing techniques to these data cubes, we can compare and measure temporal changes in the interactions between the two massive winds. Initial evaluation of these changes supports current 3D hydrodynamical models of Eta Carinae’s colliding winds. The observations can also be used to help constrain Eta Carinae’s recent mass-loss history, which is important for determining the current and future states of this likely nearby supernova progenitor.

1Society of Physics Students Summer Internship Program and Goddard Space Flight Center Summer Internship Program
2:48PM D2.00004 A Direct Measurement of the Mean Occupation Function of Quasars: Breaking Degeneracies between Halo Occupation Distribution Models

MY NGUYEN, SUCHETANA CHATTERJEE, ADAM MYERS, Univ of Wyoming, ZHENG ZHENG, Univ of Utah — Recent work on quasar clustering suggests a degeneracy in the halo occupation distribution constrained from two-point correlation functions. To break the degeneracy, we make the first direct measurement of the mean occupation function (MOF) of quasars at z ∼ 0.2 by matching quasar positions with clusters in the MaxBCG sample. We fit a power law and a 4-parameter model to the MOF. The number distribution of quasars in host halos is close to Poisson, and the slopes obtained for the power law case favor a monotonically increased MOF with halo mass. The best-fit slopes are 0.53 ± 0.04 for the power law model and 1.03 ± 1.12 for the 4-parameter model. The radial distribution of quasars within halos is described by a power law with a slope −2.3 ± 0.4. The conditional luminosity function (CLF) of quasars shows no evidence of luminosity evolution with host halo mass, similar to the inferences drawn from clustering measurements. Although the conditional black hole mass function (CMF) is consistent with no evolution, we observe a slight indication of downsizing of the black hole mass function. The lack of evolution in the CLF and the CMF shows that quasars, residing in clusters have a characteristic mass and luminosity scale independent of their host halos.

1 This work is supported at Univ of Wyo by the NSF through grant number 1211112, and by NASA through ADAP award NNX12AE38G, and EPSCoR grant NNX11AM18A. At Univ of Utah this work is supported in part by NSF grant AST-1208891

3:00PM D2.00005 Differential Proper-Motion Measurements of The Cygnus Egg Nebula; The Presence of Fast Equatorial Outflows . RACHAEL TOMASINO, TOSHIYA UETA, Univ of Denver, BRIAN FERGUSON, Des Moines University Medical School — We present the results of differential proper-motion analyses of the dust shell structure in the Egg Nebula (RAFGL 2688, V1610 Cyg), based on the archived two-epoch imaging-polarimetric data in the optical taken with the Hubble Space Telescope. We measured the amount of motion of local structures and the signature concentric arcs in the nebula by determining their relative shifts over an interval of 7.25 yr. We discovered that the optical polarization characteristics of the Egg Nebula was influenced by the marginal optical thickness of the circumstellar shell and the illumination of the nebula was done in two-step mechanism - most of the nebula is illuminated by the secondary/dust-scattered starlight emanating from the bipolar lobes themselves due to the central concentration of dust grains of more than 10^4 AU diameter that regulates the seepage of the starlight from the central region. Nevertheless, based on two types of differential proper-motion analyses we revealed interesting dynamics of the lobes and concentric arcs, which should provide solid constraints on the subsequent theoretical/numerical investigations.

3:12PM D2.00006 What is the singular behavior of the gravitational field near generic big-bang type events? , ELLERY AMES, JAMES ISENBERG, University of Oregon, FLORIAN BEYER, University of Otago, NZ — While specific examples of solutions to the Einstein equations are well-known and provide useful physical models, significantly less is known about the behavior of general solutions to the these equations. One outstanding set of questions concerns the behavior of general solutions in their singular regions. We consider certain classes of solutions to the Einstein equations in the cosmological setting, and show that within these classes there are families of solutions whose singular behavior can be well-understood using analytical techniques. These results are based on a so-called “Fuchsian method,” which we develop, for investigating the behavior of solutions to singular hyperbolic partial differential equations. Similar techniques should be adaptable for broader applicability in physics.

Monday, October 18, 2013 2:00PM - 3:12PM –
Session D3 Condensed Matter II: Magnetics

2:00PM D3.00001 Theory and simulations linking molecular features to morphology in polymer nanocomposites , ARTHI JAYARAMAN, University of Colorado at Boulder — To engineer polymer nanocomposites for target macroscopic properties, it is important to find ways to control the spatial arrangement of nanoscale additives within the polymer matrix. In this talk, I will present our recent theory and simulation work focused on linking molecular features of the additives and polymers to the morphology of the composite. Two specific studies will be discussed. First, I will show how polydisperisity in homopolymers grafted on the nanoadditives stabilizes dispersed morphology of the additives in the nanocomposite. Second, I will show how polymer architecture and additive-polymer miscibility affect morphological features, such as interfacial area and domain shapes, in conjugated polymer based composites.

2:24PM D3.00002 Damping in Nanometer-Thick Yttrium Iron Garnet Films Capped by Platinum

HUOCHEN CHANG, YIYAN SUN, MICHAEL KABATEK, YOUNG-YEAL SONG, ZIHUI WANG, MICHAEL JANTZ, WILLIAM SCHNEIDER, MINGZHONG WU, Colorado State University. ERIC MONTOYA, BARTEK KARDASZ, BRET HEINRICH, Simon Fraser University, SUZANNE TE VELTHUIS, HELMUT SCHULTHEISS, AXEL HOFFMANN, Argonne National Laboratory — Damping in magnetic materials can be realized through energy redistribution within the magnetic subsystem, energy transfer to non-magnetic subsystems and to external systems via spin pumping. This presentation reports on experimental evidences for a new damping. In samples of nm-thick ferromagnetic yttrium iron garnet (YIG) films capped by Pt films, the 3 nm or thicker Pt layer produces an extra damping much larger than the expected damping from spin pumping and with a shift in the ferromagnetic resonance (FMR) field. This damping can be switched off by a Cu spacer The damping may originate from the FM ordering in the Pt atomic layers by magnetic proximity effect near the YIG/Pt interface and the dynamic exchange coupling between the ordered Pt spins and the YIG spins. The YIG-Pt coupling allows for transfer of the damping of the FM Pt to the YIG film. The presence of the FM Pt causes spin pumping from FM Pt into paramagnetic Pt instead of conventional spin pumping from YIG to Pt.

1This work was supported in part by U.S. National Science Foundation (No. ECCS-1231598), the U.S. Army Research Office (No. W911NF-12-1-0518, No. W911NF-11-C-0075), and the U.S. National Institute of Standards and Technology (No. 60NANB10D011).

2:36PM D3.00003 Computational Analysis of Exchange Bias XRMS Data , ALEX SAFSTEN, Brigham Young University — Magnetic thin films possess a domain structure which is easily affected by the influence of external magnetic fields. Under proper conditions, however, the film will exhibit the property of “magnetic memory,” in which the film shows a preference for reforming in a domain structure similar to the original if possible. Previous work has shown the extent of magnetic memory in films whose preferred domain structure yields zero net magnetization on the sample. We show computational results for films under “exchange bias” conditions, in which the preferred state of the film has a nonzero net magnetization.

Session D3 Condensed Matter II: Magnetics
2:48PM D3.00004 Spin Pumping due to Traveling Spin Waves in Yttrium Iron Garnet Thin Films1. PASDUNKORALE JANANTHA, YIYAN SUN, HOUCHEN CHANG, MINGZHONG WU, Colorado State University — Yttrium iron garnet (YIG) has a very small magnetic damping and thereby represents a good candidate material for the generation of spin currents. Previous work has demonstrated the use of ferromagnetic resonance (FMR) and standing spin waves in YIG thin films to produce spin currents. In this presentation, we will report on spin pumping from traveling spin waves. Experiments used a micron-thick YIG strip capped by a nanometer-thick Pt layer. The YIG film was biased by an in-plane magnetic field. The spin waves pumped spin currents into the Pt layer, and the latter produced electrical voltages across the width of the Pt strip through the inverse spin Hall effect (ISHE). Two distinct modes were observed, one at a lower frequency and another at a higher frequency, which were due to the spin pumping from the traveling spin waves and FMR modes, respectively. The spin-wave pumping shows several important features. For example, it yields stronger ISHE signals and is broadband, in comparison with the FMR pumping.

1Supported in part by the National Nuclear Security Administration under the Stewardship Science Academic Alliances program through DOE Cooperative Agreement No. DE-FG52-08NA28552 and under DOE grant DE-FG02-93ER40789.

3:00PM D3.00005 Properties of protein-based ferrihydrite nanoparticles. STEPHEN ERICKSON, JOHN COLTON, TREvor SMITH, RICHARD WATT, Brigham Young University — Absorption spectroscopy was used to optically measure the band gaps of ferrihydrite nanoparticles within ferritin protein shells. These band gaps were measured accurately to within 0.01 eV and the nanoparticles were shown to be indirect gap semiconductors. The effects of anions in solution, nanoparticle size, and aging were examined. Orderly variations in band gap due to these conditions show the potential for selectively tuning that gap. Band gaps increased with time as the ferritin worked to crystallize the ferrihydrite, with stronger trends for larger nanoparticles. Nanoparticle size was shown to be inversely proportional to band gap. Evidence of a second indirect absorption edge suggests the possibility of a second local minimum in the conduction band.

Friday, October 18, 2013 2:00PM - 2:36PM — Session D4 Nuclear Physics

2:00PM D4.00001 Using the 11Be(p, d)10Be* transfer reaction at 110 MeV at TRIUMF-ISAC II to study halo features1. K. KUHN, R. BRAID, F. SARAZIN, D. SMALLEY, U. HAGER, S. ILYUSHKIN, P. O’MALLEY, Colorado School of Mines, M. ALVAREZ, J. GOMEZ, Universidad de Sevilla, C. ANDREOUI, Simon Fraser University, P.C. BENDER, G. HACKMAN, C. UNSWORTH, Z. WANG, TRIUMF, W.N. CATFORD, University of Surrey, C.A. DIGET, University of York, A. DIPETRO, P. FIGUERA, INFN Laboratori Nazionali del Sud, T.E. DRAKE, University of Toronto, E. NACHER, A. PEREA, O. TENGUBLAD, Instıtuto de Estructura de la Materia, C.E. SVENSSON, University of Guelph — To simultaneously study the halo wavefunction of the 11Be ground-state and also possible excited halo states in 10Be, the 11Be(p, d)10Be* reaction was studied at 10 MeV/nucleon at TRIUMF-ISAC II. This one-neutron transfer reaction allows the study of the single-particle states in 11Be and in 10Be by removing either the halo neutron or a core neutron respectively. A compact silicon array along with the TRIUMF ISAC Gamma-Ray Escape-Suppressed Spectrometer (TIGRESS) was used to detect the outgoing deuterium in coincidence with gamma-rays to determine the final state of the 10Be nucleus. Results from the May 2013 experiment will be shown.

1Supported in part by the National Nuclear Security Administration under the Stewardship Science Academic Alliances program through DOE Cooperative Agreement No. DE-FG52-08NA28552 and under DOE grant DE-FG02-93ER40789.

2:12PM D4.00002 Improved neutron time of flight apparatus. ALEC RAYMOND, JOHN ELLSWORTH, Physics and Astronomy, Brigham Young University — Time-of-flight (ToF) facilities are useful for determining the energy spectra of neutrons from nuclear reactions. The ToF apparatus at Brigham Young University is used to support laboratory nuclear astrophysics research; products of both fission and fusion reactions are of particular interest. Reported here are improvements made to our apparatus. In the past, the gamma start pulse was detected with a 5” x 5” NaI(Tl) scintillator with a 10 dynode PMT. The current start detector uses a 5” x 2” EJ-200 plastic scintillator with a 14 dynode PMT. The plastic detector has improved timing resolution over the NaI(Tl) detector. Future plans include replacing our sealed Cf-252 source with a Cf fission chamber. We’re anticipating using this facility to improve understanding of the fission process.

2:24PM D4.00003 Monte Carlo simulations of VANDLE1. SERGEY ILYUSHKIN, FREDERICK SARAZIN, Colorado School of Mines, WILLIAM PETERS, Joint Institute for Heavy Ion Research & ORNL, ROBERT GRZYWACZ, MIGUEL MADURGA, STANLEY PAULUSKAS, UTK, JOLIE CIZEWSKI, Rutgers, VANDLE COLLABORATION — The Versatile Array of Neutron Detectors at Low Energy (VANDLE) is a plastic-scintillator array designed for various experimental setups including β-delayed neutron spectroscopy and (d,n) transfer reactions in inverse kinematics. The neutron energy is determined through the time-of-flight technique. The array has energy resolution of ~120 keV @ 1 MeV and energy threshold of ~100 keV. We have developed a Geant4 simulation of VANDLE to optimize array geometry for different types of experiments and test neutron scattering models provided by Geant4. A typical β-delayed neutron decay study involves coupling with γ detectors to collect β-γ coincidence information. The experimental assembly including VANDLE bars, β plastic scintillators, HPGe detectors, along with the detector support structure was modeled in Geant4 in the fine-tuning of the setup and gave a detailed understanding of the array performance. The simulation was validated by comparing to available experimental data and could serve as an important guide for the design of future experiments.

1Supported in part by the National Nuclear Security Administration under the Stewardship Science Academic Alliances program through DOE Cooperative Agreement No. DE-FG52-08NA28552.

Friday, October 18, 2013 2:00PM - 3:24PM — Session D5 Particle Physics II: Experiment

251 - John Cumalat, University of Colorado
2:00PM D5.00001 Review of Recent Neutrino Oscillation Results, WALTER TOKI, Colorado State University — Neutrino oscillations can be parameterized in terms of four parameters called $\theta_{12}$, $\theta_{23}$, $\theta_{13}$ and $\delta_{CP}$. Non-zero values of the angles $\theta_{13}$ and $\delta_{CP}$ could explain the profound mystery of why the observable universe only has matter and little anti-matter. Until recently only weak limits existed on $\theta_{13}$ and nothing was known about $\delta_{CP}$. But in the last two years there has been a dramatic improvement in our understanding of $\theta_{13}$ and $\delta_{CP}$, which comes from neutrino oscillation results from the long baseline experiment T2K in Tokai, Japan, which observes the neutrino appearance mode $\nu_e \rightarrow \nu_x$ and from reactor experiments, Daya Bay, Double CHOOZ, and RENO, which measure the neutrino disappearance oscillation mode $\nu_x \rightarrow \nu_e$ in reactors operating in China, France, and Korea, respectively. These results now provide compelling evidence that $\theta_{13}$ is about 9 degrees. In this talk, the puzzling neutrino properties and the theory of neutrino oscillation mixing will be briefly introduced. These new experimental results will be reviewed and their impact on neutrino physics will be discussed.

2:24PM D5.00002 Charged Current Inclusive Analysis using the Pi-Zero Detector and the Time Projection Chambers of the T2K Experiment, EREZ REINHERZ-ARONIS, ALEX CLIFTON, RAJ DAS, Colorado State University, ROBERT JOHNSON, ALYSIA MARINO, University of Colorado, WALTER TOKI, Colorado State University, TIANLU YUAN, University of Colorado — $\nu_e$ Charge-Current events are produced and collected by the Tokai-to-Kamioka (T2K) Near Detectors (ND280). The talk focuses on the interactions which are created in the Pi-Zero ($P0D$) detector and their momentum is measured by the Time Projection Chambers (TPCs). The events selection and procedure of the analysis is described with its results. These results are presented as a ratio between selected Data events and simulated Monte Carlo events.

2:36PM D5.00003 Charged Current Anti-Muon Neutrino Events in the Near Detector at T2K, BRYAN BARNHART, University of Colorado — Boulder, T2K COLLABORATION — The main goal of the near detector at Tokai to Kamioka (T2K) is to constrain the flux of neutrinos present in the neutrino beam produced for the experiment. In addition to this neutrino flux is an anti-neutrino flux which is difficult to measure. To do so requires separating the large positive pion, proton, and wrong sign muon signals from the anti-muons that are generated by interactions in the detector. This talk will focus on the separation of the charged current anti-muon neutrino events from the various backgrounds present in the near detector.

2:48PM D5.00004 Future Neutrino Oscillation Parameter Sensitivities for T2K and NO$\nu_A$, MATTHEW BASS, DANIEL CHERDACK, ROBERT WILSON, Colorado State University, T2K COLLABORATION — Long-baseline neutrino experiments have the ability to measure the parameters of the mixing matrix that describes neutrino oscillations. Projecting the sensitivity of current and future experiments to these parameters plays a critical role in planning the next generation of experiments. After a brief introduction neutrino oscillations preliminary future sensitivity projections from a combined analysis for the Tokai to Kamioka (T2K) and NuMI Off-Axis Electron-neutrino Appearance ($NO\nu_A$) experiments will be discussed with particular emphasis on the methods used and the ability of these experiments to constrain the oscillation parameters, detect Charge-Parity (CP) violation, and determine the neutrino mass hierarchy.

3:00PM D5.00005 Preliminary Monte-Carlo Studies on Detecting Multi-Nucleon Events in the T2K Pi0 Detector, JACLYN SCHWEHR, Colorado State University, T2K COLLABORATION — The interaction of neutrinos with heavy nuclei is a field of study that has grown rapidly as more experiments are built with heavier targets. Neutrinos interacting with these targets are thought to interact with not just single nucleons, but also with correlated groups of nucleons. Models describing these interactions have been included in neutrino interaction simulation software, giving experimentalists the opportunity to compare these new theories with data. The T2K experiment has included the Nieves et.al. model for multi-nucleon interactions in NEUT (the neutrino interaction simulation program at Super-K) to generate events in the T2K near detector, ND280. This talk will look at initial studies of the feasibility of using the Pi0 Detector in the ND280 detector complex to identify multi-nucleon events using these newly generated simulations.

3:12PM D5.00006 Vertex Detection Sensitivity Study for Proposed P0D Upgrade, THOMAS CAMPBELL, Colorado State University, T2K COLLABORATION — The T2K experiment is a neutrino oscillation experiment located in Japan contributing to the measurement of various parameters relevant to neutrino oscillations. The Pi0 detector (P0D) is a portion of ND280, the near detector 280 meters from the J-PARC facility. The sensitivity of the Pi0 detector after a proposed upgrade for detecting neutrino events was studied using a particle-gun simulation and certain beam Monte-Carlo files used by the T2K collaboration.

