14th Annual Meeting of the Northwest Section of the APS

Vancouver, British Columbia, Canada

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Thursday, October 18, 2012 7:30PM - 9:00PM –

Session A1 Public Lecture SFU Harbour Centre 1900 Fletcher Challenge Theatre - Chair: Andrew DeBenedictis, Simon Fraser University

7:30PM A1.00001 The Nuclear Physics of Stars REINER KRUECKEN, TRIUMF — Atomic nuclei are at the core of all the matter around us and are the fuel of stars. Nuclear reactions produce the energy in our sun that enables live on our planet and nuclear processes during the live and death of stars produce most of the chemical elements in our world. The atomic nucleus in every atom and molecule in our bodies and the world around us is a remnant of the star in which it was produced. Thus in the most literal sense we are all star dust. Many aspects of the production of the chemical elements have been solved but many mysteries remain. In this talk I will summarize what we know about the production of the elements in stars and show how nuclear physics experiments carried out at TRIUMF, Canada's national laboratory for particle and nuclear physics in Vancouver, can help to answer the open questions in this quest for understanding the origins of the chemical elements.

Friday, October 19, 2012 8:25AM - 12:00PM –

Session B1 Welcome and Plenary Session I SFU Harbour Centre 1900 Fletcher Challenge Theatre - Chair: Oscar Vilches, University of Washington

8:25AM B1.00001 Welcome –

8:30AM B1.00002 Using the Aurora to Remote Sense Near-Earth Space , ERIC DONOVAN, University of Calgary — The Earth's magnetosphere is formed by the interaction of the solar wind and Earth's magnetic field. Sitting like a giant wind sock in the solar wind, the magnetosphere is an enormous and dynamic region. The processes at work within the magnetosphere serve as exemplars of phenomena that happen throughout the cosmos, and have consequences in the upper atmosphere. One of those is the aurora, a truly global and multi-scale phenomenon that we are only beginning to understand. Of all the countries on Earth, Canada has the largest region of land under the auroral zone, something Canadian scientists have capitalized on for more than fifty years. In this talk, I will outline how we use observations of the aurora to remote sense the magnetosphere, focusing on Canadian ground-based and space-based programs that provide remarkable images of this beautiful natural phenomenon.

9:06AM B1.00003 Quantum hydrodynamics in dilute-gas Bose-Einstein condensates[1] , PETER ENGELS, Washington State University — The peculiar dynamics of superfluids are a fascinating research topic. Since the first generation of a dilute gas Bose-Einstein condensate (BEC) in 1995, quantum degenerate atomic gases have taken the investigation of quantum hydrodynamics to a new level. The atomic physics toolbox has grown tremendously and now provides unique and powerful ways to explore nonlinear quantum systems. As an example, pioneering results have recently revealed that the counterflow between two superfluids can be used as a well controlled tool to access the rich dynamics of vector systems. New structures, such as beating dark-dark solitons which only exist in multicomponent systems and have never been observed before, can now be realized in the lab for the first time. Furthermore, the field of nonlinear quantum hydrodynamics is entering new regimes by exploiting Raman dressing as a tool to directly modify the dispersion relation. This leads to the generation of spin-orbit coupled BECs, artificial gauge fields, etc. that are currently receiving tremendous interest due to their parallels to complex condensed-matter systems. Studies of quantum hydrodynamics help to develop a profound understanding of nonlinear quantum dynamics, which is not only of fundamental interest but also of eminent importance for future technological applications, e.g. in telecommunication applications using optical solitons in fibers. This talk will showcase some "classic" hallmark results and highlight recent advances from the forefront of the field.

[1] We acknowledge funding from NSF and ARO.

9:42AM B1.00004 Material and Optical Properties of ZnO-Based Alloys[1] , LEAH BERGMAN, University of Idaho — ZnO is emerging as one of the materials of choice for UV applications. It has a relatively benign chemical nature, a deep excitonic energy level, and a direct bandgap of ~ 3.4 eV. The latter two properties make ZnO a highly efficient light-emitter at room and above room temperatures. Alloying ZnO with certain atomic constituents has the potential to add new optical and electronic functionalities to ZnO. This work will focus on two alloy systems of ZnO: one is Mg(x)Zn(1-x)O, and the other is ZnS(1-x)O(x). The x in the formula is the percent composition of the alloy constituents; upon changing the composition, the bandgap and the optical properties can be tailored from those of one end member to the other. At the low Mg composition range, the Mg(x)Zn(1-x)O alloy has the hexagonal wurtzite structure and a bandgap that is tunable in the range of ~ 3.4 (that of ZnO) up to approximately 4 eV. At the high composition range the alloy forms with the cubic NaCl structure, and importantly its bandgap shifts into the deep UV range up to 7.4 eV (that of MgO). Thus, Mg(x)Zn(1-x)O can provide an alloy system with bandgaps and bandedge photoluminescence spanning the range of 3.4 eV to 7.4 eV that are achieved via the choice of the composition x. However, due to the two different crystal structures of the end members, ZnO with the wurtzite and MgO with the cubic structure, at intermediate composition range the alloy is phase segregated. The other alloy system to be discussed is the ZnS(1-x)O(x). The bandgap of ZnO is 3.4 eV and that of ZnS is 3.8 eV; upon alloying ZnO with sulfur, the bandgap behavior exhibits a strong deviation from linearity due to the large difference in atomic size and chemical characteristics of the alloy constituents. Unlike Mg(x)Zn(1-x)O, the ZnS(1-x)O(x) is a highly lattice mismatched system that results in a strong bowing of its bandgap toward the visible range at the green-blue part of the spectrum. In this research, we present studies of the material and optical properties of both alloys. The issue of solubility and phase segregation studied via X-ray diffraction, photoluminescence, and atomic imaging, is addressed. The optical properties that were studied via absorption and photoluminescence are discussed. The optical properties studied include bandgap tailoring, the nature of the optical emission specifically exciton and defect photoluminescence, and the phonon dynamics of the alloys.

[1] This research was supported by NSF grant DMR-1202532.

10:18AM B1.00005 BREAK –

10:48AM B1.00006 Recent LHC results , ANADI CANEPA, TRIUMF — What is the Universe made of? What is the nature of matter? How can we explain the matter vs antimatter asymmetry? Are there extra dimensions of space-time? The Large Hadron Collider (LHC) by recreating the same conditions as those soon after the Big Bang has the potential to answer these questions. The LHC is the highest energy proton-proton collider in the World. Collisions are recorded by the ATLAS and CMS detectors, which are both unprecedented in scale and complexity. The data recorded in 2011 and 2012 lead to the discovery of a Higgs-boson like resonance assumed to be the key ingredient for the generation of mass. Thanks to the excellent performance of the accelerator and of the detectors, future searches have the potential to discover new phenomena, such as Supersymmetry or extra dimensions. We live in a time when the exploration of fundamental particles and their interactions can lead toward a revolutionary new understanding of the universe.

11:24AM B1.00007 The Experiences of an Entrepreneurial Physicist , MOE KERMANI, Kermani Inc. — The majority of pre- and post-graduate training in physics is focused on the acquisition of hard skills necessary to pursue academic research within a specific discipline of the broader field. Often many physics graduates view a career transition from academia to the private sector with much consternation. In this presentation, Moe Kermani will share his experience in making the transition and discuss how elements of post graduate training in physics provide a good foundation for success as an entrepreneur. This presentation is primarily aimed at young physicists and graduate students that are considering a transition from the academic sector to the world of technology startups.

Friday, October 19, 2012 1:30PM - 5:38PM –

Session C1 Astronomy, Cosmology, and Gravity SFU Harbour Centre 1700 Labatt Hall - Chair: Sukanta Bose, Washington State University

1:30PM C1.00001 Peering through the EoR window with the Murchison Widefield Array , MIGUEL MORALES, University of Washington — Measurement of the spatial distribution of neutral hydrogen via the redshifted 21 cm line promises to transform our knowledge of the Epoch of Reionization (EoR). In my talk I will give an accessible introduction to this new field, discuss how we plan to observe the faint 21 cm fluctuations in the face of strong foregrounds, and show our latest results from prototype and early commissioning observations with the MWA as we start to peer through the EoR window.

2:06PM C1.00002 Estimates of the Neutrino Dynamics of Black Hole-Neutron Star Mergers , M. BRETT DEATON, MATTHEW D. DUEZ, Washington State University, SPEC COLLABORATION — In an attempt to further understand black hole-neutron star systems (BHNS) as potential gamma ray burst central engines we explore the dynamics of BHNS mergers of low mass ratio and high spin. Our simulations include radiative cooling through a leakage approximation. We examine the neutrino signal, the remnant disk dynamics, and the energy deposited by neutrino pair annihilations around the disk.

2:18PM C1.00003 Status of Advanced LIGO , MICHAEL LANDRY, LIGO Hanford Observatory/Caltech, LIGO SCIENTIFIC COLLABORATION COLLABORATION — Installation of Advanced LIGO, a second-generation interferometric gravitational wave observatory, began in earnest in October of 2010. Initial LIGO instrumentation was de-installed, vacuum chambers and envelope modified, and the installation of scientific payloads begun. At LIGO Hanford Observatory, optics and suspensions comprising one of two 4km Fabry-Perot arms have been deployed and commissioned, resonating green light in an experiment to test and understand the process of controlling cavity lengths ("lock acquisition"). At LIGO Livingston, cornerstation optic and seismic isolation installation has matured such that the primary infrared laser and a suspended mode cleaner cavity (employed to spacially clean the interferometer input beam) are locked and under commissioning test. In this talk we present the status of Advanced LIGO installation and integration, and sketch the promising future of gravitational wave observation and astronomy.