Friday, October 18, 2013 2:00PM - 3:12PM
Session D6 Renewable Energy and Materials
253 - Michael Petras, Freescale Semiconductor, Inc

2:00PM D6.00001 Silicon Quantum Dot Mesomaterials for Solar Energy Harvesting, MARK LUSK, Colorado School of Mines — Recent progress in understanding electronic wave functions in condensed matter nanostructures has led to an ability to synthesize isolated, quantum confined building blocks with a variety of tailored optical properties. No matter what optical gap is engineered and how cleverly exciton energy is redistributed, though, novel materials composed of such nanostructures need to also exhibit efficient carrier dynamics. Transport of energy and charge is now the central issue in harnessing the true power of quantum dot materials for solar and many other uses. This is a critical bottleneck in the science because charge and exciton transport tend to proceed via low mobility, incoherent hopping associated with weak electronic coupling and high reorganization energies in these nanostructures. A number of promising strategies seek to improve energy and charge transport between quantum dots by focusing on important properties such as translational symmetry, electronic overlap, matrix encapsulation, and crystalline orientation. Our approach, though, is to consider the entire assembly as a quantum dot mesomaterial (QDM), wherein entire new transport physics may emerge from the complex interactions between components. For instance, the superb exciton harvesting efficiency of photosynthetic complexes is at least partly due to conditions that support an element of coherent character for exciton transport. Here proteins and pigments are exquisitely structured and combined so that they perform a number of integrated functionse.g. proteins serve to correlate electronic excitations on neighboring pigments, supporting coherence and allowing exciton transport with a degree of wave-like character. We seek to design materials composed of quantum dots in which components may carry out integrated tasks that optimize dynamics ranging from incoherent random walks to coherent transport. An emphasis is placed on the robustness of such transport in the face of geometric uncertainties intrinsic to synthesized systems. The computational facet of our investigation, emphasized in this talk, utilizes an open dissipative system approach, wherein a cumulant expansion strategy is used to approximate the quantum Liouville equation via a hierarchy of density operators. This has been successfully employed to scrutinize partially coherent transport in protein/pigment complexes, but here we focus on silicon quantum dot mesomaterials and use excited state many-body calculations to populate the associated meta-Hamiltonian. After an overview of the mesomaterial perspective, this talk will focus on our computational assessment of the prospects for partially coherent exciton transport through these silicon quantum dot mesomaterials.
2:24PM D6.00002 The Effect of Charge Transport Properties in OPVs. ALEX DIXON, University of Denver, NIKOS KOPIDAKIS, NREL, SEAN SHAHEEN, CU Boulder, RASEI — The Organic Photovoltaic (OPV) field is rapidly advancing, however several important issues regarding the device physics in these systems remain unresolved. We investigated the relationship between morphology and charge transport properties in OPV materials. To do this, we created devices with poly 3-hexothiophene (P3HT) of a range of molecular weights (from 13kDa to 331kDa). These various molecular weights cause the films to have different morphologies. The low molecular weight P3HT forms semi-crystalline domains, as the molecular weight increases, amorphous regions appear connecting and surrounding the semi-crystalline domains. The devices were measured using the Charge Extraction by Linearly Increasing Voltage (CELIV) technique in order to determine the charge carrier mobility and recombination rate of the various P3HTs. We found that while the recombination rate decreases with increasing molecular weight, the mobility peaked at around 47kDa. We believe that the decrease in recombination is due to charge dissociation of electrons and holes into separate regions of the film. While the lower recombination rate from the separate amorphous and semi-crystalline domains raises the mobility, the increasing amount of amorphous material at larger molecular weights causes a decrease in mobility, resulting in observed mobility peak.

2:36PM D6.00003 Mott-Schottky Analysis of Normal and Inverted Organic Photovoltaic Devices. XIN JIANG, Dept. of Physics and Astronomy, University of Denver, ALEXANDRE NARDES, National Renewable Energy Laboratory, ALEXANDER DIXON, Dept. of Physics and Astronomy, University of Denver, NIKOS KOPIDAKIS, National Renewable Energy Laboratory, SEAN SHAHEEN, Dept. of Electrical, Computer, and Energy Engineering, University of Colorado at Boulder — We use impedance spectroscopy to examine the electronic structure and energy band diagrams of Organic Photovoltaic (OPV) devices based on the standard donor-acceptor combination of P3HT:PCBM. Mott-Schottky analysis is performed to characterize the dark carrier densities, built-in voltages of Schottky junctions, and overall energy band diagrams in standard and inverted geometry devices with aluminum and silver top electrodes, respectively. Evidence for the decrease of dark carrier densities upon post-production thermal annealing is seen for devices in both geometries, illustrating the impact of thermal processing on the energetic band diagram. Furthermore, we find evidence for p-n junction formation at the ZnO/active layer interface in inverted devices, owing to the existence of dark carriers on both sides of the interface. We suggest that the resulting band bending at this interface helps explains the enhanced photocurrents often seen in inverted devices when compared to normal geometry devices for nominally identical active layer structures.

2:48PM D6.00004 J-V Distortion of CIGS Solar Cells with Sputtered Zn(O,S) Buffer Layer1, TAO SONG, J. TYLER MCGOFFIN, RUSSELL GEISTHARDT, Department of Physics, Colorado State University, KANNAN RAMANATHAN, National Renewable Energy Laboratory, JAMES SITES, Department of Physics, Colorado State University, NATIONAL RENEWABLE ENERGY LABORATORY COLLABORATION — Sputtered-deposited Zn(O,S) is an attractive alternative to CdS for Cu(In,Ga)Se2 (CIGS) thin-film solar cells' buffer layer. It has a wider band gap and thus allows greater blue photon collection to achieve higher photon current. A key parameter for the sputtering deposition of Zn(O,S) is the oxygen fraction in the argon sputtering beam. Current-Voltage (J-V) distortion, observed in some cases, varied with oxygen fraction in Zn(O,S). The details are in good agreement with predictions of a photodiode model, in which a conduction-band offset (CBO)-induced barrier at the buffer-absorber interface is responsible for the distortions (both red kink and crossover). Varying oxygen fraction in Zn(O,S) may play a role in adjusting the CBO at the interface and thus modulating the J-V distortion.

3:00PM D6.00005 Optimization of Layer Properties for High Efficiency CdTe solar cell with Higher Band Gap CdMgTe Layer as Back Electron Reflector. JINMING ZHANG, JAMES SITES, Colorado State University — Thin film CdTe solar cell has been an option for PV energy solution with a potential of massive terrestrial installation. The open circuit voltage of traditional CdTe cell (up to 0.85V) has been the biggest limit to higher cell efficiency. Adding an additional layer of CdMgTe as back electron reflector with fitted band alignment to CdTe has been proposed to increase Voc by as high as 0.2V. We have also found that the resulting band bending at this interface helps explains the enhanced photocurrents often seen in inverted devices when compared to normal geometry devices for nominally identical active layer structures.

Friday, October 18, 2013 3:45PM - 4:55PM — Session E1 Plenary II

3:45PM E1.00001 AMO Talk, ERIC CORNELL, NIST —

4:20PM E1.00002 Remote Sensing of the Earth’s Environment from Space: Past, Present, and Future, MICHAEL KING, University of Colorado — With the wide variety of satellites encircling the Earth, provided by many countries and government agencies, satellites provide an invaluable means of monitoring our planet with a consistent measurement capability across national and other political boundaries. Satellite observations regularly reveal features of the planet that take scientists by surprise and remind us that we remain a long way from fully understanding the behavior of the complex web of physical, chemical, and biological processes that take place on our home planet. In this presentation, I will review the current state of Earth remote sensing capabilities, with a particular focus on US space observations. I will highlight what we know and how we know it, and will illustrate many applications of "routine" space-based observing systems that have led to applications across a wide range of environmental issues. In addition to planned environmental observations, I will also present examples of (i) aerosol profiles of atmospheric constituents, (ii) land surface properties, (iii) biological and physical oceanography, and (iv) cryospheric properties, satellites have led to a large number of unanticipated applications that are of a broad interest to the human condition. Among these are (i) monitoring of air quality, (ii) number, distribution and energy of fires, (iii) floods, (iv) droughts, (v) volcanic eruptions, and other natural disasters.

Friday, October 18, 2013 5:00PM - 7:24PM — Session F1 Nobel Laureates Session

248 - John Mumalat, University of Colorado-Boulder
Using information geometry, we systematically coarsen models from the bio-chemical level into effective models of the emergent biology. The approach begins by identifying feedback loops, that control the system. The microscopic components may interact to form feedback loops, which control the system. Coarse-grained models remain written in terms of the microscopic parameters but vividly illustrate the emergent control mechanisms, such as feedback loops.

For example, numerous chemical reactions may coordinate to form an effective feedback loop. Understanding and modeling the relationship when modeled at the bio-chemical level, systems often have an elegant simplicity when modeled at a more abstract, coarse-grained level.

**G1.00001 Spatailly Resolved Fluorescence Correlation Spectroscopy for Monitoring Biomolecular Dynamics**

Farshad Abdollah-Nia, Department of Physics, Colorado State University, Fort Collins, CO 80523; Kevin Whitemb, Department of Chemistry, Utah State University, Logan, UT 84322; Martin Gelfand, Department of Physics, Colorado State University, Fort Collins, CO 80523; Alan Van Orden, Department of Chemistry, Utah State University, Logan, UT 84322 — Two-beam Fluorescence Correlation Spectroscopy has been used to examine the diffusion, flow, and reaction rates of various ions and biological molecules, such as DNA, RNA, and proteins. Two laser beams were focused to form femtoliter probe regions in a capillary through which the analyte solution flowed continuously under the influence of an applied electric field or mechanical pressure. This poster introduces the theoretical and experimental concepts behind this technique, and presents some example results obtained by this group.

**G1.00002 Collective Excitations in Quasi-2D Condensates**

Andrew Barentine, Dan Lobser, Heather Lewandowski, Eric Cornell, Jila, National Institute of Standards and Technology and Department of Physics, University of Colorado, Boulder — Quantum gases confined to lower dimensions exhibit remarkable physical properties such as the Berezinskii-Kosterlitz-Thouless transition or the Tonks-Girardeau gas. Confinement effects in a quasi-2D condensate are predicted to shift the frequency of certain collective excitations, in particular the monopole mode. In our experiment, quasi-2D condensates are created by loading a 3D condensate into a 2D optical lattice, collectively modulating the strength of the trap. We have characterized a potential source of systematic error associated with a cross dimensional anharmonicity in the trap. This so called “anharmonic shear” also allows us to separate and simultaneously image each individual layer in the lattice.

**G1.00003 The behavior of Neutral Densities between 45 and 90 km Determined from Rayleigh Lidar Observations above Logan, Utah**

David Barton, Vincent Wickwar, Leda Sox, Physics and CASS, Utah State University, Joshua Herron, Space Dynamics Lab, Utah State University — A Rayleigh-scatter lidar operated at the Atmospheric Lidar Observatory (ALO; 41.7°N, 111.8°W), part of CASS on the campus of Utah State University (USU), and collected extensive data between 1993 and 2004. From the Rayleigh lidar photon-count returns relative densities throughout the mesosphere, from 45 to 90 km, were determined. Using these relative densities three density climatologies were derived, each using a different density normalization at 45 km. The first normalized the relative densities to a constant; the second normalized them to the NRL-MSISE00 empirical model, which has a strong semiannual component; and the third normalized them to the CPC analyses model, which has a strong annual component. In each case the density profile for every night of a composite year was found by averaging the nighttime density profiles in 31-day by 11-year window centered on that day. Despite the different normalizations, many common features were found in the seasonal behavior of the densities. One is a large seasonal variation maximizing in June at ~70 km. Another, above 80 km was a large shift in the maximum to earlier in the year. While these relative densities provide much useful information about mesospheric behavior, the current lidar upgrade will add an absolute.

**G1.00004 Progress Towards Real-Time Radiation Measurements on Aircraft**

L. Duane Bell, W. Kent Tobiska, Robert W. Schunk, Donald D. Rice, Utah State University — The Space Weather Center (SWC) at Utah State University has created a team to deploy and obtain radiation effective dose rate data from dosimeters flown on commercial aircraft. The objective is to improve the accuracy of radiation dose and dose rate estimates for commercial aviation flight crews. There are two general sources of radiation exposure for flight crews: (1) the ever-present, background galactic cosmic ray (GCR), which originate outside the solar system, and (2) the solar energetic particle (SEP) events (or solar cosmic rays), which are associated with solar flares and coronal mass ejections lasting for several hours to days with widely varying intensity. The Automated Radiation Measurements for Aviation Safety (ARMAS) project is making substantial progress, currently implementing dosimeters flown in commercial aircraft to provide and improve sample data collected for the Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) estimates. We report on the results of our flights and the calibrations of the dosimeters.

**G1.00005 Coarse-graining systems biology models with Information Geometry**

Dane Bjork, Mark Transtrum, Brigham Young University — Microscopically, biological signaling pathways can be very complex, involving a large number of bio-chemical reactions organized to perform specific cellular functions. In spite of the immense complexity of these systems when modeled at the bio-chemical level, systems often have an elegant simplicity when modeled at a more abstract, coarse-grained level. For example, numerous chemical reactions may coordinate to form an effective feedback loop. Understanding and modeling the relationship between the microscopic components and the macroscopic function is an important, challenging problem that is central to systems biology. Using information geometry, we systematically coarsen models from the bio-chemical level into effective models of the emergent biology. The coarse-grained models remain written in terms of the the microscopic parameters but vividly illustrate the emergent control mechanisms, such as feedback loops, that control the system.

**G1.00006 Power law structure of the ISM: HI, CO and IR fractal dimension analysis in nearby galaxies**

Lorraine Bowman, Dave Westpfahl, NRAO and NMT, Juergen Ott, NRAO — The properties of turbulence in galaxies are a fundamental part of our understanding of the ISM as a complex and dynamic system. Turbulence can be probed by analyzing the fractal dimension of contours of the gas. The fractal dimension of an object is linked to its change of detail with change of scale. Any structure with non-integer fractal dimension obeys a power law. The Things (HI), Heracles (CO) and Sings (IR) surveys share a common goal of understanding the ISM in nearby galaxies. The fractal dimension of contours for each map were found to have overall different trends and different averages over intensity. This hints that the turbulence has different effects, and likely different causes in the various constituents of the ISM. In particular, the dust phase (70 microns IR) and the gas phases (HI and CO) have different fractal dimensions. We discuss here the meaning of these results.
G1.00007 Standardized AGN Fields for Photometric Reverberation Mapping, CARLA JUNE CARROLL, MICHAEL D. JONER, Brigham Young University — We present standardized Johnson/Cousins BVR photometry for comparison stars in the fields of several Active Galactic Nuclei. Our targets are part of a larger project using reverberation mapping techniques to determine the internal structure of the active region and to estimate the mass of the central black hole. We plan to present standard stars for fields including Zw 229-015, KA 1858, Mrk 817, Mrk 50, and NGC 4051. The next step will be to produce well-standardized light curves for the active galaxies. All data for this project have been secured using the 0.91-meter telescope at the BYU West Mountain Observatory.

G1.00008 Influence of Externally-applied Magnetic Fields on initial Ultracold Plasma Expansion Rates1, WEI-TING CHEN, JACOB ROBERTS, Colorado State University — Ultracold plasma expansion is influenced by the application of external magnetic fields even at the relatively small field magnitude of 0.1 mT. We present recent measurements of the short-time acceleration in ultracold plasma expansion under the influence of such applied magnetic fields. The observation of this acceleration has implications for electron diffusion rates in the ultracold plasmas, and has implications for efficient loading of ultracold plasmas into trap potentials.

1Supported by the AFOSR.

G1.00009 Diverse Light Emissions from Epoxy Due to Energetic Electron Bombardment1, JUSTIN CHRISTENSEN, JUSTIN DEKANY, J.R. DENNISON, Utah State University — Dielectric materials subjected to energetic electron fluxes can emit light in several forms. We have observed three distinct types of emissions: (i) short-duration (< 1 ms), high-intensity electrostatic discharge (ESD) or “arc” events; (ii) intermediate-duration, high-intensity events which begin with a bright arc followed by an exponential decay of intensity (∼10 to 100 se decay constant), termed “flares”; and (iii) long-duration, low-intensity emission, or cathodoluminescence, that continues as long as the electron flux is on. These events were studied for bulk samples of bisphenol/amine epoxy, using an electron gun with varying current densities (0.3 to 5 nA-cm−2) and energies (12 to 40 keV) in a high vacuum chamber. Light emitted from the sample was measured with high-sensitivity visible and near-infrared video cameras. We present results of the spatial and temporal extent for each type of event. We also discuss how absolute spectral radiance and rates for each type of these events are dependent on incident electron current density, energy, and power density and on material type, temperature, and thickness. Applications of this research to spacecraft charging and light emissions are discussed.

1This work was supported through funding from NASA GSFC.

G1.00010 How Can the Heisenberg be the Heisenberg Uncertainty Relation?1, JACOB J. COLLINGS, JEAN-FRANCOIS S. VAN HUELE, Brigham Young University — Since Heisenberg introduced the relation p1q1 ≥ h in 1927 (Zeitschrift für Physik, 43, 172), great effort has been made to refine this expression and better understand its meaning. At least two completely different interpretations of Heisenberg’s original relation have been developed; namely, an uncertainty (or indeterminacy) principle and an error-disturbance relation. In this contribution we emphasize the difference between these two manifestations of Heisenberg’s original relation: on the one hand, a lower bound for the product of the standard deviations of non-commuting operators, and on the other hand, the intrinsic error and disturbance that occur in the measurements of complementary observables. It is especially this last relation that is currently the subject of debate. We review the different relations with concrete examples using spin measurements.

G1.00011 Analytical modeling of line shapes in multidimensional spectroscopy, REBECCA CONRAD, MARK SIEMENS, University of Denver — Two-dimensional coherent spectroscopy (2DCS) is a powerful tool that has provided new insight into decoherence dynamics and coherent energy transport in biological and nanostructured materials. In order to determine physical properties from experimental 2D spectra, comparisons must be made to calculations based on the Optical Bloch Equations (OBEs). In this work, analytical and graphical models were produced to discover more about the connection between fundamental physical properties of materials and spectroscopic line shapes. We used the Projection-Slice theorem of Fourier transforms to simplify the calculation by rotating the solution to the OBEs to a diagonal/cross-diagonal space, which enabled an analytical solution. In contrast to numerical computational models used in the past to simulate solutions to the OBEs, our analytical representation is much more efficient, and therefore provides a faster and more direct way to analyze experimental data.

G1.00012 FalconSAT-7: A CubeSat Deployable Solar Telescope, THOMAS DICKINSON, United States Air Force Acadm, AIR FORCE ACADEMY FALCONSAT-7 TEAM1 — The United States Air Force Academy’s Department of Physics is building FalconSAT-7, a membrane solar telescope. The primary optic is a photon sieve – a diffractive element consisting of billions of tiny holes in a polymer sheet. Due for launch in 2015, FalconSAT-7 will serve as a pathfinder for future missions in lightweight, high-resolution, space-based surveillance.

1Comprised of USAFA Department of Physics, Department of Electrical/Computer Engineering, and Department of Astronautical Engineering.

G1.00013 Study of ion transport in sodium/proton antiporter proteins by molecular dynamics simulations, DAVID DOTSON, Arizona State University, CHIARA LEE, Imperial College London, DAVID DREW, Stockholm University, ALEXANDER CAMERON, University of Warwick, OLIVER BECKSTEIN, Arizona State University — Na+/H+ antiporters serve a vital role in cell homeostasis. New crystallographic X-ray structures for two antiporters exhibit two different conformations: a cytoplasmic-open one (NhaA from Escherichia coli) and a periplasmic-open one (NapA from Thermus thermophilus). NhaA and NapA show low sequence identity but high structural similarity, including a set of highly conserved residues at the sites considered to be vital for transport. The way in which these transporters operate at the molecular scale remains largely undetermined, but using molecular dynamics computer simulations to study the interaction of Na+ ions with the transport proteins affords us new insights. We identify likely ion binding sites in the inward and outward facing conformations, noting that Na+ binding is dependent on the protonation state of a conserved aspartate residue. We also identify a conserved salt bridge that can be destabilized by Na+ binding. Taken together, the combination of structural and simulation data suggests a new model for ion binding and transport for this class of antiporter.
G1.00014 Seeing the Cosmos at 1440 MHz, GREGORY ERICKSON, Utah State University — Hydrogen is the most plentiful element in the universe. Relaxation of energetic excited states of H emit light; the most intense emission is at a wavelength of 21 cm. This wavelength is much too long for detection in the visible part of the spectrum, so a radio telescope must be used to study these emissions. For this reason, construction and troubleshooting of a radio telescope is underway at Utah State University to study the universe at this 1440 MHz frequency. We present the design of the instrument, along with a status report of its construction and testing. Once the telescope is fully functional, a map of the sky will be acquired to determine the accuracy of the instrument and other experiments can then be underway.

G1.00015 Physics of Superluminal Communication and Estakhrt Relativistic Omega Factor, AHMAD REZA ESTAKHR, Researcher — Superluminal communication is a process by which one might send information at FTL (Faster Than Light). I try to developed this idea in detail and with mathematical rigor. The velocity of particle (information) is represented by the group velocity $v_g$. If $v_g \geq c$ then $\gamma = \sqrt{\frac{c^2}{c^2 - v_g^2}} = -i\Omega$ that which means $\gamma$ (Lorentz factor) is an imaginary number (at $v_g \geq c$), that can be written as a real number multiplied by imaginary unit $i$, which is defined by its property $i^2 = -1$. and this is $\Omega = \frac{1}{\sqrt{\frac{c^2}{c^2 - v_g^2}}}$ Estakhrt Omega factor. then kinetic energy of FTL particle is Complex number $E = E_o - E_o(i\Omega + 1)$. we still use Lorentz Symmetry, $\gamma^2 - c^2\beta^2 = 1$ which means faster than light is particle-like, $i^2\Omega^2 - i^2\Omega^2\beta^2 = \Omega^2\beta^2 - \Omega^2 = 1$. The phase velocity can be found from $v_{ph} = \frac{c^2}{\gamma}$, this shows that the phase velocity of FTL particle is less than the speed of light $v_{ph} = \frac{c^2}{\gamma} \leq c$. which means that speed of material particles can exceed $c$ but finally, the product of the group and phase velocities is equal to $c^2$, in general: if $v_g \leq c$ then $v_{ph} \geq c$, if $v_g \geq c$ then $v_{ph} \leq c$, if $v_g = c$ then $v_{ph} = c$ i.e., $v_gv_{ph} = c^2$.

G1.00016 Competition enhances stochasticity in biochemical reactions, TAYLOR FIRMAN, KINGSHUK GHOSH, Department of Physics and Astronomy, University of Denver, Denver, CO — We investigate the complex interplay between competition and stochasticity using coupled complexation reactions, (i) $A + B \leftrightarrow AB$ and (ii) $A + C \leftrightarrow AC$, as the model system, a reaction scheme common in biology. Within the master equation formalism, we compute the exact distribution of the number of complexes to analyze equilibrium fluctuations of several observables, which reveals that the presence of competition from one reaction can enhance fluctuation in the other. We provide quantitative estimates of this enhancement for different combinations of rate constants and reactant molecule quantities typical to biology. We notice that fluctuations can be significant even when two of the reactant molecules (say $B$ and $C$) are infinite in number, maintaining a fixed stoichiometry, while the other reactant ($A$) is finite. This is purely due to the coupling mediated via resource sharing and is in stark contrast to the single reaction scenario, where large numbers of one component ensure zero fluctuation. These observations indicate that averages can be a poor representation of the system, hence analysis that is purely based on averages such as mass action laws can be potentially misleading in such noisy biological systems.

G1.00017 Molecular Gas in the Andromeda Galaxy, BENJAMIN GERARD, JEREMY DARLING, NIKTA AMIRI, Center for Astrophysics and Space Astronomy, University of Colorado at Boulder — We present results from an Andromeda Galaxy (M31) survey of star-forming regions based on 24 $\mu$m luminosity for H$_2$O masers, NH$_3$ (1,1) and NH$_3$ (2,2) lines, and Hydrogen recombination lines (H66o). Although five H$_2$O masers were detected in the initial survey of 206 regions towards M31, we do not detect additional masers in a follow up survey of 300 similar compact 24 $\mu$m regions. We do not detect NH$_3$ (1,1), NH$_3$ (2,2), or H66o lines in any of the 506 regions. The typical rms noise for 3.3 km s$^{-1}$ channels in individual spectra is 2.5 mJy. Additionally, averaging all 506 spectra, shifted to the correct radial velocity, yields no detection for H$_2$O, NH$_3$ (1,1), NH$_3$ (2,2), or H66o. The typical rms noise for 3.3 km s$^{-1}$ channels in stacked spectra is 0.13 mJy. The non-detection of NH$_3$ provides an upper limit on NH$_3$ column density and corresponding dense gas fraction. In calculating this upper limit, we use both Herschel infrared continuum data and CO integrated line data to independently determine the mean molecular gas mass of each region and corresponding upper limits on the dense gas fraction.

G1.00018 Frequency stabilization of a silicon magneto-optical trap repump laser, JONATHAN GILBERT, SAMUEL RONALD, SIU AU LEE, WILLIAM FAIRBANK, Colorado State Univ — The primary goal of this research is to trap a single silicon atom in a magneto-optical trap. The trapped atom can be photoionized and used as a deterministic ion source.

G1.00019 Line Scribe Defect Characterization through Electroluminescence$^1$, ISAAC GONZALEZ, TYLER MCGOFFIN, None — Electroluminescence (EL) occurs when light is emitted from a material in response to a current through the material. Under forward bias, a photovoltaic device will exhibit this property. Using a CCD camera, we can collect spatially resolved information on the performance of a device. This technique can also be used with photovoltaic modules. In this poster, we will focus specifically on issues within the monolithic interconnects of full scale CIGS modules. Using varied magnifications and injection current densities and comparing these EL images to their optical counterparts allows us to diagnose these problem areas. Different combinations of partial, overlapping, and/or incomplete scribing can produce defects, and in turn, different signal responses.

$^1$Jim Sites
G1.00020 Emergent error correction in distributed controller networks, DAVID GRIFFIN, DAVID PEAK, Utah State University — Sparsely connected networks of sensor/controller-units have been successfully implemented in transportation and electric power systems, factory automation, and robotics applications. Usually, such distributed networks lack a central controller capable of globally coordinating unit activity; the tasks they perform, therefore, have to emerge from dynamics associated with how the units communicate. To investigate physical constraints on such communication, we studied a simple model in which the target task was to convert all controller outputs to the same on/off state in a specified time after start-up. The initial configuration of states in the network was determined by allowing each unit to respond independently to what it sensed (perhaps incorrectly) its environmental input to require. The uniform target configuration was assumed to consist of the unit state that was initially in the majority. The architecture of our network was a square array of units with communication between nearest neighbors only. We found communication rules for synchronously updating controller-unit states (in discrete time steps) that competently performed the target task with high accuracy despite strong initial disagreement between units and random persistence of incorrect unit state. Interestingly, the competent rules asymmetrically interrogate only two of a unit’s four nearest neighbors (depending on what its own state is) at each time step. Our goal is to apply insights gained from this study to try to understand the structure and function of controller-like networks found in multicellular biological organisms.

G1.00021 Structure and Morphology of Gold Nanoparticles Revealed with the Aid of Coherent X-Ray Diffraction, JAMES HANSON, New Mexico State University, KATE PAGE, Los Alamos National Laboratory, S. MANNA, University of California San Diego, R. HERDER, Argonne National Laboratory, O.G. SHPYRKO, ERIC FULLERTON, University of California San Diego, EDWIN FOHTUNG, New Mexico State University — Exceptional optoelectronic properties with applications in plasmonics, biosensing, and cancer therapy have been manifested by transition metal nanostructures. New nanostructure synthesis techniques have enabled precise control over the sizes/shapes of metal nanoparticles, leading to exotic morphologies that cannot be properly characterized using standard techniques. The optical response of these nanoparticles is size/shape dependent and locally variable. This sensitivity to morphology makes precise control over the growth of these nanoparticles and knowledge of their external/internal structures essential. One example is five-fold-twinned decahedral and icosahedral Au nanoparticles; which are strained as a result of their geometry. We present a detailed analysis of the local structure of a single Au nanoparticle by mapping the strain field from Coherent X-ray Bragg diffraction patterns. Our results confirm the presence of a disclinations within the structures consistent with the commonly accepted strain model, we however observe shear gradients. A comparison of the retrieved strain fields with finite-element calculations demonstrates the effects of elastic anisotropy on the strain state of these particles.

1 Also affiliated with Los Alamos Neutron Science Center, Los Alamos National Laboratory

G1.00022 Domain Morphology of Co/Pt Ferromagnetic Thin Films, KELSEY HATCH, None — I work with Co/Pt ferromagnetic thin films. The films are made of 50 bi-layers of Co and Pt. This layering causes the magnetic domains within the Co layers to align perpendicular to the film. My goal is to better understand the magnetic domain morphologies of Co/Pt thin films in the presence of a magnetic field. I apply magnetic fields of various strengths to a sample with a Vibrating Sample Magnetometer (VSM). The sample’s domain depends on its magnetic history, which creates a hysteresis loop when plotting the magnetic domain vs the field applied. After each application I use Magnetic Force Microscopy (MFM) to map the domains of the sample at remanence. The hysteresis causes domains to develop differently for different field strengths, resulting in domains that appear either maze-like or bubbly. By analyzing the MFM images I am able to correlate field strength to the domain morphology.

G1.00023 Microwave pulse compression utilizing nonlinear spin waves in magnetic thin films, PASDUNKORALE JANANTHA, Colorado State University, BORIS KALINIKOS, St. Petersburg Electrotechnical University in Saint Petersburg, Russia, MINGZHONG WU, Colorado State University — Narrow microwave pulses are desired for many microwave applications. In this presentation, a novel pulse compression is proposed. The pulse compression is realized through soliton-associated techniques which are widely known and used in optics to compress optical pulses. The experiments used yttrium iron garnet thin films as the dispersive nonlinear media to compress microwave pulses. The operational frequency is in the GHz range and could be tuned by varying the bias magnetic field. Compression rates of up to 7 times were observed. Due to the simplicity and tunability of the configuration, the compressor has a promising future for potential applications in radar and telecommunications systems.

1 This work was supported in part by U.S. National Science Foundation (No. ECCS-1231598), the U.S. Army Research Office (No. W911NF-12-1-0518, No. W911NF-11-C-0075), and the U.S. National Institute of Standards and Technology (No. 60NANB10D011).

G1.00024 Detection of Water Masers Toward YSOs in the LMC, ADAM JOHANSON, VICTOR MIGENES, Brigham Young University — We present results from a search for water maser emission toward three regions of massive star formation in the Large Magellanic Cloud (LMC). Six water maser spots were detected toward two of the regions, including one region with no known previous emission. Four of the maser spots are found to be associated with massive young stellar objects (YSOs). One maser spot appears to identify a previously unknown massive YSO. Another maser spot is associated only with a filament due to local enhancement of the interstellar medium. We argue that this may be the first extragalactic maser associated with a low-mass YSO. The third region hosts a newly discovered 22 GHz continuum source, also associated with a massive YSO. This illustrates the usefulness of masers as probes of the star formation process, both at a local and galactic scale.

1 NASA Rocky Mountain Space Grant

G1.00025 Micro-variability of AGN Markarian 421, JEREMY JUDGE, Univ of Colorado - Denver — Several Active Galactic Nuclei (AGN) have been observed in collaboration with the international group of scientists, VERITAS. These AGN are modeled as super massive black holes in the centers of young galaxies, and have a history of flares in the very high energy gamma-ray range. The presentation will concentrate on the micro-variability of the brightness of a single object, Markarian 421, over the course of select nights over several months. These observations were made in the optical spectrum, using yellow, red, and blue filters. Micro-variability observations are crucial because they give us important clues as to the mass, size, and radiation mechanism (including high energy particle jets).
G1.00026 Increased X-ray Yield from Femtosecond Laser Irradiation of Vertically Aligned Nanostructures, DAVID KEISS, AMANDA TOWNSEND, CLAYTON BARGSTEN, REED HOLLINGER, Colorado State University, MIKE PURVIS, None, CHRIS BENTON, Colorado State University, JORGE ROCCA, Colorado State Engineering Research Center, A. PUKHOV, A. PRIETO, V. SHLYAPTSEV, None, COLORADO STATE UNIVERSITY TEAM, HEINRICH-HEINI UNIVERSITAT COLLABORATION — Our purpose is to demonstrate a novel approach for converting optical laser energy pulses into bright picosecond X-ray pulses at a high conversion efficiency. In order to do this, a high contrast, femtosecond Ti:saph laser is used to irradiate vertically aligned nanostructure targets. This allows for the volumetric heating of the nanowire structure, creating multi-Kev temperature, near solid density plasmas with increased X-ray yields due to the greatly decreased cooling lifetime to hydrodynamic lifetime ratio—a key component in conversion efficiency. Using a set of 12 filtered Si diodes and a bent Mica crystal spectrometer, we monitored the x-ray yield and spectra in different regions on a shot by shot basis. We have measured a conversion efficiency of 5% for hv>900eV in 2 pi radians for Au wires irradiated with pulses of 5x10^18Wcm^-2.

1Department of Electrical and Computer Engineering, Department of Physics, and Department of Chemistry
2Duesseldorf, Germany

G1.00027 Critical Field and Temperature of a Frustrated Antiferromagnetic Ising Model in the Mean Field Approximation, RICHARD KRANTZ, Metropolitan State University of Denver — A long-ranged, one-dimensional, antiferromagnetic Ising model on a two-sublattice Maximally Even (ME) lattice has been developed in the Mean Field Approximation (MFA). Douthett and Krantz [1996] and Krantz, Douthett, and Doty [1998] have shown that an alternative distribution of sites on a one-dimensional lattice, a so-called Maximally Even (ME) Distribution, can be used to describe unusual magnetic orderings of antiferromagnetic Ising systems. When the magnetization of the “down” lattice approaches zero the lattice makes a transition to the paramagnetic state. The magnetic field at which this occurs is the critical field. In the limit of zero applied magnetic field the temperature at which the net magnetization of the lattice goes to zero, the so-called critical temperature, can also be evaluated. Both the critical field and the critical temperature depend on: 1) the structure of the lattice—the distribution of up and down lattice sites, 2) the number of neighboring interactions accounted for, and 3) the strength of the interaction between neighboring spins. The traditional Ising model is limited to only near-neighbor pairings. This work demonstrates that modeling a one-dimensional antiferromagnetic Ising lattice as a two-sublattice ME lattice in the MFA allows us to describe the critical field and critical temperature of frustrated one-dimensional spin systems in terms of long-ranged spin interactions and the distribution of up and down lattice sites.

G1.00028 Mother’s Day Gift from the Sun: Modeling the Response of the Ionosphere to X-Class Solar Flares, MAGGIE LEWIS, JAN J. SOJKA, MICHAEL DAVID, ROBERT SCHUNK, Utah State Univ, JOSEPH B. JENSEN, University of New Hampshire, MICHAEL NICOLLS, SRI International, Menlo Park, CA, TOM WOODS, FRANK EPARVIER, LASP, University of Colorado Boulder — The following study was performed to better understand the effects of solar flares on the Earth’s ionosphere, focusing on the large X class solar flares that occurred over Mother’s Day weekend 2013. NASA’s EVE instrument aboard the Space Dynamics Observatory (SDO) satellite measures the irradiance spectrum of the Sun continuously, and data is available in real-time. The sunlight causes ionization of nitrogen and oxygen atoms and molecules in the upper atmosphere thus creating the ionosphere. The important part of the solar sector for this ionization is the X-ray and ultraviolet light. The X-class solar flares occur in from solar eruptions that increase the X-ray irradiance by over a 1000 times normal. Using the data collected by EVE to fuel the Time Dependent Ionospheric Model (TDIM), a model of how the ionosphere reacts and changes with regards to Sun’s light is simulated. The TDIM models of the ionospheric composition and behavior are then compared to empirical measurements of the ionosphere made by the Poker Flats Incoherent Scatter Radar (PFISR). The PFISR radar is located near Fairbanks, Alaska and operated continually such that a detailed history of how the ionosphere is responding to solar variations is obtained. These variations include the response to the short duration, 30 to 60 minute, X-class flares.

G1.00029 Sputtering Growth and Ferromagnetic Resonance Characterization of Nanometer-Thick Yttrium Iron Garnet films, TAO LIU, HOUCHEN CHANG, YIYAN SUN, MICHAEL KABATEK, MINGZHONG WU, Department of Physics, Colorado State University, VINCENT VLAMINCK, AXEL HOFFMANN, Materials Science Division, Argonne National Laboratory, JUNQING DENG, University of Electronic Science and Technology of China — High-quality nanometer-thick epitaxial yttrium iron garnet (YIG) films have been grown on gadolinium gallium garnet substrates by magnetron sputtering. The films had a thickness range of 5 to 30 nm and exhibited same crystalline orientation as the GGG substrates. The surface roughness of smooth films can be as small as 0.1 nm, which was very close to the roughness of GGG substrate. The ferromagnetic resonance (FMR) profiles can be fitted nicely with Lorentzian functions, but not with Gaussian functions. This indicated that the films had high uniformity. The FMR linewidth were in the range of 6 to100 Ge at 9.48 GHz and varied with both the sputtering and annealing conditions, as well as the crystalline structure of the GGG substrate. For films with very smooth surfaces, the FMR linewidth increased linearly with frequency and the damping constant was about 0.001. In contrast, for films with big grains on the surface, the linewidth-frequency response was strongly nonlinear.

1This work was supported in part by U.S. National Science Foundation (No.ECCS-1231508), the U.S. Army Research Office (No. W911NF-12-1-0518, No.W911NF-11-C-0075), and the U.S. National Institute of Standards and Technology (No. 60NANB10D011).

G1.00030 Time Dependent Conductivity of Low Density Polyethylene, PHIL LUNDGREEN, Undergraduate, USU SURFACE PHYSICS GROUP TEAM — The time independent conductivity of Low Density Polyethylene (LDPE) is useful in determining rates of conductivity based on intrinsic properties of a material. A simple, yet elegant, parallel plate capacitor setup allowed for data collection which extended beyond 170 hours. Through precise measurements the different stages of charge distribution were determined to the level of 300E-16 A. Through the use of data analysis programs the dielectric constant and dispersion constant were both determined for LDPE and then compared with a simple, macroscopic, first-principles model to determine the quality of the fit.
G1.00031 Development Of Gas-Electron Multiplier Based Time Projection Chamber in MAMI Crystal Ball, MATHEW MEHRIAN

G1.00032 Optical properties of Sm doped CeO₂ thin films produced by liquid solution deposition, K.N MITCHELL, C.A RODRIGUEZ, T. WILLETT-GIES, Y. LI, S. ZOLLNER, New Mexico State University — Cerium(IV) oxide (CeO₂ or ceria) is a transparent, insulating oxide of the rare earth metal cerium. Ceria is an ionic conductor with applications in fuel cells, as a catalyst, or photovoltaic water splitting (hydrogen production). The films studied here were produced by liquid solution deposition followed by annealing. Additionally we investigate the effect of Sm doping (up to 20%) of ceria. The rare earth metal samarium usually forms a sesquioxide Sm₂O₃. Therefore, doping ceria with Sm is expected to lead to the formation of oxygen vacancies, which enhances the ionic conductivity of ceria. Our ellipsometry spectra can be described very well in the transparent region (below 3 eV) using a Tauc-Lorentz dispersion model for ceria. Once the thickness parameters have been determined, we obtain the optical constants of CeO₂ using a basis spline expansion. As expected from Kraut-Kronig constraint, we find a significant reduction of the height of the main absorption peak at 4 eV. The direct band gap, however, remains at 3.7 eV, independent of Sm content. We will also report XRD, AFM, and Raman results for our Sm-doped ceria films.