2:30PM C1.00004 Real-time Simulation of a Suspended Cavity with the Advanced LIGO Digital Controls System[1] , ALEXANDRA ZHDANOVA, University of Washington, LIGO COLLABORATION — LIGO is a collaboration brought together by the goal of detecting gravitational waves sent out by especially massive, quickly-moving objects. An integral part of LIGO's interferometers are the Fabry-Perot cavities in the arms. Modeling them can show us how well we understand the noise in addition to serving as a test of the control system used to keep the interferometer in resonance. While time-domain simulations of the cavity have been done, a real-time model would provide a better comparison point for the noise while accurately simulating the cavity response. This presentation outlines such a real-time model, as well as a comparison between the results of the "fake" (or simulated) cavity and the "real" cavity. The closer these results are to each other, the more successful we count our model as an accurate representation of the real-life noise and mechanics in a Fabry-Perot cavity.

[1] I gratefully acknowledge the support of the NSF and the LIGO SURF program.

2:42PM C1.00005 Heavy Dark Matter and High Energy Cosmic Rays , KYLE LAWSON, University of British Columbia — Conventional dark matter models assume that the dark matter is composed of new fundamental particles which interact only weakly with visible matter. One alternative to this picture is a model in which the dark matter is actually composed of standard model quarks (or antiquarks) bound into macroscopically large composite objects. If these objects are sufficiently massive they become unobservable due to their correspondingly small number density. For dark matter with very low density experimental searches are limited by detector size rather than sensitivity. I will outline the basic properties of quark nugget dark matter and analyze their interactions with molecules of earth's atmosphere. Depending on the nature of the quark matter involved the total energy deposited can be observably large. In this case the quark nugget will trigger an extensive air shower similar to that initiated by a single ultrahigh energy proton or nucleus. As such, it is possible that large scale cosmic ray experiments are capable of detecting this type of dark matter. A dark matter signal may be seen in both fluorescence and surface detectors as well as in radio detection experiments. I will offer a description of the potential signal in each of these channels and a brief summary of detection potential.

2:54PM C1.00006 Searching for dark matter axions with ADMX , DMITRY LYAPUSTIN, University of Washington, AXION DARK MATTER EXPERIMENT COLLABORATION — Axions are hypothetical elementary particles that may help provide the answer as to why QCD preserves the discrete symmetries P and CP. Light axions also have properties that make them ideal dark-matter candidates. The Axion Dark Matter eXperiment (ADMX) has been at the forefront of the dark-matter axion search for over two decades, and is currently being upgraded to improve its sensitivity to where it will either be able to detect the QCD dark-matter axion, or reject the hypothesis at high confidence. I will motivate the existence of axions, discuss ADMX and its previous results, and highlight the state of the current upgrade.

3:06PM C1.00007 The ADMX ultra-low noise receiver , CHRISTIAN BOUTAN, University of Washington, AXION DARK MATTER EXPERIMENT COLLABORATION — Finding axions would finally point to the solution to the "strong CP problem" in QCD and uncover the nature of the Mily Way's dark-matter halo. The Axion Dark Matter eXperiment (ADMX) is a sensitive search for such axions. ADMX looks for the exceedingly tiny amount of power that would be released in the very weak conversion of dark-matter axions to photons. The key to the sensitivity of ADMX is a microwave receiver sensitive to sub-yoctowatt electromagnetic power. ADMX is currently being upgraded to a lower noise temperature and a new receiver design that has the sub-Hz spectral resolution necessary for the detection of even exotic non-virialized axion dark-matter halo models. I discuss the simulation nature of the axion signal and the calibration of this receiver using simulated axion signals.

3:18PM C1.00008 BREAK —

3:38PM C1.00009 Magnetic stars as remote laboratories for magnetic physics[1] , JAYMIE MATTHEWS, University of British Columbia — Understanding the magnetic field of the Sun, its dynamo origin, its evolution with time, and its interactions with the solar corona, solar wind and interstellar medium is important and exciting. But the Sun's field is relatively weak and globally disorganized. There are more massive stars whose magnetic fields are thousands (even tens of thousands) of times stronger, with dipole geometries more reminiscent of the Earth's field than the Sun's. Such fields can help regulate processes like radiative diffusion and gravitational settling in stellar atmospheres, and their Lorentz forces can even modify the spherical harmonics and the frequencies of a star's resonant vibrations. And even in the case of weaker solar-like magnetic fields, there are stars with exoplanets in tight orbits where the planet's magnetospheres is tangled with the star's magnetic field lines, generating activity in the star's atmosphere beneath the planet in its orbit. Examples of all of these types of systems have been studied through ultraprecise time series optical photometry with Canada's space telescope, MOST, often in concert with spectroscopy and spectropolarimetry from earthbound observatories. It'll be hard to cover so much parameter space in only half an hour, but I'll try to give you a glimpse at the surfaces of these stellar magnetic labs, and even a peek inside their normally hidden interiors.

[1]Including data from MOST (Microvariability & Oscillations of STars), a Canadian Space Agency mission operated by Microsat Systems Canada Inc., and the Universities of British Columbia and Toronto, with the assistance of the University of Vienna.

4:14PM C1.00010 Studies of Galactic Magnetism , JO-ANNE BROWN, University of Calgary — Magnetic fields are an important constituent of the interstellar medium, but unlike gas, dust and cosmic rays, they do not radiate, and consequently cannot be observed directly. Instead, observations of the *signatures* of magnetic fields have allowed researchers to piece together the structure of the magnetic field in our Galaxy and others. In this talk, I will review some of the latest findings in our quest to determine the struture of the magnetic field in our Galaxy, and how this knowledge is shaping our understanding of the origin and evolution of galactic magnetic fields in general.

4:26PM C1.00011 Cosmological Inflation: Testing Initial Conditions of Inhomogeneous Inflation Fields , AUBERRY FORTUNER, PLU — The cosmological model explains how the expansion of the Universe is determined by the energy density, yet suffers from some limitations that can be overcome only if the Universe began under very specific conditions. The theory of inflation was proposed to solve these problems by introducing a period of rapid expansion in the early Universe. The mechanism that causes inflation is the evolution of a scalar field, which determines the energy density and expansion of the Universe. The evolution of the scalar fields depends on the type of field and the initial conditions we give it. Scalar fields that are flat and smooth generally cause inflation, yet scalar fields that fluctuate may delay or prevent inflation under certain initial conditions by introducing an additional energy density. Our research investigated the range of initial conditions for two models of inhomogeneous scalar fields that allow inflation to occur. The equation of motion of the scalar fields were solved numerically allowing us to determine the amount of expansion that results from each set of initial conditions, and whether or not inflation occurs.

4:38PM C1.00012 Decay of false vacuum and solar system test of f(R) gravity[1] , JUN-QI GUO, ANDREI V. FROLOV, Simon Fraser University — The scenario of false vacuum decay can describe the nucleation processes of statistical physics. Historically it was also used to build the early theory of inflation. In this talk, we will discuss another application: solar system test of f(R) gravity. f(R) gravity is to interpret the current accelerating expansion of the universe. In solar system, f(R) gravity is required to reduce to general relativity so as to meet the observations. In the "Chameleon mechanism," the scalar field, f'=df/dR, might couple to the matter density both inside and outside of the Sun. Therefore, the field, f', can be regarded to decay from the false vacuum of an effective potential to the true one. We find that, 1) the thin-wall approximation condition derived in the scenario of false vacuum decay can be written in a more intuitive way; 2) compared to the thin-shell condition obtained in Chameleon mechanism, the thin-wall approximation condition is the more proper one for an f(R) model to meet the solar system test. The numerical solutions to the equation of motion of f' for RlnR and Hu-Sawicki models verify the thin-wall approximation condition, and also explain the difficulties that the RlnR model faces in the solar system test.

[1]NSERC, Canada

4:50PM C1.00013 A Breathing mode for Compactifications , BRET UNDERWOOD, Pacific Lutheran University — Reducing a higher dimensional theory to a 4-dimensional effective theory results in a number of scalar fields describing, for instance, fluctuations of higher dimensional scalar fields (dilaton) or the volume of the compact space (volume modulus). But the fields in the effective theory must be constructed with care: artifacts from the higher dimensions, such as higher dimensional diffeomorphisms and constraint equations, can affect the identification of the degrees of freedom. The effective theory including these effects resembles in many ways cosmological perturbation theory. In this talk I will briefly outline how constraints and diffeomorphisms generically lead the dilaton and volume modulus to combine into a single degree of freedom in the effective theory, the "breathing mode."

5:02PM C1.00014 Statistical mechanics of graph models and their implications for emergent manifolds , SI CHEN, STEVEN PLOTKIN, University of British Columbia — Inspired by "quantum graphity" models for spacetime, a statistical model of graphs is proposed to explore possible realizations of emergent manifolds. Graphs with a given number of vertices and edges are considered, with a Hamiltonian that favors graphs with near-constant valency and local rotational symmetry. The ratio of vertices to edges controls the dimensionality of the emergent manifold. The model is simulated numerically in the canonical ensemble for a given vertex to edge ratio, where it is found that the low energy states are almost triangulations of two dimensional manifolds. The resulting manifold shows intricate topological structures in a higher dimensional embedding space. The transition is first order, underlying the difficulty of graph models in describing criticality that is independent of the details of the underlying graph. A further perplexing phenomenon is that the entropy of the graphs are super-extensive, a fact known since Erdös, which results in a transition temperature of zero in the limit of infinite system size. Aside from a finite-universe as a possible solution, long-range interactions between vertices also resolve the problem and restore a non-zero transition temperature.