G1.00033 Winter Climatology of Short-Period Polar Mesospheric Gravity Waves Observed Over Poker Flat Research Range, Alaska (65°N, 147°W), MICHAEL NEGALE, Utah State University, KIM NIELSEN, Utah Valley University, MIKE TAYLOR, DOMINIQUE PAUTET, Utah State University, MARGIT DYRLAND, The University Centre in Svalbard — Short-period gravity wave observations over the Arctic region are few and their impact on the Arctic mesosphere lower thermosphere region via momentum deposition is of high interest. The Mesospheric Airglow Imaging and Dynamics project was initiated in January 2011 to investigate the presence and dynamics of these waves over the interior of Alaska. Observations were made from Poker Flat Research Range (PFRR) using an all-sky imager. This site provides an exceptional opportunity to establish a long-term climatology of short-period gravity waves in the Arctic Region. We present summary measurements of prominent gravity waves over two consecutive winters and compare their characteristics with recent observations at Resolute Bay, Canada (75°N), ALOMAR Station, Norway (69°N), Svalbard (78°N), and Rothera Station (76°S). The wave parameters measured at PFRR were found to be similar to the other high-latitude sites, except for the wave headings. The waves at PFRR exhibited dominant eastward motion, while the other observations reported westward motion. To investigate this wave directionality, we look at the effects of critical level filtering.

G1.00034 Infrared and Visible Dielectric Properties of (LaAlO₃)₀.₃ (Sr₂AlTaO₆)₀.₇¹, TIMOTHY NUNLEY, TRAVIS WILLETT-GIES, STEFAN ZOLLNER, New Mexico State University — LSAT (LaAlO₃)₀.₃ (Sr₂AlTaO₆)₀.₇ is a crystalline with a perovskite structure that has a good lattice match for many oxide materials and could replace LaAlO₃ and SrTiO₃ substrates. We measured the pseudo-dielectric function of LSAT from 0.6 to 6.3 eV using spectroscopic ellipsometry. The dielectric function was then modeled allowing us to obtain the optical band gap of 4.9 eV. A transmission series was also taken in vacuum from 77 K to 600 K in 25 K steps showing that the change in the band gap of LSAT is inversely proportional to the change in temperature. Transmission measurements were also taken in air at room temperature allowing us to calculate and plot the absorption coefficient as a function of photon energy. Fourier-transform infrared (FTIR) ellipsometry was also performed from 250 to 8000 cm⁻¹. The dielectric function in this range was then modeled using a factorized dispersion model containing transverse (TO) and longitudinal (LO) optical phonon energies and independent broadenings for each mode. Five TO phonons were found at 284, 392, 444, 663, and 756 cm⁻¹. There were five corresponding LO phonons located at 355, 434, 551, 753, and 788 cm⁻¹. A possible strong TO mode located at 150 cm⁻¹ is below our spectral range.

G1.00035 Low Band Gap Small Molecule Acceptors for Organic Photovoltaics, DAVID P. OSTROWSKI, University of Denver, UNSAL KOLDEMIR, ALAN SELLINGER, Colorado School of Mines, SEAN E. SHAHEEN, University of Colorado at Boulder and RASEI — Organic photovoltaics (OPVs) have demonstrated solar power conversion efficiencies in the regime of 10-12% from several classes of materials, including conjugated polymers and small-molecules. Of note, in each of the classes, the electron-accepting molecule is based on C₆₀. While C₆₀ is a very effective electron-acceptor and transporter, it has several non-optimal properties, including low optical absorption strength in the visible spectrum as well as the difficulty required to tune its optoelectronic properties through changes in chemical composition or substituents. Here we present results on a family of small molecule acceptors based on a core unit of benzothiadiazole (BT). The optoelectronic properties, specifically optical band gap and Lowest Occupied Molecular Orbital (LUMO), of these small molecules are readily tunable through addition of substituent groups onto the BT core. A library of these small molecule acceptors has been synthesized with broad absorbance bands of roughly 200 nm, which vary in peak absorbance from 400 nm to 640 nm. Additionally, the higher energy LUMO level of these materials, 0.3 eV higher than the C₆₀ derivatives, results in OPVs with open-circuit voltages (V_{oc}) close to 1 V. The studies presented investigate overall device performance and compare the efficiencies of the two mechanisms for charge generation: channel 1 (light absorbed in donor with sequential electron transfer to acceptor molecule) and channel 2 (light absorbed in the acceptor with sequential hole transfer to donor molecule).

1 We would like to acknowledge the National Science Foundation (DMR-11049334), CINT at Sandia National Laboratory, and the New Mexico Space Grant Consortium.
G1.00036 Puzzling Results from a new Spacecraft Plasma Sensor Experiment, STEVEN OWENS, United States Air Force Academy — Current space plasma sensors require multiple high voltage power supplies and a spinning spacecraft to acquire a full reading of the surrounding plasma. These requirements drive the cost of launching space plasma sensors higher, decreasing their true effectiveness (no launches means no data). To resolve this issue, a new design for plasma spectrometers is needed. Such a device must be capable of taking ultrafast measurements using only one high voltage power supply. One solution, designed by Los Alamos National Laboratory, is called the 2-Pi Plasma Spectrometer, or 2PiS. During the first phase of the project, a prototype was built to compare proof of concept against simulated data. Testing the prototype produced an odd result: the prototype performed better than the simulation predicted. To understand why this occurred and to exploit the problem in the future, the background theory was tested in the simulation. After the equations proved to be correct, internal parts of the 2PiS were skewed from perfect in a simulation to see what effect this would have. While skewing the plates does have some effect, no single skew could cause the difference seen in the data.

G1.00037 Asymmetric disk heating in an extreme binary, epsilon Aurigae: a useful tool for unveiling a system’s unknowns, RICHARD PEARSON, University of Denver — Epsilon Aurigae is a 27-year eclipsing binary system consisting of a large, warm FO star and a hidden companion inside a semi-grey, opaque disk. The evolutionary state (and hence, the characteristics of the system components) is not well-defined due to a large uncertainty in the determined distance. By using the observed disk temperatures, I attempt to resolve the distance discrepancy by analytic and numeric means. Both methods require investigation of the disk properties. Examination of disk temperatures in epsilon Aurigae creates a blueprint for a novel way of determining dust properties and other characteristics of additional dusty systems. This is another tool for extracting information from systems with limited known quantities. I am grateful to the estate of William Herschel Womble for the support of astrophysics at the University of Denver.

G1.00038 Atomic Oxygen Modification of the Nanodielectric Surface Composition of Carbon-Loaded Polyimide Composites, KELBY PETERSON, JR DENNISON, Utah State University — Black Kapton is a nanodielectric composite of carbon particles (100-500 nm) embedded in an insulating polyimide polymer matrix (100-5000 nm depth). Analysis of this nanodielectric composite has been done via optical imaging, scanning electron microscopy, and energy-dispersive x-ray analysis in order to gain insight into its nanodielectric properties. The insulating polyimide is known to be inert and impervious to strong bases and acids, but is affected by atomic oxygen exposure. We have observed changes in the surface structure and relative carbon-polymer concentrations in MISSE-6 samples that were exposed to the low earth orbit environment for 18 months outside the International Space Station. The MISSE-6 sample tray conducted studies of the effects due to varied atomic oxygen exposure. MISSE samples received maximum atomic oxygen exposure on the ram side with decreased exposure on the wake and shielded sides, respectively. Early observations suggest that the atomic oxygen modifications reduce the polymer matrix on the surface, whilst the carbon-loaded regions remain largely unaffected by the exposure. Effects of the surface modifications on spacecraft charging and cathodoluminescence will be discussed.

1Work supported through funds from NASA GSFC and the USU College of Science.

G1.00039 Optical Properties of Bulk Nickel as a Function of Temperature, LAURA PINEDA, STEFAN ZOLLNER, New Mexico State University — Nickel is a silvery-white metal, element number 28 in the first row of the transition metals. It is ferromagnetic below the Curie temperature (TC=630 K), i.e., it retains a net magnetization in the absence of a magnetic field. When heated above the Curie temperature, it becomes paramagnetic and loses its magnetization. The literature reports a distinct change in the slope of the DC electrical resistivity of nickel versus temperature near the Curie transition. Similarly, a change in the optical reflectivity of nickel has been reported at TC. We therefore used spectroscopic ellipsometry to measure the complex refractive index of nickel with very high precision from 77 to 800 K. In our data for n(T), we find deviations from linearity near 150 K and near 590 K. The refractive index also changes again at even higher temperatures. We believe that our data are affected by two factors: (1) The native oxide on the Ni surface disintegrates above 700 K, leading to a change in the surface condition of our sample. (2) The optical constants also change near the Curie temperature. Work is in progress to separate the two observed phenomena.

1Alliance for Minority Participation

G1.00040 Functionalizing Carbon Nanotube Forests with 1,5-diaminonaphthalene, BENJAMIN POUND, T.C. SHEN, Utah State University — Carbon Nanotube (CNT) Forests are vertically grown carbon nanotubes. They can be as tall as millimeters, with radii from less than one nanometer (single-walled) to tens of nanometers (multi-walled). Their high surface area to volume ratio provides a unique material system for biosensor applications. However, the CNT surface does not provide covalent bonding sites to many antibodies of interest. One approach is to attach linker molecules with aromatic rings via π-stacking to the CNT surface and activating the linker molecules to bind covalently to specific antibody molecules. Unfortunately, the conventional solution-based functionalization approach often leads to collapse of the CNT forest and hence a significant loss of binding sites. In this presentation we report our study of depositing 1,5-diaminonaphthalene on CNT forest by a vapor deposition method. We characterize the amount of deposition by fluorescence spectra. We plan to pattern CNT forest to further enhance the surface coverage by varying the geometry of CNT forest columns.

G1.00041 Satellite and Ground-Based Measurements of Mesospheric Temperature Variability over Cerro Pachon, Chile (30.3° S), JONATHAN PUGMIRE, MICHAEL TAYLOR, YUCHENG ZHAO, P. DOMINIQUE PAUTET, Center for Atmospheric and Space Sciences, Utah State University, JAMES RUSSELL, Center for Atmospheric Sciences, Hampton University — Observations of mesospheric OH (6,2) rotational temperatures by the Utah State University Mesospheric Temperature Mapper (MTM) located at the Andes Lidar Observatory, Cerro Pachon, Chile (30.3° S, 70.7° W) reveal a large range of nightly variations induced by atmospheric gravity waves and tides, as well as strong seasonal oscillations. This study investigates MTM temperature variability over the past 4 years comprising over 800 nights of high-quality data and compares the results with MTM measurements from Maui, Hawaii (2001-2005) and coincident mesospheric temperature measurement by the SABER instrument on the NASA TIMED satellite.

1This research is supported under NSF collaborative grant #0737608.
G1.00042 Investigating Proto-Planetary Nebulae through Angular Differential Imaging. REBECCA RATTRAY, TOSHIYA UEITA, University of Denver — Studying the Proto-Planetary Nebula (PPN) stage of a star’s life sheds light on the critical mass-loss mechanism that leads to the morphological change from spherically symmetric to axisymmetric circumstellar material. However, when studying material very faint in reflection so close to a star, the brightness of the star itself becomes prohibitive. Therefore, in order to study the circumstellar material more effectively, it is necessary to block out the central star. The method of Angular Differential Imaging (ADI), used in this research, creates a better characterization of the point-spread-function (PSF) of the central star for more effective subtraction than previous PSF subtraction techniques. ADI has successfully been used to verify extrasolar planets, but this is one of the first attempts at adopting ADI techniques for extended structures as opposed to point sources. In this study, ADI techniques were applied to PPN observations to better study the most recent mass-loss histories of PPNs. Data for the PPNs were taken at the Near Infrared Coronographic Imager (NICI) at Gemini South between March and September 2012. New details on the circumstellar structure of 6 PPNs will be presented.

G1.00043 Correlating cell morphology and stochastic gene expression using fluorescence spectroscopy and GPU-enabled image analysis. EVAN SHAPIRO, Department of Physics, University of Colorado Denver, Denver, CO 80217, EVAN PERILLO, Biomedical Engineering, University of Texas at Austin, Austin, TX, DOUGLAS SHEPHERD, Department of Physics, University of Colorado Denver, Denver, CO 80217 — Biological processes at the microscopic level appear stochastic, requiring precise measurement and analytical techniques to determine the nature of the underlying regulatory networks. Single-molecule, single-cell studies of gene expression have provided insights into how cells respond to external stimuli. Recent work has suggested that macroscopic cell properties, such as cell morphology, are correlated with gene expression. Here we present single-cell studies of a signal-activated gene network: Interleukin 4 (IL4) RNA production in rat basophil leukemia (RBL) cells during the allergic response. We fluorescently label individual IL4 RNA transcripts in populations of RBL cells, subject to varying external stimuli. A custom super-resolution microscope is used to measure the number of fluorescently labeled IL4 transcripts in populations of RBL cells on a cell-by-cell basis. To test the hypothesis that cell morphology is connected genotype, we analyze white light images of RBL cells and cross-reference cell morphology with IL4 RNA levels. We find that the activation of RBL cells, determined by white-light imaging, is well correlated with IL4 mRNA expression.

G1.00044 Probing Ancient Mass Loss with AKARI’s Extended Thermal Dust Emission Objects. RACHAEL TOMASINO, TOSHIYA UEITA, Univ of Denver — We present the results from the calibration and analysis of 166 far-IR extended thermal dust emission objects that were observed with AKARI’s FIS detector. The primary goal is to map the circumstellar shells of evolved stars in detail to excavate the ancient history of dusty mass loss. After establishing an extended aperture photometry method, we characterized the flux dependent slow transient response correction factors for each of the four wavelength bands. Using the new correction factors for extended (far-IR) emission, we present the photometric values that were calculated for the entire data set and also report our work on morphology characterization of the extended dust shells.

G1.00045 Bright X-ray Sources from Ultra-high Density Matter in Volumetrically Heated Nanowire Arrays. AMANDA TOWNSEND, REED HOLLINGER, CLAYTON BARGSTEN, MICHAEL PURVIS, DAVID KEISS, CHRIS BENTON, AMY PRIETO, Colorado State University, ALEXANDER PIKHOV, Heinrich-Heine-Universitat, V.N. SHLYAPTSVE, JORGE ROCQA, Colorado State University — Trapping femtosecond laser pulses of relativistic intensity within ordered nanowire arrays results in the volumetric heating of matter to multi-Kev, near solid density plasmas. Using high contrast pulses of 60fs FWHM duration from a frequency doubled Ti:Saph laser, we irradiated arrays of 55nm and 80nm diameter Au and Ni targets with 12% of solid density at intensities of 5x10^18 Wcm^-2. We observed strong He-like line emission that surpassed the characteristic K-a emission by an order of magnitude. The Au nanowire spectrum displayed strong Au M-shell emission with unresolved 4-3 lines from ions ranging from Co-like to Ga-like Au. Filtered photodiode measurements show a ~100x emission increase with respect to smooth solid targets for photon energies >9keV.

1Work supported by Defense Threat Reduction Agency grant HDTRA-1-10-1-0079 and by the HEDLP program of the Office of Science of the U.S Department of Energy. Equipment developed under NSF grant MRI-ARRA 09-561. A.P was supported by DFG-funded project TR18

G1.00046 Analysis of interface node dynamics in Drosophila during germ-band extension. TIMOTHY VANDERLEEST, ASHLEY MOTLONG, MARISSA KUHL, TODD BLANKENSHIP, DINAH LOERKE, University of Denver — Tissue elongation is a fundamental morphogenetic process crucial to embryogenesis and organogenesis in vertebrates and invertebrates. One widely studied example of tissue elongation is Drosophila germ-band extension (GBE) in which an initially hexagonal array of cells approximately doubles in length along the anterior-posterior (AP) axis. This process is driven by cell intercalation where interfaces between cells along the AP axis fully contract to a common vertex and interfaces form between dorsal-ventral neighboring cells. The current model holds that intercalation is caused by anisotropic tension mediated by actomyosin contractility. Using automated computational image segmentation we have tracked the motion of cells during GBE with high spatial and temporal resolution, which includes the tracking of interfaces and interface vertices. Through cross correlation analysis on the motion of vertices of contracting AP interfaces we have found that vertex behavior is not correlated and, in fact, display independent displacements. These results are inconsistent with a tension-based model in which supracellular actomyosin networks drive coordinated node behaviors.

G1.00047 Ultracold plasma expansion rate dependence on non-neutrality. CRAIG WITTE, JACOB ROBERTS, Colorado State University — Ultracold plasmas are formed by photoionizing a collection of laser cooled atoms. Once formed, these plasmas expand. This expansion is driven by both the thermal energy of the plasma electrons, as well as electrostatic energy owing to non-neutrality. Both the parameters can be experimentally controlled with a significant degree of independence. Combining previous work[1-3] we have developed a theoretical model designed to investigate the dependence of ultracold plasma expansion on the degree of non-neutrality of these plasmas in a parameter range relevant to experiments. We find that variations of the plasma neutrality produce non-negligible changes in predicted electron temperature evolution and plasma expansion rate. Such behavior needs to be taken into account for an accurate interpretation of ultracold plasma parameters relevant to experimental measurements.

1Supported by the AFOSR
G1.00048 Detecting cosmic ray electrons in the tracking region of space borne instruments. AARON WORLEY, JONATHAN ORMES, University of Denver — Cosmic Ray Electrons (CREs) contribute only \( \sim 1\% \) to the total number of particles we observe here on Earth and are of current interest because of the recently discovered rising fraction of positrons as measurements approach 1 TeV. We review our recent progress in particle identification (PID) methods using dedicated information from the tracking region of a space borne detector. Our primary focus is the identification of CREs in the Fermi Large Area Telescope and the Calorimetric Electron Telescope, current and future missions respectively. The impact of including a dedicated PID algorithm in the tracker to improve the efficiency and rejection power of the detectors above will also be discussed.

G1.00049 Plasma sheath effects in the sampler and skimmer cones of the ICP-MS. MATTHEW ZACHRESON, ROSS SPENCER, Brigham Young University — In the ICP-MS, plasma neutrality and the associated issue of the plasma potential are governed by what happens in the plasma sheath. Plasma sheaths can generally be described by two model types: collisional, where the Debye length is long compared to the mean free path; and collisionless, where the mean free path is long compared to the Debye length. In the sampler cone, the Debye length is \( \sim 3\) micrometers, while the ion mean free path is 5 micrometers, nearly in the collisionless regime. In the skimmer cone, the Debye length is 2 micrometers, while the ion mean free path is 400 micrometers, well into the collisionless regime. Doing a full calculation with the Direct Simulation Monte Carlo algorithm, FENIX, would involve simulating electron physics, performing electrostatic field calculations, and resolving the small Debye length, all of which are computationally expensive. To approximate sheath formation in the sampler and skimmer, a forced ion flux model is made by first estimating the number of ions per second that should recombine at the wall using a simple, planar, collisionless sheath model, and then forcing the ions near the wall to have that flux by modifying their velocities each time step. The ion loss through the sheath results in a steep drop in the ion density at the nozzle wall which both diffuses and is sheared by the nozzle flow. Another plasma effect is that the sheath inhibits electron flow to the wall, greatly reducing thermal conduction to the wall. This means that the electron temperature of the plasma in the nozzle is hardly affected by the presence of the metal wall. In particular, setting the electron temperature equal to the wall temperature at the wall is inappropriate.