5:14PM C1.00015 The Photon may have mass, RICHARD KRISKE, University of Minnesota — The argument for a particle having mass is now days predicated on a Quantum Mechanics. The argument involves the distance that a particular force can be felt, and in the case of the Photon that should be infinity, and if it is infinity then the mass of the Photon has to be zero. This author has some doubts about the distance the Electomagnetic Force can be felt. This author has previously stated that if the Universe has a Horizon wherein there is a three space embedded in four dimensions, where time is perpendicular to the three space dimensions, then if there is curvature, like the curvature of the Earth, then one should see time tilt backward away from the observer at the Horizon (just as a large tower would tilt away from the observer if it where on the other side of an ocean for instance-on the Earth's surface). If this tilting does take place (if Space-Time is not flat, but positively curved), then the Photon redshifts in every direction even if Space-Time is not expanding. This redshift limits the distance of the Electromagnetic Field, and therefore the Photon should have rest mass, as the Horizon acts as a boundary for each observer, but may not be the actual size of Infinity, the Universe may go on for a large distance beyond the Horizon.

5:26PM C1.00016 Gravity Driven Universe: Energy from a Unified Field, ROY MASTERS, Independent Researcher — One way or another, whether push or pull, we know for sure that gravity is omnidirectional with identical mathematics. With PULL, gravity can be seen as as a property of matter. If so something is wrong. The Moon, lifting the tides twice-daily, should have fallen into orbital decay, with Earth having pulled it down eons ago. It is puzzling that physicists are not troubled by the fact that the Moon not only insists on forever lifting the tides, but, adding insult to injury, *keeps moving it about 4 cm further away* from Earth each year. Now if instead, we consider gravity as driven by an omnidirectional pressure–a PUSH force, another possibility arises. We can consider that it is mysteriously infusing energy into the Earth-Moon system, sustaining the Moon's orbit with the appearance of raising the tides and actually pushing it away from Earth. Here we can show push and pull, while being identical in their mathematics, have different outcomes. With push, gravity is a property of the universe. If this is true, then gravitation is flowing from an everlasting source, and the Earth/Moon system is one example of many other vacuum energy machines in the universe.

Friday, October 19, 2012 1:30PM - 5:14PM –

Session C2 Nuclear Physics SFU Harbour Centre 1315 Scotiabank Lecture Room - Chair: Corina Andreoiu, Simon Fraser University

1:30PM C2.00001 25 Years of Radioactive Beams at TRIUMF[1], JOHN M. D'AURIA, Simon Fraser University — It has been 25 years since the first radioactive beams were produced at TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics. These first beams, ^{37,38}K and ^{25}Na, were produced using the innovative TISOL (Test Isotope Separator On-Line) prototype facility and started the path to the present ISAC (Isotope Separator and ACcelerator) facility, considered one of the best accelerated radioactive beam facilities in the world today, and the new ARIEL (Advanced Rare IsotopE Laboratory) facility, presently under construction. It is time to acknowledge the role TISOL played in opening this path, and explore some of its achievements during its years of operation. TISOL enabled experiments measuring the decay of very short-lived isotopes, including information needed for energy production in novae, an atom trap to measure neutrino momenta from beta decay, a key experiment in understanding the production of carbon and oxygen in the Universe, and other studies. This presentation will give a short history of TISOL, aspects of its original technical characteristics and a summary of its scientific achievements.

[1]Work done in collaboration with Corina Andreoiu, Simon Fraser University; John Behr, Lothar Buchmann, Marik Dombsky, and Peter Jackson, TRIUMF.

2:06PM C2.00002 Examining Shape Co-existence in 116Sn via the Beta Decay of 116In, J. PORE, C. ANDREOIU, D. CROSS, R. ASHLEY, A. CHESTER, K. STAROSTA, SFU, G.C. BALL, P. BENDER, R. CHURCHMAN, P. VOSS, Z. WANG, A.B. GARNSWORTHY, B. HANDINIA, B. JIGMEDDORJ, TRIUMF, P.E. GARRETT, G. DEMAND, A.T. LAFFOLEY, A. LIBLONG, R. DUNLOP, C.E. SVENSSON, A.D. VALERA, A.D. VARELA, University of Guelph, R. KANUNGO, St. Mary's University, J.L. WOODS, Georgia Institute of Technology, S.W. YATES, University of Kentucky — The stable even-even tin nuclei have a closed proton shell at Z=50 and occupy the mid-shell region of neutrons, which has led to interest in them, and they have emerged as good candidates for shape co-existence studies. The 116Sn nucleus, which sits exactly at the mid-shell (N=66), has been extensively studied in the past through fusion evaporation, coulomb excitation, neutron scattering and beta decay experiments, which has revealed an extensive level scheme and evidence for shape co-existence. However, with our advanced detection set-up and good beam intensity we are able to see additional weak transitions, some of which could yield evidence for another deformed excited state at 2545 keV. The experiment was conducted at TRIUMF, Canada's National Laboratory for Nuclear and Particle Physics. A beam of 116In was used to populate states in 116Sn via beta decay. The resulting gamma rays were observed with the 8pi array consisting of 20 high-purity germanium detectors coupled with a suite of ancillary detectors. We will present the enhanced level scheme constructed from this experiment.

2:18PM C2.00003 Conversion-Electron Spectroscopy of ^{116}Sn via the β-decay of ^{116}In[1], DAVID CROSS, CORINA ANDREOIU, JENNIFER PORE, Simon Fraser University, G.C. BALL, TRIUMF, V. BILDSTEIN, University of Guelph, A. CHESTER, Simon Fraser University, R. CHURCHMAN, TRIUMF, G.A. DEMAND, A. DIAZ VARELA, R. DUNLOP, University of Guelph, A.B. GARNSWORTHY, TRIUMF, P.E. GARRETT, B. HADINIA, University of Guelph, G. HACKMAN, TRIUMF, B. JIGMEDDORJ, University of Guelph, R. KANUNGO, St. Mary's University, A.T. LAFFOLEY, A. LIBLONG, University of Guelph, B. NOAKES, Simon Fraser University, C.E. SVENSSON, University of Guelph, P. VOSS, Z.-M. WANG, Simon Fraser University, J.M. WILSON, University of Guelph, J.L. WOOD, Georgia Institute of Technology, S. YATES, University of Kentucky — Motivated by a study of the prevalence of shape coexistence and collectivity in nuclei at closed shells [1], we have revisited the ^{116}Sn (Z=50; N=66) nucleus, known to exhibit these characteristics [2], using a ^{116}In beam produced via the ISOL technique at TRIUMF. The beta decay of ^{116}In to ^{116}Sn has been measured using the 8π spectrometer and its suite of ancillary detectors. In this presentation we focus on the conversion-electron coincidence spectroscopy of the ^{116}Sn nucleus, in order to augment and improve the existing knowledge of its structure via the high-statistics spectroscopic data obtained in our experiment. In particular, re-measurements of internal conversion coefficients will be discussed as they pertain to the possibility of mixing of different shapes between bands in ^{116}Sn. [1] K. Heyde and J.L. Wood, Rev. Mod. Phys. 83, 1467 (2011). [2] S. Raman et al., Phys. Rev. C 43 521 (1991)

[1]This work was supported by the Natural Sciences and Engineering Research Council of Canada

2:30PM C2.00004 β-decay study of neutron-rich ^{102}Rb at TRIUMF-ISAC[1] , ZHIMIN WANG, SFU and TRIUMF — Experimental investigations of the β-decay properties of nuclei which lie along the astrophysical r-process are becoming possible with modern facilities and detection systems. In this experiment, a ^{102}Rb beam was produced by 500 MeV, 10 μA protons impinging on a multilayer UC$_x$ target at TRIUMF-ISAC Facility. The beam of ^{102}Rb ions was implanted on a movable tape at the center of the 8π spectrometer. The 20 HPGe 8π γ-ray detectors were coupled with SCEPTAR, an hemispherical array of scintillators for β-tagging and DANTE, an array of five LaBr$_3$ detectors for fast γ-ray timing. A preliminary analysis has allowed the first identification of the 4^+ to 2^+ transition in the daughter nucleus, ^{102}Sr. A near identical low-lying band structure of ^{102}Sr with $^{98,\ 100}$Sr nuclei has been observed, indicating the rigidly deformed rotational nature continues towards to the $N = 66$ midshell. The current experimental measurements of ^{102}Rb β-decay half life as well as the β-delayed neutron emission branching ratio compared with reported values, the shorter β-decay half life and the larger β-delayed neutron emission branching ratio will locally reshape astrophysical r-process predictions.

[1]This work is supported by the NSERC (Canada). The contribution of the ISAC staff from TRIUMF-ISAC facility is gratefully acknowledged.

2:42PM C2.00005 Optics for Nuclear Spin Polarization[1] , SCOTT SMALE, SFU, JOHN BEHR, TRIUMF, SPENCER BEHLING, Texas A&M, ALEXANDER GORELOV, TRIUMF, MELISSA ANHOLM, UBC — At TRINAT (TRIumf Neutral Atom Trap) the current goal is a precision measurement of the angular asymmetry of beta particles with respect to the nuclear spin, A_β, from the beta decay of ^{37}K nuclei. To measure beta asymmetry to 10^{-3} accuracy the nuclear spins of the atoms in the trap must be spin polarized in the same direction to at least the same degree of accuracy. To achieve this level of spin polarization the degree of circular polarization of the pumping light must also be very good, with Stokes parameter S$_3$ better than 0.999. There are two challenges: creating well circularly polarized light and transmitting it to the cloud in the center of the experimental chamber. My talk will discuss these challenges in the context of our experiment.

[1]Supported by NSERC, NRC through TRIUMF, and DOE.

2:54PM C2.00006 Towards an Atomic Parity Violation Measurement with Laser Trapped Francium at ISAC[1] , R. COLLISTER, M. TANDECKI, G. GWINNER, University of Manitoba, J. ZHANG, L. OROZCO, University of Maryland, J.A. BEHR, M.R. PEARSON, TRIUMF, E. GOMEZ-GARCIA, Universidad Autonoma de San Luis Potosi, S. AUBIN, College of William and Mary — The neutral atom trap for parity violation measurements at TRIUMF has recently accepted its first radioactive beam. The longest lived francium isotopes have half-lives of minutes, requiring us to produce them with the online mass separator of the ISAC facility. The ion beam is embedded into a catcher made of yttrium foil where it is neutralized. Subsequently, the foil is rotated and heated to release a pulse of atomic francium into the laser trap cell. Francium isotopes 207, 209 and 221 have successfully been cooled and confined in a magneto-optical trap, a crucial first step for later experiments. The next online measurements are planned for November 2012 where two physics goals will be pursued. Firstly, the hyperfine anomaly will be probed via high precision spectroscopy on the atomic D1 transition in order to investigate the nuclear magnetization distribution. This will be followed by ionization cross-section measurements from the 7p$_{3/2}$ state to evaluate this as a potential problematic trap loss mechanism for future parity violation measurements.

[1]Supported by NSERC and NRC Canada, NSF and DOE USA, CONACYT Mexico.

3:06PM C2.00007 Longitudinal Response Function of ^{3}H from Chiral Potentials[1] , MICHAEL DESROCHERS, SONIA BACCA, TRIUMF, 4004 Wesbrook Mall Vancouver, BC V6T 2A3 — In the electron scattering off a nucleus, the cross section is proportional to the longitudinal response function

$$R_L(\omega, \mathbf{q}) = \sum\!\!\!\!\!\!\int_f \left| \langle \Psi_f | \rho(\mathbf{q}) | \Psi_0 \rangle \right|^2 \delta\left(E_f - E_0 - \omega\right), \quad (1)$$

where $\rho(\mathbf{q})$ is the current operator. We aim at calculating it for the ^{3}H nucleus using Chiral Effective Field Theory (EFT) potentials. Electron scattering observables are sensitive to three-nucleon forces [1], and thus, it is relevant to test EFT on reactions in the continuum. We use the Lorentz Integral Transform (LIT) to reduce the continuum problem to the solution of a bound state like equation [2] which is solved by expanding wave functions in terms of hyperspherical harmonics [3]. The response is obtained by a numerical inversion of the (LIT). Preliminary results are presented for low energies at q = 174 MeV/c, along with a comparison with experimental data and previous calculations [4].

[1] Bacca *et al.* Phys. Rev. Lett. 102, 162501 (2009)
[2] Efros *et al.* Phys. Lett. B, 338 130 (1994)
[3] Barnea *et al.* Phys. Rev. C 61, 054001 (2000)
[4] Efros *et al.* Phys. Rev. C 69, 044001 (2004)

[1]The work of This work is supported in part by the Natural Sciences and Engineering Research Council (NSERC) and in part by the National Research Council of Canada.

3:18PM C2.00008 BREAK —

3:38PM C2.00009 Weak Interaction Studies with ^{6}He[1] , ALEJANDRO GARCIA, University of Washington — The CENPA laboratory at the University of Washington has recently developed the world's most intense source of ^{6}He. With the aid of this new source the ^{6}He half-life has been measured with high accuracy, solving a long standing experimental discrepancy and illuminating issues regarding the renormalization of the axial coupling constant in the nuclear medium. Recent advancements in ab-initio nuclear-structure calculations were crucial in the interpretation of the data for this light nucleus. The ^{6}He source -delivering about 10^{10} atoms per second- makes possible a planned search for a signature of new physics called "tensor currents" to unprecedented precision. The tensor currents would be revealed either in the correlation between the direction of emission of the electron and the neutrino or in the shape of the beta spectrum in the decay of 6He. Laser trapping is being developed to be used for producing an ideal source for precise measurements. In this talk we will describe the source developments, the determination of the 6He half-life, the recent laser-trapping improvements, and the prospects for the future measurements.

[1]With support from the US Department of Energy

4:14PM C2.00010 Taming Highly Charged Radioisotopes

USMAN CHOWDHURY, TRIUMF & University of Manitoba, BENJAMIN EBERHARDT, FULUNI JANG, BRAD SCHULTZ, VANESSA SIMON, PAUL DELHEIJ, JENS DILLING, TRIUMF, GERALD GWINNER, TRIUMF & University of Manitoba, TITAN COLLABORATION — The precise and accurate mass of short-lived radioisotopes is a very important parameter in physics. Contribution to the improvement of nuclear models, metrological standard fixing and tests of the unitarity of the Caibbibo-Kobayashi-Maskawa (CKM) matrix are a few examples where the mass value plays a major role. TRIUMF's ion trap for atomic and nuclear physics (TITAN) is a unique facility of three online ion traps that enables the mass measurement of short-lived isotopes with high precision ($\sim 10^{-8}$). At present TITAN's electron beam ion trap (EBIT) increases the charge state to increase the precision, but there is no facility to significantly reduce the energy spread introduced by the charge breeding process. The precision of the measured mass of radioisotopes is linearly dependent on the charge state while the energy spread of the charged radioisotopes affects the precision adversely. To boost the precision level of mass measurement at TITAN without loosing too many ions, a cooler Penning trap (CPET) is being developed. CPET is designed to use either positively (proton) or negatively (electron) charged particles to reduce the energy spread via sympathetic cooling. Off-line setup of CPET is complete. Details of the working principles and updates are presented

4:26PM C2.00011 Charge Breeding Techniques in an Electron Beam Ion Trap for High Precision Mass Spectrometry at TITAN

T.D. MACDONALD, University of British Columbia, TRIUMF, M.C. SIMON, TRIUMF, J.C. BALE, Simon Fraser University, TRIUMF, U. CHOWDHURY, Univerity of Manitoba, TRIUMF, M. EIBACH, Johannes Gutenberg-Universität Mainz, Ruprecht-Karls-Universität Heidelberg, A.T. GALLANT, University of British Columbia, TRIUMF, A. LENNARZ, Westfälische Wilhelms-Universität, TRIUMF, V.V. SIMON, Ruprecht-Karls-Universität Heidelberg, Max Planck Institute, TRIUMF, A. CHAUDHURI, A. GROSSHEIM, A.A. KWIATKOWSKI, B.E. SCHULTZ, TRIUMF, J. DILLING, University of British Columbia, TRIUMF — Penning trap mass spectrometry is the most accurate and precise method available for performing atomic mass measurements. TRIUMF's Ion Trap for Atomic and Nuclear science is currently the only facility to couple its Penning trap to a rare isotope facility and an electron beam ion trap (EBIT). The EBIT is a valuable tool for beam preparation: since the precision scales linearly with the charge state, it takes advantage of the precision gained by using highly charged ions. However, this precision gain is contingent on fast and efficient charge breeding. An optimization algorithm has been developed to identify the optimal conditions for running the EBIT. Taking only the mass number and half-life of the isotope of interest as inputs, the electron beam current density, charge breeding time, charge state, and electron beam energy are all specified to maximize this precision. An overview of the TITAN charge breeding program, and the results of charge breeding simulations will be presented.

4:38PM C2.00012 GEANT4 simulations for in trap decay spectroscopy for electron capture branching ratio measurements using the TITAN facility

SHAKIL SEERAJI, C. ANDREOIU, F. JANG, T. MA, Simon Fraser University, A. CHAUDHURI, A. GROSSHEIM, A.A. KWIATKOWSKI, B.E. SCHULTZ, E. MANE, G. GWINNER, J. DILLING, A. LENNARZ, D. FREKERS, U. CHOWDHURY, V.V. SIMON, T. BRUNNER, P. DELHEIJ, M.C. SIMON, TRIUMF — The TITAN-EC project has developed a unique technique to measure electron capture branching ratios (ECBRs) of short lived intermediate nuclide involved in double beta decay. The ECBR information is important for determination of nuclear matrix elements of double-β decay for both double beta decay ($2\nu\beta\beta$) and neutrino-less double beta decay ($0\nu\beta\beta$) processes. An important feature of this technique is the use of open access penning trap. Radioactive ions are stored in the trap and their decays are observed. Electrons produced from β decay are guided out of the trap by the Penning trap's strong magnetic field and the x-ray from EC are detected by seven Si(Li) detectors placed radially around trap using thin Be windows. This set-up provides a lower background for the x-ray detection compared to earlier ECBC measurements where the beam is implanted in mylar tape. Detailed GEANT4 simulations have been performed to characterize the efficiency of the detectors and understand their response. In addition the impact of different sizes and shapes of the ion cloud inside the trap has also been investigated to optimize the experimental set-up.

4:50PM C2.00013 Precision mass measurements of highly charged ions

A.A. KWIATKOWSKI, TRIUMF, J.C. BALE, Simon Fraser Univ. and TRIUMF, T. BRUNNER[1], Tenische Universitaet Muenchen and TRIUMF, A. CHAUDHURI, TRIUMF, U. CHOWDHURY, Univ. of Manitoba and TRIUMF, S. ETTENAUER, Univ. of British Columbia and TRIUMF, D. FREKERS, Westfaelische Wilhelms-Universitaet, A.T. GALLANT, Univ. of British Columbia and TRIUMF, A. GROSSHEIM, TRIUMF, A. LENNARZ, Westfaelische Wilhelms-Universitaet, E. MANE, TRIUMF, T.D. MACDONALD, Univ. of British Columbia and TRIUMF, B.E. SCHULTZ, M.C. SIMON, TRIUMF, V.V. SIMON, Ruprecht-Karls-Universitat and MPI and TRIUMF, J. DILLING, Univ. of British Columbia and TRIUMF — The reputation of Penning trap mass spectrometry for accuracy and precision was established with singly charged ions (SCI); however, the achievable precision and resolving power can be extended by using highly charged ions (HCI). The TITAN facility has demonstrated these enhancements for long-lived ($T_{1/2}$ ≥50 ms) isobars and low-lying isomers, including ^{71}Ge^{21+}, $^{74}Rb^{8+}$, ^{78}Rb^{8+}, and ^{98}Rb^{15+}. The Q-value of ^{71}Ge enters into the neutrino cross section, and the use of HCI reduced the resolving power required to distinguish the isobars from 3×10^5 to 20. The precision achieved in the measurement of ^{74}Rb^{8+}, a superallowed β-emitter and candidate to test the CVC hypothesis, rivaled earlier measurements with SCI in a fraction of the time. The 111.19(22) keV isomeric state in ^{78}Rb was resolved from the ground state. Mass measurements of neutron-rich Rb and Sr isotopes near A = 100 aid in determining the r-process pathway. Advanced ion manipulation techniques and recent results will be presented.