G1.00050 Beyond Exoplanets: Taking advantage of Kepler Object of Interest fields after the presence or absence of an exoplanet has been documented. PAMELA LARA, Brigham Young University and Utah Valley University — Since the Kepler Mission made public its data on planet-candidates we have observed a few Objects of Interest -KOI- with our 0.9 m telescope at West Mountain Observatory to confirm or reject their nature as planets. Most of our chosen targets were found not to be planets. However, the data acquired need not be discarded since other bodies in the fields may present interesting light curves deserving of further investigation and study. This is the case for one of our KOI candidates, which turned out to be an eclipsing binary system. While performing differential photometry with stars in the field, I found a contact eclipsing binary that was not in the Kepler data base. In this poster I will present data on the new contact binary and discuss other interesting variable objects I have found in the Kepler field of view. This research was performed while participating in the Physics and Astronomy REU program at Brigham Young University during the summers of 2012 and 2013.

1Brigham Young University and the National Science Foundation

Friday, October 18, 2013 8:00PM - 9:00PM —
Session H1 Reception and Banquet  Driscoll Ballroom - John Cumalat, University of Colorado

8:00PM H1.00001 Banquet Talk , DAVID WINELAND, NIST —

Saturday, October 19, 2013 8:00AM - 9:36AM —
Session I1 ÆMO III: Quantum Computing and Ultracold Dynamics 151 - William Fairbank, Colorado State University

8:00AM I1.00001 Two-dimensional quantum turbulence in Bose-Einstein condensates. BRIAN ANDERSON, College of Optical Sciences, University of Arizona — One of the most challenging problems in the study of turbulence is the development of a quantitative understanding of the relationships between microscopic attributes of the flows, such as vortex dynamics, and statistical flow characteristics, such as energy spectra. Within the field of two-dimensional quantum turbulence (2DQT), this hurdle may be surmountable using atomic Bose-Einstein condensates. With highly oblate BECs, numerous experimental methods are available to generate the disordered distributions of quantized vortices associated with 2DQT, and new BEC and vortex detection and manipulation techniques are under development. In conjunction with experimental progress, analytical and numerical efforts are rapidly uncovering new aspects of vortices, microscopic flows, and energy spectra of 2DQT. This talk will introduce the study of 2DQT in BECs, mainly focusing on experimental progress and future directions in the investigation, manipulation, and detection of quantized vortices in 2DQT.

1The experimental portions of this work have been supported by the National Science Foundation, grants PHY-0855677 and PHY-1205713.

8:24AM I1.00002 Unexpected Ultracold Plasma Physics at Lower Densities: Oscillations and Evaporation. JACOB ROBERTS, Colorado State University — We have constructed an experimental apparatus designed to confine ultracold plasmas in a modified Penning trap. As an unanticipated consequence of this design, the ultracold plasmas in our system are formed at significantly lower densities than is typically the case in experiments elsewhere. These lower densities allowed the observation of a qualitatively different type of resonant electron motion in response applied rf fields. Also, we found that lower ultracold plasma density enhanced the influence of evaporation on the cooling of the electrons as the ultracold plasma expands. These observations will be described along with an overview of planned future measurements to be conducted with our system.

1Supported by the AFOSR
9:00 AM I1.00003 Algebraic and Numerical Algorithms for Quantum Evolution. TY BEUS, ALBERTO ACEVEDO, MANUEL BERRONDO, JEAN-FRANCOIS S. VAN HUELE, Brigham Young University — Quantum evolution requires the manipulation of infinite series of products of non-commuting operators. Lie algebra techniques allow us to reduce the time-dependent operator calculus to the solution of a set of coupled differential equations for scalar functions, while automatically guaranteeing unitarity of the factorized evolution operator. We discuss the development of computer programs to implement this technique of combined factorization and application to quantum states. We use them on driven anharmonic and optomechanical oscillators to find how transition probabilities in these systems evolve in time.

9:12 AM I1.00004 The quest for greater strong coupling in ultracold neutral plasmas1. MARY LYON, SCOTT BERGESON, Brigham Young University — In most physical systems, a few energy scales appear naturally. For interacting many-body systems such as ions in a plasma, electrons in a metal, or even Bose-Einstein condensates or nuclear collisions, the two most natural energy scales are the average energy per particle and the average nearest-neighbor potential energy. When the ratio of nearest-neighbor potential energy to kinetic energy is greater than 1, we say that the system is “strongly coupled.” When this happens, the system can display medium-to-long-range many-body behavior that is more typical of a glass or crystal rather than a gas of atoms. In our experiments, we are working with plasmas in this exotic regime. The plasmas are created by photo-ionizing laser-cooled atoms. The ratio of energy scales in our work is about 2. Of course, we would like to see this number increase to something like 100, making our plasmas more like fluffy crystals than disordered liquids. In my talk I will describe our work and some of the things we are doing to make our plasma ions extremely cold.

1 NSF, AFOSR, NASA

9:24 AM I1.00005 Cavity-aided non-demolition measurements for enhanced spin squeezing1. MATTHEW NORCIA, JUSTIN BOHNET, KEVIN COX, JOSHUA WEINER, ZILONG CHEN, JILA, University of Colorado at Boulder, JAMES THOMPSON, JILA, University of Colorado at Boulder, NIST — Projection noise sets a maximum resolution for all sensors that use population measurements of unentangled atoms to sense a quantum phase — the “Standard Quantum Limit.” This limitation can be overcome through the use of entangled, “squeezed” ensembles of atoms, allowing for potential improvements in sensor performance. We use quantum non-demolition measurements to prepare and directly observe spin-squeezed states with phase resolution 10.2(6)dB below the SQL, with no background subtraction.

1 This material is based upon work supported by the National Science Foundation under Grant Number 1125844; NSF PFC, DARPA Quasar, ARO, NIST, NSF GRF, NDEG, A*STAR

Saturday, October 19, 2013 8:00AM - 9:24AM — Session I2 Condensed Matter III: Magnetics 281 - Lincoln Carr, Colorado School of Mines

8:00 AM I2.00001 Yttrium Iron Garnet Nano Films for Spintronics Applications1. MINGZHONG WU, Department of Physics, Colorado State University — Magnetization precession in yttrium iron garnet (YIG) damps slower than in any other known magnetic materials. This fact gives rise to the recent birth of a new paradigm in the discipline of spintronics — “spintronics using yttrium iron garnets.” This presentation will touch on several important topics related to YIG spintronics. The first part will demonstrate the feasibility of the use of pulsed laser deposition and magnetron sputtering to grow low-damping, nanometer-thick YIG films. The second part will present the determination of efficiency of spin angular momentum transfer across YIG/normal metal interfaces. The last part of the presentation will report on the impacts of the magnetic proximity effect on spin pumping in YIG/Pt heterostructures.

In collaboration with Yiyan Sun, Tao Liu, Houchen Chang, Zihui Wang, Michael Kabatek, William Schneider, Department of Physics, Colorado State University; B. Kardasz, C. Burrowes, E. Montoya, B. Heinrich, Department of Physics, Simon Fraser University; and Suzanne Velthuis, Vincent Vlaminck, Helmut Schultheiß, Axel Hoffmann, Materials Science Division, Argonne National Laboratory.

1 This work was supported in part by U.S. National Science Foundation (No. ECCS-1231598), the U.S. Army Research Office (No. W911NF-12-1-0518, No. W911NF-11-C-0075), and the U.S. National Institute of Standards and Technology (No. 60NANB10D011).

8:24 AM I2.00002 Ferromagnetic Resonance in CoFeB Ultrathin Films with Perpendicular Anisotropy1. DAVID ELLSWORTH, LEI LU, MINGZHONG WU, Colorado State Univ, DING-SHUO WANG, CHIH-HUANG LAI, National Tsing Hua University, Hsinchu, Taiwan — Magnetic ultrathin films with perpendicular anisotropy have potential applications in high-density, fast-switching magnetic memories. This presentation reports on ferromagnetic resonance (FMR) in CoFeB films which are only 1 nm thick and have strong perpendicular magneto-crystalline anisotropy. The samples were a multi-layered structure of Si/SiO2/Pd(3nm)/CoFeB(1nm)/MgO(1.6nm)/Pd(3nm). The FMR measurements were carried out by placing the film sample on a co-planar waveguide (CPW), magnetizing the film with an out-of-plane magnetic field, and measuring the transmission coefficients of the film/CPW structure with a vector network analyzer. The measurements were conducted over a frequency range of 10-33 GHz. The fitting of the measured FMR field vs. frequency responses with the Kittel equation yielded effective anisotropy fields that were close to the values obtained from the hysteresis loop measurements of the films. The linear fitting of the FMR linewidth vs. frequency responses gave rise to an effective Gilbert damping constant range of 0.01-0.02. The fitting also indicated a strong contribution (200-500 Oe) to the FMR linewidth from long-range film inhomogeneity.

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Microscopy imaging of the structures showed successful AV formation at the fields predicted from the MOKE measurements. The process and critical fields depend on the details of the structure shape and size. Hysteresis loops were obtained with a high signal-noise ratio arrays. MOKE measurements were made on a series of micron-sized pound-key-like structures made of Permalloy to examine how the reversal magnetic hysteresis measurements, especially for magnetic nanostructures since measurements can be made on individual structures or small arrays. MOKE measurements were made on a series of micron-sized pound-key-like structures made of Permalloy to examine how the reversal process and critical fields depend on the details of the structure shape and size. Hysteresis loops were obtained with a high signal-noise ratio even though the amount of magnetic material and consequently the Kerr rotation angle were small (less than 0.02 mrad). Subsequent magnetic force microscopy imaging of the structures showed successful AV formation at the fields predicted from the MOKE measurements.

This work was supported by the NSF.

Detection of Magnetic Antivortices with Magnetic Force Microscopy. Key-like magnetic nanostructures are expected to exhibit interesting physical behavior and it may also be useful for applications. Recent work showed that magnetic antivortices can be created in pound-key-like structures via a two-step magnetic field procedure [1]. In this procedure, magnetic hysteresis measurements are important to predict the field values at which the AV’s will form. The Magneto-Optical Kerr Effect (MOKE) is widely used to make magnetic hysteresis measurements, especially for magnetic nanostructures since measurements can be made on individual structures or small arrays. MOKE measurements were made on a series of micron-sized pound-key-like structures made of Permalloy to examine how the reversal process and critical fields depend on the details of the structure shape and size. Hysteresis loops were obtained with a high signal-noise ratio even though the amount of magnetic material and consequently the Kerr rotation angle were small (less than 0.02 mrad). Subsequent magnetic force microscopy imaging of the structures showed successful AV formation at the fields predicted from the MOKE measurements.

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This work was supported by the NSF.
8:24AM I3.00002 Unifying Geometrical Interpretations of Gauge Theory. SCOTT ALSID, MARIO SERNA, US Air Force Academy — We seek to unify three camps that have developed geometric interpretations of gauge theory over the last century: those who use the compactified dimensions of Kaluza-Klein theory, those who use an embedding to represent gauge fields, and those who use a hidden spatial metric to replace the gauge fields. This paper identifies a correspondence to directly relate the geometrical interpretations of the three camps. Each camp attempts to isolate the gauge-invariant core responsible for the resulting physics. By providing a mapping between geometrical interpretations, we provide a shared framework and share results between each camp. In addition, we provide visual examples of the geometrical relationships between each camp for U(1) electric and magnetic fields.

8:36AM I3.00003 Using Lie Algebras to Extract Non-Classical Evolution in Optomechanics. ALBERTO ACEVEDO, California State University, San Bernardino and Brigham Young University, TY BEUS, MANUEL BERRONDO, JEAN-FRANCOIS S. VAN HUELE, Brigham Young University — The task of finding the time evolution of quantum systems governed by time-dependent, noncommuting Hamiltonians \( [H(t), H(t')] \neq 0 \), is generally quite complex. Factorization of the evolution operator into time-dependent exponential functions of the time-independent basis elements of the Lie algebra constructed from the Hamiltonian, makes it possible to separately resolve the issues of operator ordering and time-dependence. We apply this method to oscillator dynamics and obtain analytic results. We then consider optomechanical systems, consisting of coupled optical and mechanical oscillator modes to study the generation of non-classical states. We also show how the same method allows for the inclusion of dissipative effects.

8:48AM I3.00004 Variance for weak measurement. PRASHANNA SIMIKHADA, JEAN-FRANCOIS S. VAN HUELE, Brigham Young Univ - Provo — Weak value is an important quantum tool, as illustrated in weak measurements; but what is the interpretation of weak value? We define several possible second moments for the weak value in search of a useful weak variance. We compare the properties of these moments when applied to spin measurements, and extrapolate our results to disembodiment as illustrated in Cheshire cat situations.

9:00AM I3.00005 Bound quantum system of electron or proton orbiting a small black hole. DANIEL GRAY, ALEXANDER PANIN, Utah Valley University — Mini black holes (BH) of various mass could be left over in space from the early expansion Big Bang phase (so called primordial BHs). As a result of interaction of those BHs with interstellar hydrogen they could form a bound system with an electron or a proton (or both). What would such system look like? Would it be stable, metastable, or would BH quickly consume the orbiting particle? How much is life time of such “gravitational atom”? If such system is stable then what is the size of it; how much is the bonding energy of its ground state (= ionization potential energy) and how much are the energies of its exited states? Are those “gravitational atoms” observable? What other properties do they have? Based on known physics we try to analyze the behavior of such exotic system and answer the above questions for black holes of various masses.

9:12AM I3.00006 A Minimal Model to Relate Dynamics to Entanglement, JOHN GAR-DINER, JEAN-FRANCOIS S. VAN HUELE, Brigham Young University — Quantum entanglement is a correlation between systems beyond what is possible classically. There are multiple distinct ways for systems to be entangled with each other. When systems interact the particular entanglements that arise between them are dictated by the dynamics of the interaction. With different dynamics leading to possibly different entanglement, we can ask what the entanglement says about the dynamics that caused it. Can we understand interactions in terms of the entanglements they form? To explore this question, we propose a minimal model of a system and its environment consisting of three qubits with spin interactions. We relate the structure of the model’s dynamics with the complexity of the resulting entanglement.

Saturday, October 19, 2013 8:00AM - 9:24AM –
Session I4 Particle Physics III: Experiment 251 - Norm Buchanan, Colorado State University

8:00AM I4.00001 The Long-Baseline Neutrino Experiment (LBNE). ROBERT WILSON1, Colorado State University — I will report on the status of the Long-Baseline Neutrino Experiment (LBNE), which is a broad scientific program being developed in the United States as an international partnership. LBNE is proposed as an intense neutrino beam produced at Fermi National Accelerator Laboratory (Fermilab), a highly capable set of neutrino detectors on the Fermilab campus, and a large underground liquid argon time projection chamber at Sanford Underground Research Facility (SURF) in South Dakota. The high-intensity neutrino beam will allow LBNE to make high precision measurements of neutrino and anti-neutrino mixing separately. LBNE will make detailed studies of neutrino oscillations including measurements of the mass hierarchy and CP violation that take advantage of the 1300 km baseline. At the near site, the high-statistics neutrino scattering data will allow for many cross-section measurements and precision tests of the Standard Model. At the far site, the large underground detector will also open a new window to the search for nucleon decay, supernova neutrinos, and other astrophysical phenomena.

1With the LBNE Collaboration.

8:24AM I4.00002 The LBNE Photon Detector. RYAN WASSERMAN, NORM BUCHANAN, Colorado State University — The Long Baseline Neutrino Experiment (LBNE) is a proposed neutrino oscillation experiment with a goal of measuring the orientation of the neutrino mass hierarchy and delta cp in the lepton sector. The LBNE neutrino beam will be generated at FermiLab and be detected by a 34 kton liquid argon time projection chamber located at the Homestake Mine in South Dakota. In this presentation I will give an overview of the motivation for and progress towards designing a photon detection system for the LBNE far detector that utilizes wavelength shifting light guides and silicon photon multipliers to collect light from neutrino interactions.

8:36AM I4.00003 Prototype Gas Cherenkov Radiation Muon Detector For LBNE. BEN SCHLITZER, None — The proposed Long Baseline Neutrino Experiment (LBNE) beamline at Fermilab will require muon detectors in order to record the muon flux and eventually correlate this measurement to the muon-neutrino flux. At the University of Colorado, we have been conducting research to assemble a prototype muon detector using cosmic ray muons. This detector will exploit Cherenkov radiation emitted by incoming cosmic rays in order to detect whether a muon has passed though the detector. My presentation will examine the methods and apparatus used in performing experiments and analyzing data, as well as summarize results of all data collected up to the current date.

8:48AM I4.00004 Variance for weak measurement. PRASHANNA SIMIKHADA, Brigham Young University — Weak value is an important quantum tool, as illustrated in weak measurements; but what is the interpretation of weak value? We define several possible second moments for the weak value in search of a useful weak variance. We compare the properties of these moments when applied to spin measurements, and extrapolate our results to disembodiment as illustrated in Cheshire cat situations.
8:48AM I4.00004 Simulation of Photon Detector Prototypes for LBNE, ANDREA SHACK-LOCK, NORM BUCHANAN, RYAN WASSERMAN, Colorado State University — LBNE is the Long Baseline Neutrino Experiment utilizing an intense beam of neutrinos originating at Fermilab. Neutrinos will be sent from Fermilab to the Homestake mine in Lead, South Dakota, where neutrino oscillations will be studied. A photon detector, based on wavelength shifting plastics and silicon photomultipliers, will be part of the LBNE far detector and used to determine the start time of an event. In order to determine the optimal design of the photon detector simulations are necessary. Using Geant4 and LarSoft, we have made representations of photon detector prototypes and test facilities used to study them. I will present details of the models developed for the simulations, as well as comparisons between simulation and measured data.

9:00AM I4.00005 Improving Tau Neutrino Background Rejection using the LBNE Fast Monte Carlo, MATTHEW HOGAN, Colorado State Univ, LONG BASELINE NEUTRINO EXPERIMENT COLLABORATION — The Long Baseline Neutrino Experiment (LBNE) science collaboration is planning an experiment built around a 10kt liquid Argon TPC (LAr TPC) neutrino detector 1300km downstream of a wide band neutrino beam from Fermi National Accelerator Lab. Since a full Monte Carlo (MC) simulation is still under development, a Fast MC has been implemented. The Fast MC incorporates simulations of the neutrino beam flux and neutrino interactions while replacing the detector response and event reconstruction with parameterizations. The current Fast MC event selection algorithms, based on the identification of final-state lepton candidates, have a high background acceptance from charge-current (CC) tau neutrino interactions producing taus which decay leptonically (branching ratios of 17-18%). In this work an improvement in CC tau neutrino background rejection is explored for electron neutrino appearance and muon neutrino disappearance event samples. A multivariate analysis (MVA) based discriminator built from reconstructed kinematic variables has been shown to significantly improve background rejection with little loss in signal efficiency. Techniques for constructing the discriminator and estimates of the resulting improvements in background rejection will be presented.

9:12AM I4.00006 Measurement of muon neutrino induced Charged Current Single Charged Pion Production Flux-averaged Absolute Cross-Section on Water in the PØD Detector1, SHAMIL ASSYLBEEKOV, TOMASZ WACHALA, ROBERT WILSON, Colorado State University, T2K COLLABORATION — Using T2K experiment’s near detector data samples of Charged Current interactions after analysis cuts and utilizing a water event rate subtraction technique we report a preliminary measurement of single charged pion production cross-section on water. The preliminary data result with the statistic and systematic uncertainties is presented in comparison to the NEUT Monte Carlo prediction.