[1]Now Stanford University

5:02PM C2.00014 Precision Mass Cartography near the Island of Inversion

AARON GALLANT, University of British Columbia, THOMAS BRUNNER, TRIUMF, USMAN CHOWDHURY, University of Manitobia, STEPHAN ETTENAUER, TEGAN MACDONALD, University of British Columbia, VANESSA SIMON, ANKUR CHAUDHURI, ANIA KWIATKOWSKI, BRAD SCHULTZ, MATRIN SIMON, TRIUMF, DAVID LUNNEY, CSNSM-IN2P3-CNRS, JENS DILLING, TRIUMF — A cornerstone of modern nuclear theory is the existence of the so-called "magic" numbers. Nuclei with a magic number of protons or neutrons are marked by a significant increase in binding energy. Recently much experimental and theoretical effort has been expended trying to elucidate how the magic numbers evolve towards the particle drip-lines. For example, it was recently found that new magic numbers N = 14, 16 appear far from stability, while the magic number N=20 disappears in the nuclide 32Mg. A method to investigate the evolution of the N=20 magic number is through atomic mass measurements. One of the first indications that the known magic numbers may begin to disappear was in the Na isotopic chain. It was observed that the two neutron separation energy S2n turns up at the neutron magic number N=20. This is opposite to the trend one would expect at a magic number. To investigate the disappearance of the N=20 shell closure the TITAN Penning trap mass spectrometer was employed to perform precision mass measurements in the Na, Mg and Al isotopic chains. We will present new precision mass measurements of 29-31Na, 30-34Mg and 29-34Al and discuss their role in determining the behavior of the N=20 shell gap.

Friday, October 19, 2012 1:30PM - 4:14PM –

Session C3 Particle Physics I SFU Harbour Centre 2270 Sauder Industries Policy Room - Chair: Janis McKenna, University of British Columbia

1:30PM C3.00001 Prototype of a Cluster-Counting Drift Chamber, JEAN-FRANCOIS CARON, The University of British Columbia, SUPERB CANADA COLLABORATION — In August 2012 a prototype drift chamber was tested at TRIUMF using a ~ 200 MeV/c beam of electrons, muons, and pions. The drift chamber is instrumented to allow the use of a cluster-counting technique, whereby the full waveform on the sense wire is recorded. The signal from each primary ionization can be resolved with suitable algorithms, allowing for better particle identification than traditional charge measurements which merely integrate the sense wire signal. Instrumenting a full-scale drift chamber for cluster counting would be expensive, and this study quantifies the particle identification aspect of the potential improvements obtained from such an expense.

1:42PM C3.00002 SRF cavity and HOM damper tests at TRIUMF for ARIEL, PHILIPP KOLB, ROBERT LAXDAL, VLADIMIR ZVYAGINTSEV, TRIUMF — The eLINAC for ARIEL[1] consists of 5 superconducting nine cell cavities operating at 1.3 GHz, each cavity with a accelerating voltage of 10 MV. The design requires a quality factor of $1 \cdot 10^{10}$ or higher at the operating temperature of 2 K for 10 W dissipated power in the cavity walls. Latest SRF[2] tests of a 1.3 GHz niobium single cell cavity will show that procedures at TRIUMF are capable of exceeding the RF requirements of ARIEL. Future upgrade plans for the eLINAC include a recirculating arc to either increase the energy of the 10 mA electron beam or drive an FEL[3] in ERL[4] mode. BBU[5] is a limitation in recirculating LINACs. Its strength depends on a number of parameters including the shunt impedance R_{Sh} of HOM,[6] especially dipole modes, of the SRF cavity. Using beam line absorbers made out of a low electric conductive material reduces the Q_L of the cavity and therefore reduces the R_{Sh}. Qualification of such a material is essential and measurements of the electrical conductivity of a candidate material will be presented in addition to the cavity tests.

[1]Advanced Rare Isotope Experiment Laboratory
[2]Superconducting Radio Frequency
[3]Free Electron Laser
[4]Energy Recovery LINAC
[5]Beam Break-Up
[6]Higher Order Modes

1:54PM C3.00003 TRIUMF Ultra-cold Neutron Source Facility, YUN CHANG SHIN, TRIUMF, JAPAN CANADA NEDM COLLABORATION — An ultra-cold neutron (UCN) source is planned for installation at TRIUMF, Canada, aiming to produce the world's highest density of UCNs using down-scattering of cold neutrons in superfluid helium. This project is a collaboration of Japan and Canada funded by JSPS (KEK) and CFI (University of Winnipeg). The first experiment using this UCN source will be the measurement of the electric dipole moment of the neutron (nEDM). Development of the UCN source and the prototype nEDM experiment will be done at RCNP, Japan in 2013-14. After that, the UCN source and the EDM apparatus will be moved and installed at TRIUMF. Beam commissioning is scheduled for 2015 and neutron EDM experiment is scheduled to start in 2016 at TRIUMF. The goal is to improve the current upper limit of nEDM of $d_n < 2.9 \times 10^{-26}$e-cm by two order of magnitude at TRIUMF. An overview of the TRIUMF UCN facility including design of a new beam line, development of a spallation target, and re-configuring of the shielding arrangement will be presented in this talk.

2:06PM C3.00004 Developments related to ultracold neutron detection and magnetic field stability for the nEDM experiment at TRIUMF, EDGARD PIERRE, TRIUMF, JAPAN-CANADA NEDM COLLABORATION — A new experiment to search for the neutron electric dipole moment (nEDM) is currently under development at RCNP, Japan and TRIUMF, Canada. Lowering the upper limit on the nEDM, currently $d_n < 2.9 \cdot 10^{-26}$ e cm, by a two orders of magnitude would test theoretical models beyond the Standard Model. The experiment will use ultra-cold neutrons (UCN) produced from down-scattering of cold neutrons in superfluid helium. The very high UCN density expected in the storage chamber ($\sim 5 \cdot 10^3$ UCN/cc) requires the development of a new UCN detector efficient at the MHz level. Another challenge of the experiment is the control of the magnetic field inside the storage chamber. In order to reach the expected sensitivity, the magnetic field must be stable at the pT level, and any magnetic field gradients must be less than 1 nT/m. An overview of the progress and future developments in these two fields will be given in this talk.

2:18PM C3.00005 A New Event Reconstruction Algorithm for Super-Kamiokande Water Cherenkov Detector, SHIMPEI TOBAYAMA, University of British Columbia — Super-Kamiokande is the world's largest water Cherenkov particle detector located underground in Kamioka-mine, Gifu, Japan. The detector has been used for proton decay search, and observation of atmospheric, solar and supernova neutrinos. It also serves as the far detector for T2K long baseline neutrino oscillation experiment. The detector consists of a cylindrical tank filled with 50kt of ultra-pure water, and an array of 11,000 photomultiplier tubes (PMT) installed on the tank's inner wall record the time and intensity of the Cherenkov light emitted by charged particles traveling in the water. Using the information from the PMTs, particle type, interaction vertex, direction and momentum can be reconstructed. A new reconstruction algorithm is being developed which performs a simultaneous maximum likelihood determination of such parameters. Through Monte Carlo studies, it was found that the new algorithm has a significantly better particle identification performance and vertex/momentum resolutions, compared to the existing reconstruction software. In this talk, an outline of the new algorithm, its performance and implications on physics analyses will be presented.

2:30PM C3.00006 High Precision Measurement Of The Pion Branching Ratio, TRISTAN SULLIVAN, University of British Columbia, PIENU COLLABORATION — The pion branching ratio $R = \frac{\Gamma(\pi\rightarrow e\nu\ +\ \pi\rightarrow e\nu\gamma)}{\Gamma(\pi\rightarrow\mu\nu\ +\ \pi\rightarrow\mu\nu\gamma)}$ can be calculated to a precision of better than one part in ten thousand using the Standard Model (SM). Averaging the most precise measurements of this quantity gives a value consistent with the SM prediction but whose error is more than ten times greater than the theoretical uncertainty. The PIENU experiment at TRIUMF aims to exceed the precision on the world average by more than a factor of five. The largest contribution to the overall error comes from the response function of the primary calorimeter to positrons produced by $\pi \rightarrow e\nu$ decay. Measurements have been taken to characterize this effect, and have been compared in detail to Monte Carlo simulation. The agreement between data and simulation suggests the response function can be determined to the required precision. The analysis of the data and comparison with simluation will be presented.

2:42PM C3.00007 Of Spheres and Matrices, PHILIPPE SABELLA-GARNIER, KEN HUAI-CHE YEH, JOANNA KARCZMAREK, University of British Columbia — Gauge theory with a Higgs field on a sphere emerges from a Lagrangian with matrix degrees of freedom and no explicit spatial dependence. The sphere is noncommutative, leading to a deep connection between the fields and the underlying geometry. More specifically, we examine how the Higgs field corresponds to a deformation of the sphere in the radial direction. We show that in certain cases this effect persists even in the commutative limit. We also compare this approach with the construction of surfaces from matrix representations of D-branes.

2:54PM C3.00008 A Soliton and a Black Hole are in Gauss-Bonnet gravity. Who wins?

, ANSON WONG, University of British Columbia, ROBERT MANN, University of Waterloo, UW COLLABORATION — We study here the phase-transitional evolution between the Eguchi-Hanson soliton, the orbifolded Schwarzschild Anti de-Sitter black hole, and orbifolded thermal Anti de-Sitter space in Gauss-Bonnet gravity for a small Gauss-Bonnet coefficient α. Novel phase structure is uncovered for both negative and positive α with spacetime configurations that are stable in Gauss-Bonnet gravity without being so in Einsteinian gravity. The evolutionary tracks taken towards such stable configurations are guided by quantum tunnelling and can be represented with a phase diagram constructed by comparing the Euclidean actions of each of our states as a function of α and the black hole radius r_b. According to the AdS/CFT correspondence dictionary, it is expected that some generalized version of closed-string tachyon condensation will exhibit the phase behaviour found here.

3:06PM C3.00009 BREAK —

3:26PM C3.00010 Experimental Demonstration of Fermion Spin Correlations

, ROBERT CLOSE, Clark College — Bell's Theorem places limits on correlations between local measurements of particles whose properties are independent of measurement. In particular, Bell's Theorem limits the mean product of binary spin measurements at 45° (or 135°) separation to be $|P| \leq 0.5$. However, Bell's Theorem is not valid for spins sampled on a spherical distribution because the density of sampled states depends on the sampling location. We model spin-1/2 fermions as azimuthally symmetric spherical standing waves with one hemisphere of spin up and one hemisphere of spin down. We experimentally determine the spin correlation for 45° separation by randomly placing two points with fixed separation on a ball marked with lines of latitude. The normalized product of spins is $+1$ if the two points are on the same side of the equator, and -1 if the points are on opposite sides of the equator. The expected correlation (mean product) is $P = 1 - 45/90 = 0.5$. Correcting for the lack of azimuthal symmetry in the experimental ball increases the expected correlation in our model to approximately $P = \cos 45^\circ \approx 0.71$, inconsistent with Bell's Theorem but consistent with experimental measurements on entangled spin-1/2 fermions.

3:38PM C3.00011 Nuclear recoil energy spectrum of finite-sized dark matter

, ANFFANY CHEN, Univ of British Columbia, TEXONO-CDEX TEAM — Research has shown that direct dark matter detection experiments can distinguish between pointlike and finite-sized dark-matter candidates, both of which are of theoretical interests. In particular, there is an additional form factor in the typical cross section of finite-sized dark matter, causing the nuclear recoil energy spectrum of finite-sized dark matter to decrease more rapidly with the recoil energy than that of pointlike dark matter. Since the spectrum of finite-sized dark matter peaks below 1 keV, which is the common experimental threshold, and falls off rapidly at higher energies, detector with sub-keV threshold is necessary. The current goal of TEXONO-CDEX research program, on the studies of low energy neutrino and dark matter physics at Kuo-Sheng Reactor Neutrino Laboratory and China Jin-Ping Underground Laboratory, is to open the sub-keV detector window with germanium detectors. This work derives a model-independent, theoretical prediction of the nuclear recoil energy spectrum of finite-sized dark matter and is working toward using the predicted spectrum to analyze the experimental data of TEXONO-CDEX, in hope to substantiate or rule out dark matter candidates.

3:50PM C3.00012 Dark Matter Antibaryons from a Supersymmetric Hidden Sector

, NIKITA BLINOV, TRIUMF/University of British Columbia, DAVID MORRISSEY, TRIUMF, KRIS SIGURDSON, University of British Columbia, SEAN TULIN, University of Michigan — The cosmological origin of dark matter and the baryon asymmetry of the universe can be explained through a unified mechanism called hylogenesis where baryon and antibaryon number are sequestered into a visible and a GeV-scale hidden sector. The universe remains baryon symmetric and the hidden antibaryons are the dark matter. We study the cosmology and phenomenology of this scenario in a supersymmetric theory in order to stabilize the electroweak and GeV hidden sector mass scales. This class of models contains a novel direct detection signature where a dark matter particle can scatter inelastically off a nucleon, destroying it and producing a meson and a dark matter antiparticle. This induced nucleon decay can be searched for in present and future nucleon decay experiments.

4:02PM C3.00013 Reactor neutrino anomaly and sterile neutrinos revisited

, ANNIKA LENNARZ, WWU Muenster and TRIUMF Vancouver, MUENSTER/RCNP/KVI/ISTANBUL/BRATISLAVA/NSCL-MSU/UW-SEATTLE/TITAN-VANCOUVER/INR-MOSCOW COLLABORATION — In this contribution we will present results from two separate experiments dealing with the neutrino response on 71Ga. Both experiments provide input to the calibration of the SAGE and GALLEX solar neutrino detectors and address a long-standing discrepancy between the measured and evaluated capture rates from the 51Cr and 37Ar neutrino calibration sources. The first is a 71Ga(3He,t)71Ge charge-exchange experiment performed at RCNP, Osaka, which allows to extract with high precision the Gamow-Teller transition strengths to the three lowest-lying states in 71Ge, i.e., the ground state (1/2-), the 175 (5/2-) and the 500 keV (3/2-) excited states. These are the states, which are populated via a charged-current reaction induced by neutrinos from reactor produced 51Cr and 37Ar sources. In the second part we present a new precision Q-value measurement for the 71Ga(nu,e-)71Ge reaction using the TITAN mass measurement facility at TRIUMF. From the results of the two experiments we now conclude that there are no further unknowns in the nuclear structure, which could remove the persistent discrepancy in the SAGE and GALLEX calibration measurement performed with neutrinos from 51Cr and 37Ar sources.

Friday, October 19, 2012 1:30PM - 4:26PM —

Session C4 Condensed Matter I SFU Harbour Centre 1520 Barrick Gold Lecture Room - Chair: Simon Watkins, Simon Fraser University

1:30PM C4.00001 Free Electron Beams with Helical Wavefronts and Quantized Angular Momentum[1]

, BENJAMIN MCMORRAN, Department of Physics, University of Oregon — Electron vortex beams, composed of helical electron wavefunctions that carry quantized orbital angular momentum (OAM), are analogous to optical vortices in beams of light. Electrons in the beam possess quantized amounts of orbital angular momentum (OAM) and have an associated magnetic moment. To produce such states, we use nanofabricated diffraction holograms to coherently imprint a phase vortex onto free electron matter waves in a transmission electron microscope (TEM). We also use this approach to place free electrons in coherent superpositions of orbital states, and we apply this to observe the Gouy phase for matter waves and to measure the orbital magnetic moment of the vortex state. Electron vortex beams can interact with surfaces and materials in unique ways. For example, electron vortex beams can transfer quantized OAM to an atom through inelastic scattering, inducing the same atomic and molecular transitions induced by circularly polarized light. Such OAM-dependent scattering provides a "dichroic" signal that can be measured in electron energy loss spectra from samples in a TEM. We will discuss our efforts toward using this to measure optical, electronic, and magnetic properties of samples with sub-nanometer resolution.

[1]Work done in collaboration with Tyler Harvey, Jordan Pierce, and Tyler Yahn, Department of Physics, University of Oregon; Peter Ercius and Martin Linck, National Center for Electron Microscopy, Lawrence Berkeley National Laboratory.

2:06PM C4.00002 Precision microwave spectroscopy of the heavy fermion superconductor $CeCoIn_5$ reveals nodal quasiparticle dynamics

, COLIN TRUNCIK, WENDELL HUTTEMA, PATRICK TURNER, Simon Fraser University, SIBEL OZCAN, University of Cambridge, NATALIE MURPHY, PAUL CARRIERE, ERIC THEWALT, KEVIN MORSE, Simon Fraser University, JOHN SARRAO, Los Alamos National Laboratory, DAVID BROUN, Simon Fraser University — $CeCoIn_5$ is a heavy fermion superconductor with strong similarities to the high-T_c cuprates, including quasi-two-dimensionality, proximity to antiferromagnetism, and probable d-wave pairing arising from a non-Fermi-liquid normal state. Each system therefore forms an important testing ground for ideas relevant to the other system. Experiments that allow detailed comparisons of electronic properties are of particular interest. Here we use low temperature microwave spectroscopy to carry out a high-resolution study of the charge dynamics of the $CeCoIn_5$ superconducting state. The similarities to cuprates, in particular to ultra-clean $YBa_2Cu_3O_y$, are striking: the frequency and temperature dependence of the quasiparticle conductivity are instantly recognizable, a consequence of rapid suppression of quasiparticle scattering below T_c; and penetration depth data, when properly treated, reveal a clean, linear temperature dependence of the quasiparticle contribution to superfluid density. The measurements also expose key differences, including prominent multiband effects and a temperature-dependent mass renormalization.

2:18PM C4.00003 The Local Properties of Superconducting LiFeAs: From the Pure Crystal to the Influence of Defects

, STEPHANIE GROTHE, SHUN CHI, PINDER DOSANJH, RUIXING LIANG, WALTER N. HARDY, SARAH A. BURKE, DOUG A. BONN, YAN PENNEC, Department of Physics and Astronomy, University of British Columbia, Vancouver BC, Canada V6T 1Z1 — The iron pnictide superconductor LiFeAs is of particular interest as it is superconducting without chemical substitution and therefore presents a clean system to study the mechanisms behind unconventional superconductivity. We study the unreconstructed surface of LiFeAs by scanning tunneling microscopy and spectroscopy [1]. In regions free of defects, spectra at 2 K show two nodeless superconducting gaps, homogeneous over tens of nanometers, as well as a dip-hump structure with an energy scale consistent with a magnetic resonance recently reported by inelastic neutron scattering [2]. The gaps close at the bulk T_c, indicating that the surface accurately represents the bulk properties. We study how the superconducting phase of LiFeAs is modified in the vicinity of defects. The most commonly observed Fe site defect exhibits a bound state near the edge of the smaller gap. Three other common defects, including another one on an Fe site, are pair-breaking indicated by clear in-gap bound states, in addition to states near the smaller gap edge. Spectroscopic mapping reveals the high complexity of the real space bound state patterns.