1DOE support acknowledged

Saturday, October 19, 2013 8:00AM - 8:48AM — Session I5 Physics Education 287 - Steven Iona, University of Denver

8:00AM I5.00001 A Research-validated Approach to Transforming Upper-division Physics Courses1, STEVEN POLLOCK, University of Colorado, Boulder — At most universities, including the University of Colorado, upper-division physics courses are often taught using a traditional lecture approach that does not make use of many of the instructional techniques that have been found to improve student learning at the introductory level. We are transforming several upper-division courses using principles of active engagement and learning theory, guided by the results of observations, interviews, and analysis of student work at CU and elsewhere. In this talk I outline these transformations, including the development of faculty consensus learning goals, clicker questions, tutorials, modified homeworks, and more. We present evidence of the effectiveness of these transformations relative to traditional courses, based on student grades, interviews, attitude surveys, and through research-based assessments of student conceptual mastery. Our results suggest that many of the tools that have been effective in introductory courses are effective for our majors, and that further research is warranted in the upper-division environment. (See www.colorado.edu/sei/departments/physics.htm for materials)

1NSF DUE 1023028 and DUE 0737118.

8:24AM I5.00002 40 Years of Metrication in the US, DAVID BARTLETT, University of Colorado at Boulder — In July 1971, Maurice Stans, the Secretary of Commerce, presented the proposal of the National Institute of Standards and Technology for “A Metric America.” Envisioned was a ten-year plan which would, with some compulsion, establish SI as the dominant language for commerce, education, and science in the US. The Metric Conversion Act of 1975 was, however, voluntary. Evidently, the machinists’ union demanded $1000 per man to replace tools. The rallying cry was “Two, Four, Six, Eight, We Ain’t Going to Metricate—and we’ll come over your head with a 9/16th unless you force us.” The government obliged with an evolving set of guidelines. Today the U.S. Metric Association is gloomy; the Dozenal Society of America is happy. I will argue that the evolution of Metric in the US is a triumph for democracy, not ignorance.

8:36AM I5.00003 Assessing Conceptual Knowledge for the Physics of Semiconductors, EMANUELA ENE, Oklahoma State University — Following the trend in science and engineering education generated by the visible impact created by the Force Concept Inventory, the investigator developed a Physics of Semiconductors Concept Inventory (PSCI). PSCI fills the need of standardized concept tests for undergraduate education in photonics and electrical engineering. The structure of the PSCI test followed a concept map reflecting the input from a panel of experts from different universities and from a survey of textbooks currently used in engineering schools in the United States. Based on the statistical analysis of the scores and response patterns, the test was calibrated as an instrument to measure participants’ cognitive ability independent of items’ difficulty. The models employed were the Rasch Model and the Rasch Partial Credit Model. The estimation procedure employed was Conditional Maximum Likelihood. The analysis was carried on using algorithms written in the open-source language R. The current PSCI BETA test contains eighteen calibrated items covering six concepts of the physics of semiconductors. PSCI BETA may be used for three purposes: individual student diagnostic if applied at the beginning of a physics of semiconductors course; predictor for students’ academic performance in the field of semiconductors if applied at the end of instruction; assessment instrument for instructional strategies if applied both for pre- and post-instruction. The PSCI BETA instrument can be applied in any English speaking college setting.

Saturday, October 19, 2013 9:45AM - 10:55AM — Session J1 Plenary III 248 - Shufang Su, University of Arizon

9:45AM J1.00001 Dark Matter, PAOLO GONDOLO, University of Utah — .
 directional dark matter detection and the DRIFT experiment. \(11:15 \text{AM} \ K1.00001 \ \text{The Status of Supersymmetric Dark Matter} \)

JOHN HARTON, Colorado State University — Evidence for a form of matter unlike normal atoms and molecules has become very compelling in the decades since the early 1930’s when it was discovered that the gravitational mass in a cluster of galaxies far exceeded the mass of the visible matter in that cluster and that the orbital velocity of stars in the Milky Way could not be accounted for by the visible matter alone. The search for the nature of this ‘dark matter’ is one of the most compelling mysteries in science today with experiments worldwide. A leading candidate for the dark matter is the WIMP or Weakly Interacting Massive Particle, which is posited to have a mass in the GeV/\(c^2\) range and to interact with normal matter with a cross section on the weak scale. Experimental evidence points to galaxies being surrounded by a halo of dark matter, and that halo may be a cloud of WIMPs. In the overall standard model of WIMP dark matter the halo does not rotate with the stars in a galaxy, and collisions of WIMPs with normal matter would result in recoiling nuclei with energies of a few keV to perhaps few hundred keV. This talk will focus on the subset of experiments called directional dark matter detectors; these experiments aim to exploit a daily modulation in the dark matter signal by measuring the direction of travel of the recoiling nucleus. The DRIFT dark matter collaboration is one such directional experiment, and the group is running a detector called DRIFT-Id in the Boulby mine in the UK.

\[11:39 \text{AM} \ K1.00002 \ \text{Directional dark matter detection and the DRIFT experiment} \]

JOHN HARTON, Colorado State University — Evidence for a form of matter unlike normal atoms and molecules has become very compelling in the decades since the early 1930’s when it was discovered that the gravitational mass in a cluster of galaxies far exceeded the mass of the visible matter in that cluster and that the orbital velocity of stars in the Milky Way could not be accounted for by the visible matter alone. The search for the nature of this ‘dark matter’ is one of the most compelling mysteries in science today with experiments worldwide. A leading candidate for the dark matter is the WIMP or Weakly Interacting Massive Particle, which is posited to have a mass in the GeV/\(c^2\) range and to interact with normal matter with a cross section on the weak scale. Experimental evidence points to galaxies being surrounded by a halo of dark matter, and that halo may be a cloud of WIMPs. In the overall standard model of WIMP dark matter the halo does not rotate with the stars in a galaxy, and collisions of WIMPs with normal matter would result in recoiling nuclei with energies of a few keV to perhaps few hundred keV. This talk will focus on the subset of experiments called directional dark matter detectors; these experiments aim to exploit a daily modulation in the dark matter signal by measuring the direction of travel of the recoiling nucleus. The DRIFT dark matter collaboration is one such directional experiment, and the group is running a detector called DRIFT-Id in the Boulby mine in the UK.

\[12:03 \text{PM} \ K1.00003 \ \text{Chaos in the general relativistic three-body problem} \]

TAYLOR MORGAN, JARED JAY, DAVID NEILSEN, Brigham Young University — The three-body problem in classical gravity is known to have chaotic solutions. We are investigating chaos in the three-body problem in general relativistic scattering using post-Newtonian equations. We model a binary system with an incoming star. We present results of these interactions that display features of chaos, such as sensitivity to initial conditions and scale invariance.

\[12:15 \text{PM} \ K1.00004 \ \text{Charged Particle Spectrometer for LNAR} \]

TYLER WESTOVER, BYU, JOHN ELLSWORTH, Physics and Astronomy, Brigham Young University — At BYU we are developing charged particle and neutron spectrometers. We wish to study two things: One low energy fusion reactions that compete with background and two the behavior of neutrons emitted from fission reactions. Reported here is work done to update our charged particle spectrometer using a high speed digitizer.

\[12:27 \text{PM} \ K1.00005 \ \text{Chaotic Scattering in the Post-Newtonian Three-body Problem}\]

JARED JAY, DAVID NEILSEN, Brigham Young Univ - Provo — A general solution for the three-body problem in Newtonian gravity does not exist, and the system is known to be chaotic. We consider the three-body problem in general relativity using the Post-Newtonian equations of motion that include the first gravitational-wave emission terms. Using a model problem of a binary that interacts with a third object, we present evidence that this system also has chaotic solutions.

\[1\text{NSF PHY-0960811} \]

\[\text{Saturday, October 19, 2013 11:15AM - 12:39PM – Session K2 Biological and Soft Condensed Matter Physics II} \]

11:15AM K2.00001 \text{Modeling Active Microtubule-motor Networks} \ M. BETTERTON, Univ of Colorado - Boulder — Cell division of one cell into two daughter cells is necessary for organisms to grow or reproduce. Segregation of the genetic material into the daughter cells during cell division is performed by a molecular machine called the mitotic spindle that exerts forces on chromosomes and moves them to the correct locations during cell division. The mitotic spindle is a nonequilibrium structure composed of filaments called microtubules and motor proteins that bundle and slide the filaments. The mitotic spindle is inspiring new work in which components of the mitotic spindle are taken outside of cells to make new types of biologically-inspired active materials. To improve our understanding of these active materials, we are studying course-grained models of liquid-crystalline filaments (microtubules) driven by active crosslinks (motors). This model is investigated using a combination of Brownian dynamics and kinetic Monte Carlo simulation. We observed novel states of the system, including bundles and sheets, active nematic phases, and laning.

In collaboration with Robert Blackwell and Matthew Glaser, University of Colorado - Boulder.
11:39AM K2.00002 Proteome and cell biophysics on the back of an envelope1, KINGSHUK GHOSH, University of Denver — We investigate the heterogeneity of several biophysical properties across the proteome, the entire set of proteins inside a cell. The global approach adopted here, in stark contrast to the traditional approach of one-protein-at-a-time, offers us insights to several foundational questions: 1) Why are cells so sensitive to temperature changes? How can the cell’s maximum growth temperature be so close to the cell-death temperature? 2) What makes thermophiles withstand high temperature? 3) Why are cells so crowded? 4) What are the competitions between different physical processes inside a cell and their relative importance and evolutionary implications? Predictions are made using existing experimental data, protein knowledge bases, detailed simulations and simple theoretical calculations.

1National Science Foundation

12:03PM K2.00003 Modeling stochastic cell dynamics with adhesion anisotropy quantitatively reproduces convergent extension, TAYLOR FIRMAN, KINGSHUK GHOSH, Department of Physics and Astronomy, University of Denver, Denver, CO, TODD BLANKENSHIP, Department of Biological Sciences, University of Denver, Denver, CO, DINAH LOERKE, Department of Physics and Astronomy, University of Denver, Denver, CO — Epithelial cells in Drosophila embryos intercalate together during germ-band extension in order to elongate the entire embryo along the anterior-posterior axis, a process more broadly known as convergent extension. In silico simulation of hexagonal cell matrices provides an inexpensive way to test the validity of possible mechanisms governing convergent extension of epithelial tissues. Our proposed system is node-based as opposed to pixel-based, storing data only for the node points defining the idealized polygons representing individual cells. This brings simulation times down from days to hours. Using Monte Carlo simulation techniques, the energy function used takes into account cell volume and membrane conservation as well as adhesion between surrounding cells. Our model takes a passive adhesion approach by assuming planar polarized distributions of adhesiveness within the cell. This leads to convergent extension using only Brownian motion. This adhesion-based model also allows us to add in a level of heterogeneity, where cell polarizations don’t align perfectly along the dorsal-ventral axis due to a mistake in cellular machinery. This results in longer monopolar adhesions along interfaces, leading to slower interface contraction and complex cell behaviors.

12:15PM K2.00004 Weakening the Cell Elasticity of Chlorella Vulgaris under Nitrate Starvation, ANTONIO NAVA, Astronomy and Physics Dept., University of Denver, LIEVE LAURENS, NICHOLAS SWEENEY, National Bioenergy Center, National Renewable Energy Laboratory, SEAN SHAHEEN, Astronomy and Physics Dept., University of Denver, NATIONAL BIOENERGY CENTER, NATIONAL RENEWABLE ENERGY LABORATORY COLLABORATION — Chlorella vulgaris is a unicellular, photosynthetic green alga. This strain of Chlorella is capable of producing high lipid content—up to 50% of its dry biomass when experiencing severe nutrient stress. The strength of the cell wall influences the susceptibility of the cells to rupture and is hypothesized to be related to extractability of the lipids. Upon nutrient deprivation, algae cells increase lipid content but concurrently a reduction in extraction efficiency has been observed. To study algal cell wall elasticity, Chlorella cells were grown in replete medium, which over time became depleted in nitrate and other nutrients. Samples were harvested at three distinct time points. Through Atomic Force Microscope (AFM) measurements, we obtained force vs distance data as the AFM probe tip is brought in contact with an immobilized cell, thus deforming its surface. The Hertz model for membrane deformation, modified to account for AFM probe shape, is used to fit to the quadratic curve from the force curve measurements. By fitting the model to the data, the Young’s Modulus for the cell can be extracted. Analysis of the data leads to the conclusion that nitrate deprivation results in a decreased Young’s Modulus of the cell.

12:27PM K2.00005 Expanding the locomotion repertoire of the eigenfish: Study of wildtype and mutant zebrafish larvae escape response, MARIA BENITEZ-JONES, REU Student, KIRAN GIRDHAR, Graduate Student, YANN CHEMLA, MARTIN GRUEBELE, Principal Investigator — The zebrafish larva is a thoroughly studied and extensively used model for behavioral and biomedical research. The Zebrafish Laboratory at the University of Illinois at Urbana-Champaign has applied a mathematical method to describe quantitatively the larva’s swimming behavior. By this method, 98% of the complex locomotion of the free swimming behavior of the larva was described using three main components, or three “eigenfish.” Our focus is on the quantification of a different swimming behavior called escape response in wildtype (WT) and the Space Cadet (SPC) mutant zebrafish larvae. Although more data is required before assuming certainty in our results, the escape response of both WT and SPC larva was also described up to 98% by three eigenfish. However, the eigenfish for the SPC mutant and the wildtype varied from each other.

Saturday, October 19, 2013 11:15AM - 12:39PM -
Session K3 Condensed Matter IV: Theory/Computation 281 - Charles Stafford, University of Arizona

11:15AM K3.00001 Macroscopic quantum tunneling in Bose-Einstein condensates1, LINCOLN CARR, Colorado Sch of Mines — I present three studies on macroscopic quantum tunneling of Bose-Einstein condensates. First, I show how even at the simplest mean field level already the problem of escape through a barrier has new features compared to single particle physics: the tunneling time is not the inverse of the rate and interactions allow one to tune from bound to quasi-bound to unbound states freely. Second, I show how tunneling in a double-well system leads to Josephson junction and Schrodinger cat (NOON state) physics. I demonstrate that although a very small bias or tilt in the potential can destroy Cat-like states, by intentional use of bias the many body wavefunction can be used to protect such states from destruction (or internal decoherence). Third, I present a full many-body calculation of entangled quantum dynamics of the escape problem, exploring entanglement, number correlations, and other features not accessible by instanton or other methods. I show that the tunneling process is non-smooth, and actually occurs in bursts. When approximately half the particles have tunnelled out of the well, the particles remaining are massively entangled with the escaped portion.

1Funded by NSF
11:39AM K3.00002 Computational Analysis of Energy Pooling to Harvest Low-Energy Solar Energy in Organic Photovoltaic Devices, MICHAEL LACOUNT, Colorado School of Mines, SEAN SHAHEEN, University of Colorado Boulder, GARRY RUMIBLES, JAO VAN DE LAGEMAAT, National Renewable Energy Laboratory, NAM HU, University of Colorado Boulder, DAVE OSTROWSKI, National Renewable Energy Laboratory, MARK LUSK, Colorado School of Mines — Current photovoltaic energy conversions do not typically utilize low energy sunlight absorption, leaving large sections of the solar spectrum untapped. It is possible, though, to absorb such radiation, generating low-energy excitons, and then pool them to create higher energy excitons, which can result in an increase in efficiency. Calculation of the rates at which such upconversion processes occur requires an accounting of all possible molecular quantum electrodynamics (QED) pathways. There are two paths associated with the upconversion. The cooperative mechanism involves a three-body interaction in which low energy excitons are transferred sequentially onto an acceptor molecule. The accretive pathway, requires that an exciton transfer its energy to a second exciton that subsequently transfers its energy to the acceptor molecule. We have computationally modeled both types of molecular QED obtaining rates using a combination of DFT and many-body Green function theory. The simulation platform is exercised by considering upconversion events associated with material composed of a high energy absorbing core of hexabenzenocoronene (HBC) and low energy absorbing arms of oligothiophene. In addition, we make estimates for all competing processes in order to judge the relative efficiencies of these two processes.

11:51AM K3.00003 The Adsorption of Polyatomics on Carbon Surfaces\textsuperscript{1}. JARED BURDE, MERCEDES CALBI, University of Denver — We study the adsorption of hydrocarbon chains on several carbon surfaces. We focus on the kinetics of adsorption, working to elucidate the factors that have the greatest influence on the time needed for the system to reach equilibrium. Preliminary results suggest that a major factor is the effective energy, which includes the binding energy, interaction energy with neighboring adsorbates, chemical potential and other system parameters. We use computational and analytical techniques to determine the relationship between the adsorption rate and effective energy of several hydrocarbon chains (including methane, ethane, and propane) as they condense on carbon substrates (like graphene and carbon nanotubes).

\textsuperscript{1} A special thanks to NSF for supporting this work.

12:03PM K3.00004 Matching up the Kovalev and CDML space-group IRs, REBECCA WINZER, University of Idaho, BRANTON J. CAMPBELL, HAROLD T. STOKES, Brigham Young University — We are building a correspondence between two tables of the irreducible representations (IRs) of crystallographic space groups at incommensurate k-points. The first is the table of little-group IRs prepared by Kovalev. The second is the table of little-group IRs prepared by Cracknell, Davies, Miller, and Love (CDML), which were used to induce the complete space-group IRs recently tabulated by Stokes, Campbell and Cordes. To date, we have established a correspondence between the CDML and Kovalev k-vector tables and setting-dependent space-group operator tables, and have verified that the little-group irrep characters can be matched. A few ambiguities remain to be resolved.

12:15PM K3.00005 Porous Resonators for Chemical Sensing, STEVEN NOYCE, ROBERT DAVIS, RICHARD VANFLEET, Brigham Young University — Porous resonators have the potential to overcome limitations in the micro-resonator field. For example, such structures are potentially capable of higher detection limits than solid resonators when used as sensors, due to their immensely larger surface area. We present a versatile micro-resonator fabrication process in which carbon nanotubes are grown from a patterned catalyst, after which the space between the tubes is filled to various degrees of porosity with carbon through Chemical Vapor Deposition. We present characterizations of this novel material, along with frequency shift data showing a surprising trend that opens the door to many future explorations.

12:27PM K3.00006 The role of shape anisotropy in the stabilization of magnetic antivortices in pound-key like structures, MARTIN ASMAT, LIN LI, BRIAN SHAW, ARABINDA HALDAR, KRISTEN BUCHANAN, Department of Physics Colorado State University — The magnetic vortex state has received increasing attention during recent years however its topological counterpart, the magnetic antivortex (AV), has not been explored with the same intensity. The antivortex spin configuration may have some advantages over vortices, especially for channeling spin waves emitted from the dynamic core reversal. In order to study the properties of antivortices it is necessary to have geometries and procedures that reliably stabilize antivortices, however this task is more challenging than forming a vortex. In this work, we use micromagnetic simulations to show that pound-key-like structures can be used to form stable AV’s and to explore the role of shape anisotropy in the AV formation. Our results are compared to Magneto Optical Kerr Effect (MOKE) hysteresis measurements and magnetic force microscopy images. The simulations show that the AV nucleation field depends on the sample global and relative dimensions and these results are in good agreement with the experiments. Acknowledgement: This work was supported by the NSF.

Saturday, October 19, 2013 11:15AM - 12:39PM - Session K4 Materials Physics II: Carbon 253 - Kristen Buchanan, Colorado State University

11:15AM K4.00001 Recent advances in block copolymer mesoscale modeling: Numerical Self-Consistent Field Theory Simulations, SCOTT SIDES, NREL — Using block copolymers as mesoscale templates has potential applications for improved photovoltaic devices, fuel-cells and many others where the long-range order and orientation of the copolymer phase-separated domains is crucial. Self-consistent field theory (SCFT) for dense polymer melts has been highly successful in describing complex morphologies in block copolymers. Field-theoretic simulations based on SCFT theory are able to access large length and time scales that are difficult or impossible for particle-based simulations such as molecular dynamics. This talk will present recent results using PolySwift++, an object-oriented, high-performance framework for developing new SCFT algorithms. Included is an overview of a hybrid-SCFT algorithm for studying nanocomposites. This hybrid method allows simulations where the copolymer is treated within the field-theory framework, while the nanoparticle positions and orientations are included explicitly.

11:39AM K4.00002 Nano-imaging of graphene plasmons, JUSTIN GERBER, BRIAN O’CALLAHAN, SAMUEL BERWERGER, MARKUS RASCHKE, University of Colorado at Boulder — Graphene plasmonics provides strong and wavelength-tunable spatial confinement of electromagnetic fields at mid-infrared frequencies. Near-field imaging of standing wave surface plasmon polaron (SPP) spatial distributions has been recently achieved by scattering-type scanning near-field optical microscopy (s-SNOM). The spatial patterns are a result of the interference of plasmons launched by the sharp scanning probe tip with counter-propagating plasmons reflected from graphene edges. We present a full phase and amplitude resolved near-field characterization of SPP propagation and reflection off edges, defects, and grain boundaries. Using mid-infrared excitation at $\lambda_{\text{exc}} = 19.8\mu$m, we measure deep sub-wavelength periodicity in the spatial distribution of the near-field with plasmon wavelength on the order of $\lambda_p = 250$ nm. The standing amplitude and phase patterns can be fully described based on a simple near-field SPP cavity model.
CO2 as the oxygen source with applications to CNT-MEMS growth, KENNETH HINTON, Brigham Young University — Microelectromechanical systems (MEMS) fabrication traditionally uses the same limited methods and materials as those used in the silicon-based microelectronics industry. In order to make MEMS out of a richer suite of materials, such as metals, Brigham Young University researchers are investigating chemical vapor deposition and atomic layer deposition of patterned carbon nanotube (CNT) forests, using the surface of the carbon nanotubes as nucleation sites for metal deposition. Our goal has been to fill in spaces between CNTs by atomistic deposition, thus creating a CNT-composite material possessing the original pattern of the CNT forest. We have attempted to do this using tungsten hexafluoride and hydrogen. As deposited the materials are not pure metals, but contain substantial amounts of carbon and oxygen. Most recently tungsten fluoride via both CVD and ALD is being used to attempt creation of purer tungsten structures. Efforts to remove impurities as well as the electrical and mechanical properties of the resulting composite material will be reported.

This project was funded by a BYU ORCA grant, and would not have been possible without help from the BYU Physics Department.

The low-pressure, chemical vapor deposition of SiO2 layers using CO2 as the oxygen source with applications to CNT-MEMS growth, KENNETH HINTON, Brigham Young University — Deposited silica (SiO2) has a number of applications for microfabricated structures, particularly those based on coating carbon nanotube forests. Members of our group have, for example, reported on the fabrication and use of SiO2-coated carbon nanotube forests (CNT-MEMS) to prepare liquid chromatography plates of record efficiency. SiO2 also has extremely low thermal conductivity and is stiff, coated, carbon nanotube forests could be used as thermal barrier layers. We have examined two novel methods for the LPCVD of SiO2 and oxygen-rich amorphous silicon. Both methods are based on the hypothesis that carbon dioxide could be used as the source of oxygen in preparing the material. In the case of oxygen-rich amorphous silicon (a-Si:O) we used silane as the silicon source, and the case of SiO2 used dichlorosilane. We deposited the a-Si:O material at about 800K while the SiO2 from SiH2Cl2 was deposited at about 1000 K. Depositions were done at low pressure, about 200 millitorr for the a-Si:O and at about 1 to 4 Torr for the SiO2. The substrates in all cases were three-inch single-crystal silicon wafers. We subsequently examined the deposited material using variable-angle, spectroscopic ellipsometry (VASE-John A. Woollam M 1000) for of thickness and optical constants and SEM structure and composition. The dichlorosilane deposition of SiO2 suffered from vanishingly small deposition rates at very low pressures at 1000 K and the incorporation of “snow” into the films in the case of depositions done at higher pressures. We found little evidence of carbon incorporation.

Carbon nano-fuses for permanent data storage, KEVIN LAUGHLIN, None — In today’s world, just about everything is in digital form. This includes things like pictures of family and friends, ancestral work, music, movies, and much more. Unfortunately, the way to store data has typically been put it on a hard drive, thumb drive, or CD. What many people don’t know is that these ways of data storage can only hold data reliably for about 7 years. The goal of permanent data storage is that the data gets written once and it will always be there when you need it. We have been working on a solid-state solution to this problem. The permanent data storage devices are a collection of nano-fuses that are made of a thin carbon film that is 20-40nm thick, and varying from 250-1000mm wide. The carbon pads were created using an electron beam lithography technique to etch out the pattern, and carbon was then evaporated onto the device. Voltages above 6 volts were then pulsed or ramped across these fuses, oxidizing the carbon and causing a break in the fuse. Memory elements consist of a nano-fuse, and breaking a fuse will change the bit from a 1 to a 0. After the fuses were broken, they were analyzed with an SEM and an AFM. It has been found that these carbon nano-fuses are a good possibility for the future solid-state permanent data storage devices.

Ab Initio Study of Graphene Functionalized with Benzylene, SANJIV JHA, IGOR VASILIEV, New Mexico State University, IGOR MAGEDOV, LILIYA FROLOVA, NIKOLAI KALUGIN, New Mexico Tech — The electronic and structural properties of carbon nanomaterials can be affected by chemical functionalization. We apply ab initio computational methods based on density functional theory to study the covalent functionalization of graphene with benzene. Our calculations are carried out using the SIESTA electronic structure code combined with the generalized gradient approximation for the exchange correlation functional. The calculated binding energies, densities of states, band structures, and phonon frequencies of graphene functionalized with benzene are analyzed in comparison with the available experimental data. Our calculations show that the reactions of [2+2] and [2+4] cycladdition of benzene to the surface of pristine graphene are exothermic with the binding energies of -0.73 eV and -0.58 eV, respectively.

Supported by NSF CHE-1112388. NSF ECCS-0925988, NIH-5P20RR016480-12 and NIH- P20 GM103451

Saturday, October 19, 2013 11:15AM - 12:27PM –
Session K5 Particle Physics IV: Experiment 251 - Robert Wilson, Colorado State University

Controlled Freezing of Liquid Xenon on a Cryogenic Probe for Single Daughter Atom Detection in EXO, CHANBER, Christopher, Colorado State University, EXO COLLABORATION — The EXO experiment is designed to search for zero-neutrino double beta decay of the isotope Xe136, in order to better understand the nature of neutrinos. Since the daughter of this decay is barium (Ba136), detecting the presence of Ba136 at a decay site (called “barium tagging”) is the best way to reject backgrounds in the search for this decay. This would involve detecting a single barium ion from within a macroscopic volume of liquid xenon. One proposed barium tagging method is to trap the barium ion in frozen xenon at the end of a cold probe, and then detect the ion by its fluorescence in the solid xenon. Our group at CSU has begun testing designs for cold probes inside our liquid xenon cell. We demonstrate successful freezing of liquid xenon at the end of a probe, and I discuss improvements in the design, as well as trapping/detecting barium ions.

Supported by Grants: NSF 1132428 DOE DE-FG02-03ER41255
11:27AM K5.00002 The Development of a 1-ton scale Cryogenic Detector Development Test Facility. FORREST CRAFT, NORM BUCHANAN, THOMAS CUMMINGS, JOHN JABLONSKI, DAVID WARNER, RYAN WASSERMAN, Colorado State University — The Long Baseline Neutrino Experiment (LBNE) has been proposed to use an intense neutrino beam created at the Fermi National Accelerator Laboratory (Fermilab) directed toward the Sanford Underground Research Facility (SURF), in Lead, SD to study neutrino properties. The liquid argon far detector at SURF will need to be equipped with photon detector equipment to reduce cosmic ray background (for a surface located detector) and provide a trigger for non-beam-related events such as supernovae neutrinos and proton decay. Many of these photon detectors are developed and manufactured at institutions that do not possess the equipment to do full scale cryogenic performance and calibration verification before installation in the SURF facility. To test the performance of the full sized LBNE photon detectors and their support equipment at cryogenic temperature a 1 ton scale test facility required development and implementation. A large scale cryogenic facility presented several safety and logistics concerns that were carefully controlled and mitigated before the detector could be brought online. With the facility now running with full liquid argon future plans for testing and detector improvement can be discussed.

11:39AM K5.00003 Readout and Monitoring Electronics Development for a Prototype Photon Detector. TOM CUMMINGS, NORM BUCHANAN, DAVE WARNER, Colorado State University — Current silicon photomultiplier devices require specialized interfacing hardware. We have developed electronics to accommodate these devices for the use of photon detection. These electronics are designed to isolate ambient noise, trim bias voltages for individual silicon photomultiplier devices, and amplify signals from photon activity. A dedicated voltage trimmer is being developed to reduce noise introduced into the system from a power source. This device also has the capability of digitally controlling the output to each silicon photomultiplier device, with a resolution of 50mV. The amplifier being developed uses two, high-speed operational amplifiers to amplify photon signals. Additionally, this board contains a discriminated pulse generator (NIM), triggered on photon events. Both trigger level and pulse width are digitally controlled via LabVIEW software. We have also developed methods of remotely monitoring fill levels of cryogenic liquid. The system designed utilizes a capacitive controller to monitor the liquid level, by detecting an increase in capacitance, due to an increase in liquid volume. The measurements of this controller are fed directly into LabVIEW software via USB. The current status of these electronics will be discussed.

11:51AM K5.00004 Measurement and Simulation of Cosmic Ray Background in LArTF for MicroBooNE. KATHERINE WOODRUFF, New Mexico State University — In an effort to characterize the cosmic ray background in MicroBooNE, a 80-ton Liquid Argon Time Projection Chamber (LArTPC) being built at Fermilab, our research group at New Mexico State University (NMSU) has built a plastic-scintillator cosmic ray detector. The detector measures the cosmic ray rate and angular dependence at the Liquid Argon Test Facility (LArTF), where MicroBooNE will be located during its run beginning in 2014. The detector data is compared to a Cosmic-Ray Shower Generator (CRY) Monte Carlo simulation. A description of the detector and simulation setups and results will be presented, and implications of the measured rates on the MicroBooNE detector will be discussed.

12:03PM K5.00005 Simulation of DRIFT Dark Matter Detector¹. MATTHEW WILLIAMS, Colorado State Univ, DRIFT COLLABORATION — The DRIFT dark matter experiment has the potential to provide strong evidence for dark matter by showing the presence of directionality in WIMP-nuclear recoils. The orientation of nuclear recoils is detected through the use of low pressure time projection chambers, but potential setbacks for directional capability include the random walk behavior of low energy recoils and thermal diffusion. Through Monte-Carlo simulation I aim to statistically assess the directional capability of the detector and its potential design improvements. This simulation models the galactic WIMP halo, ionization tracks from nuclear recoils, and the resulting current signals.

¹Research supported by the National Science Foundation.

12:15PM K5.00006 Attenuation Length Measurements of Custom Wavelength Shifting Fibers. DYLAN ADAMS, NORM BUCHANAN, JOHN HARTON, Colorado State University — This research focuses on studying optical fibers and their applications in high-energy particle detectors. By measuring the intensity of a light signal at the site it enters the fiber, and at a distance down the fiber, we calculate the attenuation length of the fiber (distance for signal to change by factor of e). As high energy particles move through argon detectors, the argon atoms excite and subsequently emit photons at 128nm. These particles typically are from cosmic events (such as a supernova) or injected from an accelerator. Currently, photon detectors are relatively inefficient at collecting photons at this deep UV wavelength. This light, at 128 nm, excites a wavelength-shifting component (TPB, tetra-phenyl-butadiene) doped into the fibers, which emits light in the near UV visible spectrum, around 400 nm. Studying how different TPB application processes change the attenuation length of candidate fibers gives information about how the light signal is degraded from the initial argon scintillation light to the light signal read by the silicon photomultipliers (the photon detectors). So far measurements have been practiced on a bar with an external cladding, and been made on fibers doped with TPB and annealed fibers doped with TPB.

Saturday, October 19, 2013 11:15AM - 12:39PM – Session K6 Industrial and Applied Physics  151 - Matt Kim, QuantTera

11:15AM K6.00001 The Use of Plasma Based Catalysts in the Automotive Industry. MAXIMILIAN A. BIBERGER, SDCmaterials, Inc. — Traditionally catalysts for the automotive industry are being made by using wet chemistry, i.e. PGM’s (Platinum Group Metals) being dissolved in acids and then impregnated onto porous, micron sized substrates. This technology is serving the industry well, however as demand for more fuel efficient cars as well as Hybrid cars increases, this technology begins to start showing limitations. The limitations are: a) Large amounts of precious metals being consumed, resulting in more than USD 10B/yr, which increases the cost of the vehicle and b) wet chemistry based catalysts have the tendency to age, i.e. the precious metal nano particles agglomerate during operation and the catalytic properties of the catalyst diminishes. In the present paper a novel method of manufacturing catalysts is presented. This technology is based on plasma synthesis instead of wet chemistry, resulting in thermally much more stable catalysts that have the potential to overcome above mentioned shortcomings and allow car manufacturers to introduce more fuel efficient cars as well as reducing the amount of precious metals needed. The latter is of particular interest in Hybrid cars: Due to the combination of a combustion engine and electric engine, the exhaust is much colder than in traditional cars, hence much more precious metal per catalytic converter is required. Another aspect discussed in this paper are the challenges related to the introduction of a new and novel technology into the automotive industry.
Node 11:39AM K6.00002 Wavelength Detection from Filtered Photodiodes, NILS OTTERSTROM, Brigham Young University, ATOM INTERFEROMETRY COLLABORATION — Filtered photodiodes coupled with developed algorithm reveal potential as inexpensive wavelength meter. Externally timed integration with microprocessor allows variable integration lengths and exports data through USB. Algorithm compares data to calibrated intensity curves and minimizes error to compute wavelength.

1Nils Otterstrom, Tyler Jones, Jarom Jackson, Kevin Blisset, Dr. Dallin S. Durfee

Node 11:51AM K6.00003 Mode transitions in strings with an abrupt change in mass density, TYLER ALLEN, NATHANIEL WELLS, BONNIE ANDERSEN, Utah Valley University — Previous research with bottle-shaped thermoacoustic prime movers has revealed hysteresis with transitions to higher modes as the cavity length is varied. A string with an abrupt change in mass density was studied to investigate potentially similar behavior. Three base guitar strings were studied at three different tensions with weights of 25, 30, and 35 lbs. Each string consisted of a “thin side” that was stripped to the stainless steel core and a “thick side” with an outer wrapping of nickel around the core. The strings studied had diameters of 0.65, 0.45, and 0.50 mm on the thin side and 2.14, 1.31, and 1.24 mm on the thick side, respectively. An anchor was attached on one end of a short board with a pulley at the other for hanging the weight. The end of the thick side of the string was attached to the anchor, and the string was guided over the pulley, with the change in mass density occurring approximately 12 cm from the pulley. Measurements were taken after placing a glass jar under the thick end of the string, between 42 cm and the position of the change in mass density, in 3-cm steps. The string was plucked and the dominant frequency was recorded with a microphone at each location. Frequency data is generally consistent with a solution to a 1D wave equation. Preliminary results indicate mode transitions occurring for all strings, with several hysteresis region candidates.

Node 12:03PM K6.00004 Developing an amplitude compensation method for obtaining high-resolution acoustic directivities from played musical instruments, NICHOLAS J. EYRING II, WILLIAM J. STRONG, NATHAN G.W. EYRING, Brigham Young University — When considering the acoustic radiation of a source, far-field directivity patterns are useful graphical representation of sound propagation in a given direction and frequency. Directivity measurements of played musical instruments present several experimental challenges, including the need for musicians to play consistently and reproducibly. Some researchers have chosen to implement fixed, limited-element microphone arrays surrounding instruments for rough directivity assessments. Unfortunately, with practical numbers of microphones, this approach limits spatial resolution and field decomposition bandwidth. Higher-resolution data may be obtained with a given microphone count by rotating a musician in sequential azimuthal angle increments under a fixed semicircular microphone array. The musician plays a selected note sequence with each increment, but corrections must be made for playing variability. For 5◦ resolution this results in 2664 measurements with M=37 in the polar angle and N=72 in the azimuthal angle. This paper explores the development of an amplitude compensation method that utilizes reference microphones that are fixed in the rotating reference frame. By approximating the reference and arc microphones as the input and outputs of an LTI system, transfer functions, H_{MN}, may be computed. The resulting set of H_{MN} are inviable under scalar changes in amplitude that are identical at both the reference and arc microphone positions. An experimental validation using a source with random variations in amplitude will be presented.

Node 12:15PM K6.00005 Circular orbits on a warped spandex fabric, CHAD MIDDLETON, MICHAEL LANGSTON, Colorado Mesa University — Here we investigate, both theoretically and experimentally, the circular-like orbits of a marble rolling on a warped spandex fabric. We show that the mass of the spandex fabric interior to the orbit of a marble influences the motion of the marble in a nontrivial way. In fact, the effect of the mass of the spandex fabric on the orbiting marble can actually dominate over that of the mass of the central object, for small enough central mass. By measuring the stretch of the spandex fabric near the central object for a variety of masses, we show that the modulus of elasticity describing the spandex fabric is not constant and is a function of the stretch. Lastly, we compare the Kepler-like expression for circular orbits of a marble on the warped spandex fabric in the small curvature regime to the Kepler-like expression for circular orbits about a spherically-symmetric massive object in the presence of a constant vacuum energy, as described by general relativity.

Node 12:27PM K6.00006 Why there is no noon-midnight red shift in the GPS, NEIL ASHBY, MARC WEISS, Time & Frequency Division, National Institute of Standards & Technology, Boulder, CO — Although the effects of solar (and lunar) gravitational potentials on the frequencies of orbiting Global Positioning System (GPS) clocks are actually no more than a few parts in 1015, a naïve calculation appears to show that such effects are much larger, and depend on whether the orbiting clock is between the earth and the sun, or on the side of the earth opposite to the sun. Consequently questions about whether such effects have been properly accounted for in the GPS continue to arise. This issue has been discussed in a misleading way in terms of cancellations arising from a second-order Doppler shift in the literature for almost 50 years. The purpose of this article is to provide a correct argument, based on fundamental relativity principles, so that one may understand in a simple way why the effects of external solar system bodies on orbiting or earth-bound clocks in the GPS are so small. The relativity of simultaneity plays a crucial role in these arguments.

Saturday, October 19, 2013 12:45PM - 1:45PM — Session L1 Industry Panel Lunch 248 - Matt Kim, QuanTera

12:45PM L1.00001 Industry Panel Lunch —

Saturday, October 19, 2013 2:15PM - 3:15PM — Session M1 AMO IV: Spectroscopy 151 - Mark Siemans, University of Denver

2:15PM M1.00001 Quantum Mechanical Description of Dipole-Bound Anions of Molecules and Clusters, NIKITA KIRNOsov, LUDWIK ADAMowICz, The University of Arizona — Quantum mechanical description of dipole-bound anionic complexes formation is given by means of ab-initio calculations. The electron affinities and electron detachment energies are determined at the CCSD(T) level of theory for number of molecular clusters. Photoelectron spectra peaks are assigned and the mechanisms for the formation of the anions are elucidated.