[1] Chi et al., Phys. Rev. Lett. 109, 087002 (2012)
[2] Qureshi et al., Phys. Rev. Lett. 108, 117001 (2012)

2:30PM C4.00004 Doping is Good: Enhancing Hall-Effect Sensor Performance with Doped Bismuth

, RICKY CHU, Simon Fraser University, NIGEL DAVID, University of Victoria, TARAS CHOUINARD, Simon Fraser University, ADAM SCHNEIDER, McGill University, DAVID BROUN, Simon Fraser University — Hall-effect sensors are quantitative magnetic flux detectors with sensitivity comparable to that of superconducting quantum interference devices (SQUIDs), but with superior spatial resolution [S.J. Bending, Adv. Phys. **48**, 449 (1999)]. Applications of Hall sensors include the imaging of microscopic magnetic structures such as vortices in superconductors, nanoscale domains in magnetic thin films, and nanoparticles in bioassay samples. Bismuth is being tested as a Hall probe material in order to avoid problems associated with excess noise, which arise in semiconductor Hall sensors as they are miniaturized [A. Sandhu *et al*, Jpn. J. Appl. Phys. **40**, L524 (2001)]. However, bismuth is a compensated metal, and the presence of both electrons and holes reduces its native sensitivity due to cancellations in the Hall coefficient. We present experimental results for thin films and sensors that show hole doping by Pb can be used to empty the electron band, thereby breaking the compensation and increasing flux sensitivity.

2:42PM C4.00005 Microwave measurements of vortex dynamics in the heavy fermion superconductor $CeCoIn_5$

, NATALIE MURPHY, ERIC THEWALT, WENDELL HUTTEMA, COLIN TRUNCIK, KEVIN MORSE, Simon Fraser, JOHN SARRAO, Los Alamos National Lab, Los Alamos, DAVID BROUN, Simon Fraser — Magnetic fields penetrate superconductors as a lattice of quantized tubes of magnetic flux, or "vortices." A transport current, passed through such a superconductor, exerts a transverse component of force on the vortex lattice. Subsequent motion of the vortices results in dissipation. The frictional force experienced by a moving flux line is parameterized by a *vortex viscosity*, and arises from induced electric fields coupling to charge excitations in the vicinity of the vortex core. We present vortex viscosity data on the heavy fermion superconductor $CeCoIn_5$, obtained using sensitive new microwave apparatus that operates at temperatures down to 0.07 mK and magnetic fields up to 9 T. The data we obtain is surprising, and indicates a breakdown of Bardeen–Stephen theory in this material; instead of arising from normal currents in the vortex cores, the frictional forces on the vortices appear to be caused by interactions with d-wave quasiparticles *outside* the cores. This is evident in two ways: from the temperature dependence of the viscosity, which mirrors that of the d-wave quasiparticle conductivity; and from the observation of a new type of Volovik effect, in which the vortex viscosity has a $\sqrt{B}$ dependence on magnetic field.

2:54PM C4.00006 SC2IT: a cloud computing interface that makes computational science available to non-specialists[1]

, KEVIN JORISSEN, FERNANDO VILA, JOHN REHR, University of Washington — Computational work is a vital part of much scientific research. In materials science research in particular, theoretical models are usually needed to understand measurements. There is currently a double barrier that keeps a broad class of researchers from using state-of-the-art materials science (MS) codes: the software typically lacks user-friendliness, and the hardware requirements can demand a significant investment, e.g. the purchase of a Beowulf cluster. Scientific Cloud Computing (SCC) has the potential to breach this barrier and make computational science accessible to a wide class of non-specialists scientists. We present a platform, SC2IT, that enables seamless control of virtual compute clusters in the Amazon EC2 cloud and is designed to be embedded in user-friendly Java GUIs. Thus users can create powerful High-Performance Computing systems with preconfigured MS codes in the cloud with a single mouse click. We present applications of our SCC platform to the materials science codes FEFF9, WIEN2k, and MEEP-mpi. SC2IT and the paradigm described here are applicable to other fields of research beyond materials science, although the computational performance of Cloud Computing may vary with the characteristics of the calculations.

[1] The UW-SCC project is supported by NSF grant OCI- 1048052. Additional EC2 cloud computer time is provided by an Amazon AWS in Education research grant PC3VBYVHQ3TASL8.

3:06PM C4.00008 Influence of Solvent Polarization on Electric Double Layer Interactions in Nanochannels[1]

SUSHANTA MITRA, SIDDHARTHA DAS, University of Alberta — We discuss the influence of solvent polarization effect on the Electric Double Layer (EDL) electrostatic potential distribution and the resulting EDL interaction between similar and oppositely charged surfaces in thin nanochannels with overlapping EDLs. We invoke a Langevin-Bikerman type free energy model that explicitly accounts for the solvent polarization and the finite size (of the ions and the water dipoles) effect in delineating the EDL interactions. We witness that the solvent polarization effects leads to a weaker EDL potential gradient and a larger interaction force between the surfaces. The solvent polarization effect can successfully explain the lowering of the relative permittivity of the solvent from bulk towards the charged surface. Most importantly, the EDL interaction force with finite solvent polarization can explain the large mismatch between the corresponding experimental and existing theoretical (computed using simple Poisson-Boltzmann model) results.

[1]NSERC Banting Post-doctoral Fellowship to S.D. is acknowledged here.

3:18PM C4.00007 BREAK —

3:38PM C4.00009 Investigating the morphology of ionic graft copolymers using SAXS and SANS techniques

RASOUL NARIMANI, EMILY M.W. TSANG, AMI YANG, Simon Fraser Univeristy, LAURENT RUBATAT, Université de Pau et des Pays de l'Adour, STEVEN HOLDCROFT, BARBARA FRISKEN, Simon Fraser Univeristy — We have studied the morphology of an ion-containing graft copolymer system using small angle x-ray and neutron scattering (SAXS and SANS), in addition to transmission electron microscopy (TEM). Our SAXS measurements on dry samples reveal that the poly(vinylidene difluoride) backbone of this copolymer forms quasi-spherical domains embedded in a continuous matrix of the poly(styrene) side chains. By analyzing the data we are able to calculate the size and spacing between these domains. According to SANS measurements, the ionic groups aggregate to form water-rich domains when the samples are hydrated. By comparing the SANS and SAXS results we find that the swelling properties at the nano-scale are consistent with bulk membrane properties. These results provide insight into the proton conductivity of these materials.

3:50PM C4.00010 Growth and strain relaxation of GaAs/GaSb core/shell nanowires

OMID SALEHZADEH EINABAD, KAREN KAVANAGH, SIMON WATKINS, Simon Fraser University — The nanowire geometry allows the fabrication of highly mismatched heterostructures beyond the critical thicknesses known for thin films. The GaAs/GaSb structure is of particular interest due to its staggered type-II band alignment and large valence band offset. This staggered band line-up spatially confines the carriers at opposite sides of the GaAs/GaSb interface resulting in desirable excitonic properties. Also, the large band offset makes the fabrication of infrared optoelectronic devices feasible. Previous work has focussed on the growth of axial heterostructures of GaAs/GaAs using the vapor-liquid-solid (VLS) growth mechanism. In this work we demonstrate the growth of GaAs-core/GaSb-shell heterostructures using a combination of VLS and vapour solid (VS) growth. The nanowire growth was carried out by metalorganic vapor phase epitaxy (MOVPE) at 410 $^\circ$C. The large lattice mismatch between GaSb and GaAs (7.8%) results in GaSb island formation on the GaAs NW facets. For shell thicknesses less than 1.8 nm, the GaSb shell is coherently strained to the GaAs core. For thicker shells, equal axial and radial strain relaxation between the GaAs NWs and the GaSb islands is observed, associated with the formation of periodic misfit dislocations. The degree of strain relaxation for the same shell thickness decreases from 100% to 74 $\pm$ 3% with decreasing core diameter from 50 to 15 nm. Strain relaxation was calculated from the spot spacing of selected area diffraction patterns, Moiré fringe spacing, dislocation spacing and high resolution TEM images.

4:02PM C4.00011 Relaxation after a quench in the Bose Hubbard Model[1]

MALCOLM KENNETT, Simon Fraser University, DENIS DALIDOVICH, Perimeter Institute for Theoretical Physics — Cold bosonic atoms confined in an optical lattice potential give a realization of the Bose Hubbard model, which has allowed the study of the phase transition between a superfluid and a Mott insulator as the depth of the optical lattice is varied. We study the real time dynamics of the Bose Hubbard model in the presence of time-dependent hopping using the Schwinger-Keldysh technique. Using a strong-coupling approach, we determine the effective action in the vicinity of the zero-temperature transition between superfluid and Mott insulating phases. We then study the solutions of the resulting saddle-point dynamical equations as the hopping is varied to sweep across the phase transition from the superfluid to insulating phase. We find that the dynamics can be understood within a picture where there are two timescales for relaxation. First, there is local equilibration, and on longer timescales there is mass transport. We discuss the implications of our results to realizations of the Bose Hubbard model in a harmonic trap.

[1]Supported by NSERC

4:14PM C4.00013 Effects of gas adsorption on the conductance of suspended carbon nanotubes[1]

BORIS DZYUBENKO, HAO-CHUN LEE, OSCAR VILCHES, DAVID COBDEN, Department of Physics, University of Washington — We have studied the effects of adsorbing a variety of gases on the electrical properties of individual suspended single-walled nanotubes, as a function of pressure and temperature. The quantity of gas adsorbed can be determined from the shift in the mechanical resonance frequency of the nanotube. We find that the conductance is sensitive to extremely small changes in density and can be measured on a timescale of milliseconds, permitting studies of the dynamics of the adsorbed atoms/molecules. The conductance varies nonmonotonically with coverage as a monolayer builds up and contains a contribution corresponding to charge transfer from the adsorbates of the order of one or two electrons in total. For noble gases, measurements below the 2D critical point on some devices show sharp features and fluctuations; in others these are absent. The reason for this is unclear and under investigation. In the nonlinear regime we observe features in the I-V characteristics as phase transitions are induced by the current and nonequilibrium stationary states occur.