1We thank Kit Bowen for inspiring this study. We also thank the Computer Center of the University of Arizona for the computer time used in this project.
2:27PM M1.00002 Charge asymmetry of the first excited rotational states of diatomic molecules using explicitly correlated all-particle Gaussian functions. Nikita Kirsnosof, Keeper Sharkey, Ludwik Adamowicz. The University of Arizona — Highly accurate interparticle distances and correlation functions of the HD\(^1\) cation in its first rotationally excited state found in the non-Born-Oppenheimer approach are reported. To describe each state, 8000 explicitly correlated Gaussian functions were used. After careful optimization of the linear and nonlinear parameters, the correlation function, expectation values for interparticle distances, and nuclear correlation functions were computed. The results allow us to explicate the charge asymmetry dependence on the vibrational excitation and the effects of the rotational excitation.

2:39PM M1.00003 Thermal near-field: spectroscopy of the resonant enhancement of the local electromagnetic density of states. Brian O’Callahan, William Lewis, University of Colorado Boulder, Andrew Jones, Femtolasers, Markus Raschke, University of Colorado Boulder — One of the most universal physical processes shared by all matter at finite temperature is the emission of thermal radiation. Associated with the well understood far-field radiation and its spectral characteristics, recent theoretical work has shown that the corresponding near-field can exhibit distinct spectral, spatial, resonant, and coherence properties. The electromagnetic local density of states (EM-LDOS) is a fundamental quantity determining these properties. We demonstrate the technique of thermal infrared near-field spectroscopy (TINS) to characterize the unique spatial and spectral properties of the thermal near-field by scattering with a nanoscale probe. In particular, we discuss the observed vibrational and phonon-resonant enhancement and relationship with the underlying EM-LDOS. We also demonstrate the sensitivity of the emitted spectra to local dielectric environment, tip-sample coupling, and antenna effects of the scanning probe tip.

2:51PM M1.00004 Measurement of the mobility of barium ions in xenon gas and implications for a next generation \(^{136}\text{Xe}\) double beta decay experiment in high pressure gas\(^1\). Julio Benitez-Medina, William Fairbank, Colorado State University — The Enriched Xenon Observatory (EXO) is an experiment which aims to observe the neutrinoless double beta decay of \(^{136}\text{Xe}\). The measurement of this decay would give information about the absolute neutrino mass. Since this is a very rare decay, the ability to reject background events by detecting the barium ion daughter from the double beta decay would be a major advantage. The barium ions may be detected by laser induced fluorescence spectroscopy. One of our efforts in “barium tagging” at Colorado State University has been the fluorescence detection of barium ions in xenon gas. It is important to know how fast the barium ions travel in xenon gas. The results of mobility measurements of barium in xenon gas will be presented. The variation of mobility with xenon gas pressure suggests that some molecular ions are formed when barium ions interact with xenon gas at high pressures. The results indicate that the percentage of molecular ions is greater at higher pressures. The results are of interest for a next generation double beta decay experiment, for schemes involving a \(^{136}\text{Xe}\) gas detector.

\(^1\)Work supported by DOE DE-FG02-03ER41255.

3:03PM M1.00005 Digital Revolution in Electron Paramagnetic Resonance Spectroscopy. Mark Tseytlin, University of Denver — Exponential growth in computing power has reached the level that makes reshaping of electron paramagnetic resonance (EPR) spectroscopy inevitable. An EPR spectrometer, as we know it today, conceptually is not very different from ones that were built 40-50 years ago. It performs two basic types of experiments: (i) continuous wave with magnetic field modulation and (ii) pulse. Both types of experiments produce data that are easy to interpret visually or with minimal data processing. Spectroscopy, microscopy and imaging, driven by the digital progress, are now undergoing a paradigm shift toward a different concept, which is to collect a vast amount of complex data and use a computer to process the data into meaningful results. This approach speeds up an experiment and brings in qualitatively new information. This presentation describes a concept of a digital EPR spectrometer, essential parts of which are an arbitrary waveform generator, high-speed digitizer, personal computer and new data processing algorithms.

Saturday, October 19, 2013 2:15PM - 3:39PM – Session M2 Atmospheric Physics 254 - Shane Larson, Northwestern University

2:15PM M2.00001 On the Importance of Stratospheric Chemistry to the Physics of Climate. Ken Minshwander, New Mexico Tech — The vast majority of climate studies have been focused on physical processes in the troposphere - the lowest 10 to 15 km of the atmosphere near the Earth’s surface. It makes perfect sense to focus on tropospheric processes since they generally exert a dominant influence on climate variables of most interest, such as surface temperature, precipitation, and circulation patterns. However, there are a number of chemical and photochemical processes occurring in the stratosphere - above about 15 km altitude - that can play an important role in shaping the climate system. The most obvious case is that of stratospheric ozone, but there are other trace gases and stratospheric chemical systems that exert both direct and indirect effects on climate. This talk will include an overview of some of the more important processes and present findings from recent research, such as estimating atmospheric lifetimes for many of the important greenhouse gases.

2:39PM M2.00002 Digital Interferometry for Studies of Leaders in Natural Lightning\(^1\). Richard Sonnenfeld, Jeff Lapierre, Mike Stock, Paul Krehbiel, Langmuir Laboratory, New Mexico Tech, Manabu Akita, The University of Electro-Communications, Tokyo — Fully digital broadband (20-80 MHz) radio interferometers (DITFs) optimized to study lightning are a new development. They overcome the “phase-wrap” problem of earlier narrow-band analog interferometers and can locate a source in a lightning channel as often as every 10 nanoseconds. DITFs show phenomena long suspected, but not previously visible. For example, K-changes, (millisecond steps in electric field after a cloud-to-ground discharge), are shown by the DITF to be recoil phenomena along a previously formed channel. Used in concert with a lightning mapping array and slow-antenna (1-50000 Hz) electric field sensors, DITFs are also allowing discovery and understanding of new features of lightning. For example, on 8/12/2012, at 21:45:42 UT, a “bolt-from-the-blue” negative leader emerged from a cloud-top 30-miles Southeast of Langmuir Laboratory in New Mexico. Slow-antenna measurements showed electric field steps of 0.001 s duration looking much like K-changes, but occurring BEFORE the first return-stroke of this long leader. We speculate that these steps (which we call U-changes – U for “unknown”) are (like K-changes) reionization waves that feed the growing channel and keep it hot enough to proceed all the way to ground. During a U-change, the DITF shows channels reconnected over several kilometers of altitude.

\(^1\)Supported by NSF grants #CMB-0724771 and the DARPA Nimbus/PhOCAL program
2:51PM M2.00003 A Study of Lightning Discharges over Costa Rica during a Period of Intense Electrical Activity: May and June of 2009. JOSE MARTINEZ, New Mexico Institute of Mining and Technology. WALTER FERNANDEZ, Universidad de Costa Rica. ILEANA MORA, Instituto Costarricense de Electricidad — Intense electrical activity in storm clouds is a common characteristic of rainy seasons in Costa Rica. The most common type of electrical discharge observed in this study was cloud-ground (CG) lightning, which is generally linked to its destructive potential on property and human lives. Intra-cloud (IC) lightning events, which are known to occur much more frequently on a global scale than CG events, are also present during intense storms. Using the National Network for Detection and Analysis of Electrical Discharges, operated by the Costa Rican Institute of Electricity (ICE), more than a million stroke events were recorded by the network during months of May and June 2009. Analysis of spatial and temporal distributions of lightning events show that CG discharges occur more frequently during the day, with a maximum in the afternoon, while IC discharges occur more frequently during the night. During these months, a higher concentration of both types of discharges were observed on the Pacific side of Costa Rica, rather than in the Atlantic side. This spatial and temporal information can be related to sea breeze circulations and the diurnal cycle for convective activity in tropical regions.

3:03PM M3.00003 Introduction to the Physics of Medical Imaging. JENNIFER STICKEL, Colorado Associates in Medical Physics — This talk will review the basic physics involved in medical imaging. We will cover the range of imaging modalities including radiography, fluoroscopy, computed tomography (CT), ultrasound, nuclear medicine and MRI. We will also review some of the basic machine properties that take advantage of these physics principles to generate images with varying contests.

Saturday, October 19, 2013 2:15PM - 3:27PM –
Session M3 Biological and Soft Condensed Matter Physics III: Medical Physics 287 -
Meredith Betterton, University of Colorado

2:15PM M3.00001 Nanobiophysics. ROBERT ROS, Arizona State University —

2:39PM M3.00002 Medical Physics. GERALD WHITE, Colorado University Health Sciences Center —

3:03PM M3.00003 Introduction to the Physics of Medical Imaging. JENNIFER STICKEL, Colorado Associates in Medical Physics — This talk will review the basic physics involved in medical imaging. We will cover the range of imaging modalities including radiography, fluoroscopy, computed tomography (CT), ultrasound, nuclear medicine and MRI. We will also review some of the basic machine properties that take advantage of these physics principles to generate images with varying contests.

Saturday, October 19, 2013 2:15PM - 3:39PM –
Session M4 Condensed Matter V: Thermal Properties 281 - Mingzhong Wu, Colorado State University
CHARLES STAFFORD, University of Arizona — Recent advances in thermal microscopy, where spatial and thermal resolutions of 10nm and 15mK, respectively, have been achieved, raise a fundamental question, “On how short a length scale can a statistical quantity like temperature be meaningfully defined?” We tackle this question theoretically by developing a realistic model of a scanning thermal microscope with atomic resolution, operating in the tunneling regime in ultrahigh vacuum. The thermometer acts as an open third terminal in a thermoelectric circuit. We investigate the temperature distributions in molecular junctions and graphene nanoribbons under thermal bias, and find that thermal energy takes on a fundamentally different character and manifests ballistic effects in these systems. Differences in the quantum oscillations in these systems exhibits quantum oscillations; quantum interference mimics the actions of a Maxwell Demon, allowing electrons from the hot electrode to tunnel onto the temperature probe when it is at certain locations near the system, and blocking electrons from the cold electrode, or vice versa. A crossover to a classical temperature distribution consistent with Fourier’s law of heat conduction is predicted as the spatial resolution of the temperature probe is reduced.

1This material is based on work supported by the Department of Energy under Award No. DE-SC0006699.

2:39PM M4.00002 Diffusive, Ballistic, and Quantum Thermal Transport in Thin Films and Nanostructures1, BARRY ZINK, University of Denver — The understanding and manipulation of heat flow in novel materials and small structures plays an essential role in current and future technologies, such as heat removal from integrated circuits and thermoelectric energy generation. This talk will discuss our recent work that shows there are still surprises in the fundamental physics of heat flow in such systems. One example is the role of phonons with long mean free path in heat conduction near room temperature. By adding scattering centers to the surfaces of suspended Si-N bridges via deposition of a series of discontinuous gold films, we have shown that phonons of surprisingly long mean free path and wavelength carry up to 40% of the heat even in this highly disordered material. This echoes recent results in crystalline materials, where other researchers are also finding large contributions to thermal conductivity from long mean free path phonons. By combining these two techniques we are able to measure the contribution of the leads needed to measure this far larger volume of the film. These very different methods give similar results of reduced thermal conductivity relative to macroscale values, and in combination they are a powerful tool for investigating and understanding thermal transport at the nanoscale.

1This work supported by the NSF CAREER award and the DOE (NNSA).

3:03PM M4.00003 Nanoscale thermal transport measurements: Bridging ultrafast and steady-state, BRIAN G. GREEN, MARK E. SIEMENS, University of Denver — Macroscale thermal transport is explained by classical thermal diffusion, but as nanostructure length scales are reduced towards the order of the phonon mean free path and wavelength, transport of thermal energy takes on a fundamentally different characteristic and manifests ballistic effects. We investigate nanoscale thermal transport by comparing results from two different techniques applied to a thermally isolated suspended bridge structure. One technique uses the transient thermoreflectance method to measure sub-nanosecond cooling dynamics following ultrafast laser heating in a micron-sized region of a metallic film deposited on the bridge; the second is a DC technique measuring transport driven by a thermal gradient across the bridge, through the full, far larger volume of the film. These very different methods give similar results of reduced thermal conductivity relative to macroscale values, and in the microstructure they play a powerful role for investigating and understanding thermal transport at the nanoscale.

3:15PM M4.00004 Nanoscale Absolute Thermopower Measurements, SARAH MASON, Univ. of Denver, BARRY ZINK COLLABORATION1 — Significant advancements in thermoelectric device efficiencies have been due to size reduction to the nanoscale. With reduced dimensions come complications in measuring thermoelectric material properties. Quantities needed to characterize thermoelectric material efficiency, such as the thermopower, or Seebeck coefficient, $S$, are primarily contingent upon the measurement apparatus, so that measuring a thermally generated voltage gives, $S_{\text{sample}} - S_{\text{lead}}$. If accurate values of, $S_{\text{lead}}$, are available, simple subtraction provides the film’s absolute thermopower value. This is rarely the case in nanoscale measurement devices, with leads exclusively made from thin film materials that do not have well known bulk-like thermopower values. We have developed a technique to directly measure $S$ as a function of $T$ using a micromachined thermal isolation platform consisting of a suspended, patterned SiN membrane. By measuring a series of thicknesses of metallic films up to the infinite thin film limit, in which the thermopower is no longer increasing with thickness, but still not at bulk values, along with the effective electron mean free path, we are able to show the contribution of the leads needed to measure this property. Having a comprehensive understanding of the background contribution we are able to determine the absolute thermopower of a wide variety of thin films.

1Advisor

3:27PM M4.00005 Optical thickness determination of hexagonal boron nitride flakes1, DHEERAJ GOLLA, KANOKPORN CHATTAKRUN, Department of Physics, University of Arizona, Tucson, AZ, KENJI WATANABE, TAKASHI TANIGUCHI, National Institute for Materials Science, Tsukuba, Japan, BRIAN J. LEROY, ARVINDER SANDHU, Department of Physics, University of Arizona, Tucson, AZ — Optical reflectivity contrast provides a simple, fast, and noninvasive method for characterization of few monolayer samples of two-dimensional materials. Here, we apply this technique to measure the thickness of thin flakes of hexagonal Boron Nitride (hBN), which is a material of increasing interest in nanodevice fabrication. The optical contrast shows a strong negative peak at short wavelengths and zero contrast at a thickness dependent wavelength. The optical contrast varies linearly for 1-80 layers of hBN, which permits easy calibration of thickness. We demonstrate the applicability of this quick characterization method by comparing atomic force microscopy and optical contrast results.

1K.C. and B.J.L. acknowledge support from the Army Research Office under Contract No. W911NF-09-1-0333 and NSF CAREER Award No. DMR/0953784.

Saturday, October 19, 2013 2:15PM - 3:27PM — Session M5 Cosmic Rays 251 - Johanthan Ormes, University of Denver

2:15PM M5.00001 Cosmic Rays, JOHN MATTHEWS, University of New Mexico —
and Tibet observatories have detected anisotropy on angular scales of 8,000 m A.S.L. and is a second generation water Cherenkov detector. Previously, the Milagro observatory (HAWC’s predecessor) and the ARGO is being built on the slopes of Sierra Negra in the Pico de Orizaba Mexican National Park. This gamma-ray and cosmic-ray observatory is at the simulation and reconstruction techniques used for analyzing the TALE data.

Surface array of 105 plastic scintillation counters with variable 400 to 600-meter spacing. Together with the original TAMD detector, this yields telescopes situated at the TA Middle Drum (TAMD) fluorescence detector site with 30 to 57 degree sky coverage in elevation, and an infill capability for primary energies between 3 x 10^{18} eV. The Telescope Array Low-energy Extension (TALE) will explore the energy regime corresponding to that of the LHC in center-of-mass frame. This is also the range where the transition from galactic to extra-galactic cosmic ray flux is suspected to occur. We will give a brief overview of the physics, and report on the progress of TALE.

## 2:51PM M5.00003 Calibrating a large diameter light source and multi-wavelength calibration of the Pierre Auger Observatory fluorescence detectors

BEN GOOKIN, JEFF BRACK, ALEXEI DOROFEEV, JOHN HARTON, YEVENI PETROV, Colorado State University — Calibration of the Pierre Auger Observatory fluorescence detectors is performed using a low intensity uniform 2.5m diameter light source which allows for an end-to-end measurement of all detector components that calibrates the combined effect of each component in a single measurement. There are two fluorescence detector calibrations that utilize the 2.5m diameter light source, absolute calibration at a single UV wavelength and a relative calibration at several UV wavelengths. Recent improvements in technique and equipment have increased calibration reliability and improved uncertainties. We discuss these improvements here, including digital control and monitoring of LED pulses, a technique using the $1/r^2$ attenuation of light in the calibration of this low intensity light source, and the use of a monochromator to pick out single wavelengths in a broad UV range to perform the relative calibration. Preliminary data on the relative calibration using the monochromator setup will be presented, along with the effect of this calibration on the reconstructed energy of simulated showers using the Pierre Auger Observatory fluorescence detector simulation.

1Supported by DOE

## 3:03PM M5.00004 TALE Hybrid Simulation and Analysis

DMITRI IVANOV, Univ of Utah, TELESCOPE ARRAY COLLABORATION — The Telescope Array (TA) is the largest cosmic ray detector in the Northern hemisphere that observes cosmic rays of primary energies above 10^{16} eV. The Telescope Array Low-energy Extension (TALE) is built to provide additional observational capability for primary energies between 3 x 10^{16} eV and 10^{18} eV. TALE is a hybrid detector which consists of ten additional fluorescence telescopes situated at the TA Middle Drum (TAMD) fluorescence detector site with 30 to 57 degree sky coverage in elevation, and an infill surface array of 105 plastic scintillation counters with variable 400 to 600-meter spacing. Together with the original TAMD detector, this yields a combined sky coverage of 112 degrees in azimuth and 3 to 57 degrees in elevation for the Middle Drum site. In this presentation, we describe the simulation and reconstruction techniques used for analyzing the TALE data.

## 3:15PM M5.00005 Observations of the Small Scale Cosmic Ray Anisotropy by HAWC

AHRON BARBER, Univ of Utah, HAWC COLLABORATION1 — HAWC, the High Altitude Water Cherenkov Observatory, is being built on the slopes of Sierra Negra in the Pico de Orizaba Mexican National Park. This gamma-ray and cosmic-ray observatory is at 4100m A.S.L. and is a second generation water Cherenkov detector. Previously, the Milagro observatory (HAWC’s predecessor) and the ARGO and Tibet observatories have detected anisotropy on angular scales of \sim 10-20 degrees with amplitudes of \sim 10^{-4} in the arrival directions of cosmic rays. This small-scale anisotropy has no predicted origin. Cosmic rays in the TeV energy range have gyroradii less than 0.01 pc and their arrival directions should be isotropic, as there are no known sources within this distance. Recent theories suggest that the anisotropy could be due to galactic and/or heliospheric effects. HAWC-30, the first 10% of HAWC, began operations on January 1st, 2013 and was able to detect the small-scale cosmic ray anisotropy regions. In addition, HAWC-95, which started operations in mid-June 2013, was able to detect the anisotropy after \sim 1.5 months.

1High Altitude Water Cherenkov observatory

Saturday, October 19, 2013 4:00PM - 5:00PM –
Session N1 Awards and Closing Session

248 - Richard Sonnefeld New Mexico Tech University; Davor Balzar, University of Denver

4:00PM N1.00001 Awards / Closing Session