[1]Supported by NSF grant DMR-1206208.

Friday, October 19, 2012 1:30PM - 5:14PM —

Session C5 Physics Education: Special Session on Upper-year Lab Instruction SFU Harbour Centre 1600 Canfor Policy Room - Chair: Joss Ives, University of the Fraser Valley

1:30PM C5.00001 Physics 433: Undergraduate laboratory in Biological Physics at Simon Fraser University

NANCY FORDE, Department of Physics, Simon Fraser University — In this talk, I will describe our senior undergraduate lab course in Biological Physics at Simon Fraser University. Unique in Canada, this course combines modules that teach the students basic molecular and cell biology and leading-edge biophysical techniques with independent student projects. I'll outline the structure and components of the course, provide an overview of each experimental module, and describe student interest and feedback.

2:06PM C5.00002 Developing an Advanced Lab course from scratch , RUDI MICHALAK, University of Wyoming — A few years ago the Alpha group in APS organized faculty with interests in advanced lab courses in physics. At the University of Wyoming, we re-launched an advanced lab course after doing more than 15 years without one. Our majors had to take an electronic course in the Electrical Engineering department to get familiar with any kind of electronic equipment. Now we are in the fourth teaching session of the advanced Modern Physics lab and we will expand the course into a two-term course beginning spring 2013. Forty-five majors have gone through our labs, We developed an oral exam tradition, which is now beginning to lend our department upper level outcome assessment credibility for campus wide assessment.

2:36PM C5.00005 DISCUSSION –

3:06PM C5.00004 BREAK –

3:26PM C5.00003 An advanced laboratory course that emphasizes communication , GEORG RIEGER, University of British Columbia — I will introduce a fourth-year laboratory course that has a strong focus on communication skills. The course is meant to give students a preview of how experimental physics is performed in an academic or industrial research lab. The design is such that the course approximates the experience of a graduate student in a research group, which I regard as an ideal learning environment. I will contrast this with the learning experience in a typical first- or second-year lab. Results from a small survey are also presented.

3:50PM C5.00007 Teaching Plasmonics, Scanning Probe Microscopy and Other Useful Experiments at the Upper Level , ERIK SANCHEZ, Portland State University — It is important to teach students concepts and experimental skills relating to modern research being performed today. Experiments that help educate students about the latest research helps them get jobs and into the doors at many great academic institutions. PSU's Advanced Experimental Class for physics undergraduates offers many novel experiments to help the students accomplish this task. Labs involving Plasmonics, thin film deposition, scanning probe microscopy (SPM) and more will be discussed. In addition, a new NSF funded project involving the building of a Do-It-Yourself (DIY) SPM will be discussed.

4:20PM C5.00008 DISCUSSION –

4:30PM - 4:30PM –

Session D1 Poster Session (4:30-6:00PM) SFU Harbour Centre Main Concourse - Chair: Jennifer Heath, Linfield College

D1.00001 Microsphere interaction with non-Newtonian solid-supported films to model respiratory therapies , NATHAN LEE, JAVED ALLY, MICHAEL KAPPL, HANS-JÜRGEN BUTT, Max Planck Institute for Polymer Research — Films used as lubricants and particle filters interact with microspheres. One example of a biological particle filter is the mucus lining the human respiratory system. In the conducting airways of the respiratory tract, a 10 μm thick layer of mucus sits on top of a periciliary layer. These cilia sweep the mucus towards the nose and mouth whereby debris, such as dust and bacteria that are trapped by the mucus layer, may be expelled from the body. Mucus, like other biofluids, can be modeled after a non-Newtonian fluid due to their viscoelastic properties. Interactions between particles and non-Newtonian thin films have not been widely characterized. Atomic force microscopy (AFM) is an ideal technique due to its ability to measure in the microNewtown and micrometer scale. The AFM setup also allows for calculation of the force from direct contact of the particle with the film. Data from these experiments may further the development aerosol-based respiratory therapies. Factors such as particle size and approach speed are necessary to determine improved parameters for drug deposition and retention. It is the goal of this study to analyze interaction forces between particles and non-Newtonian solid-supported films.

D1.00002 Characterization of a chiral nematic mesoporous organosilica using NMR , ALAN MANNING, University of British Columbia Physics and Astronomy, KEVIN SHOPSOWITZ, MICHAEL GIESE, MARK MACLACHLAN, University of British Columbia Chemistry, RONALD DONG, CARL MICHAL, University of British Columbia Physics and Astronomy — Using templation with nanocrystalline cellulose, a mesoporous organosilica film with a chiral nematic pore structure has recently been developed. [1] We have used a variety of Nuclear Magnetic Resonance (NMR) techniques to characterize the pore structure. The pore size distribution has been found by analyzing the freezing point depression of absorbed water via NMR cryoporometry. The effective longitudinal and transverse pore diameters for diffusing water were investigated with Pulsed-Field Gradient (PFG) NMR and compared to a 1-D connected-pore model. Preliminary data on testing imposed chiral ordering in absorbed liquid crystals is also presented.

[1] K.E. Shopsowitz et al. JACS 134(2), 867 (2012)

D1.00003 Optimization of holographic optical tweezers for multiplexed fluorescence spectroscopy[1] , MATTHEW CIBULA, DAVID MCINTYRE, Oregon State University — We are developing a multiplexed spectroscopy technique that employs holographic optical tweezers to trap and excite multiple sensor particles. Our goal is to develop a lab-on-a-chip measurement platform for monitoring pH and other ion concentrations with high spatial resolution in a microfluidic device or within biological cells. To ensure efficient use of the available laser power required to trap multiple particles, we address three aspects of the spatial light modulator (SLM) used in the holographic technique. We measure and optimize the input and output polarizations used before and after the birefringent SLM. We reduce optical aberrations by adding appropriate Zernike polynomials to the computed hologram. We optimize the diffraction efficiency of the SLM by adjusting the gray scale input-to-output table to account for the nonlinear phase response of the SLM.

[1] Supported by ONR grant N00014-07-1-0457.

D1.00004 Waveguide characterization with multi-photon photoemission electron microscopy , J.P.S. FITZGERALD, ROBERT C. WORD, SEBASTIAN SALIBA, ROLF KOENENKAMP, Portland State University — Multi-photon photoemission electron microscopy (PEEM) images surface interactions of visible light with matter, showing electromagnetic (EM) waves that propagate at or near the surface. Images are interferometric, showing where incident and surface waves are in-phase (bright) and out-of-phase (dark), with strong contrast between regions of high and low rates of photoelectron emission. Interferogram analysis can determine the amplitude, wavelength, phase evolution, and propagation decay length of the surface waves. Most multi-photon PEEM studies focus on surface plasmon polaritons. We show that this technique can also be applied to conducting thin-film waveguides, measuring the properties of confined EM waves in a two-mode slab waveguide made of indium tin oxide on glass, which are consistent with waveguide theory. This research was funded by the US Department of Energy Basic Science Office under contract DE-FG02-10ER46406.

D1.00005 Evaluation of Low-Thrust Propulsion Options for Cargo Missions to Near-Earth Objects[1] , CHRISTOPHER GROCHOWSKI, JONATHAN HOFF, Whitworth University — This study evaluated the ability of eight existing ion and Hall thrusters to meet some of the key requirements of the OSIRIS-REx mission – to carry a dry mass of 750 kg to the asteroid 1999RQ36, land on it in 2019, stay for 219 days, and return it with a 10 kg sample to Earth. The thrusters were chosen based on demonstrated performance and lifetime characteristics at power levels higher than 5 kW, and were evaluated for this mission at their measured performance levels. It was shown that all the evaluated thrusters could complete the mission in a significantly less time ($<$ 4 years) then the current 7-year round-trip plan of the OSIRIS-REx mission, and still remain within the mass requirements of conventional launchers considered for the mission (10000 kg at 500-km LEO). This study was conducted with a fixed landing date, and did not specifically estimate the shortest trip possible. Because it was assumed that the thrusters always operated at full power, and did not consider throttling to reduce fuel requirement, there could be other options to save even more time and fuel with these thrusters than what has been discussed here.

[1]Supported by NASA Washington Space Grant Consortium

D1.00006 Solar Wind - Mars Interactions: Energetic Neutral Atom Production , ERENA FRIEDRICH, ANDREW YAU, University of Calgary, JERRY BRACKBILL, LANL, retired — We study the energetic neutral atoms (ENAs) that are formed by charge exchange between solar wind ions and neutral particles in the Martian atmosphere. Mars Global Surveyor has shown that Mars has no notable global intrinsic magnetic field. Consequently, the neutral particles in the Martian atmosphere are unshielded from the flow of energetic solar wind protons. There results extensive production of energetic neutral hydrogen atoms (H-ENAs). In our study, we use a 3D hybrid (kinetic ions, fluid electrons), quasi-neutral, particle-in-cell (PIC) plasma simulation to investigate the production of H-ENAs due to collisions with neutral oxygen (O, O) and nitrogen (N) molecules in the near-space environment of Mars. A detailed chemical model that comprises multi-species reactions, such as ionization by photons, electron recombination, particle collisions, and charge exchange, is self-consistently included in the simulation. These chemical interactions, which take place between ions, atoms, and molecules in the martian exosphere and ionosphere, control the production of the H-ENAs. What is presented is a "work in progress" highlighting the ionospheric chemical and physical model as we work towards our goal of computing the flux of escaping H-ENAs due to charge exchange.

D1.00007 Using Graphene as Gas Detector[1] , CHRISTINA BIBLER, KYEL LAMBERT, MICHAEL CROSSER, Linfield College — The resistivity of graphene is sensitive to the presence of gas molecules adsorbed on it. Since graphene is one atom thick, a gas detector made from it might be sensitive to the presence of even single molecules of gas. We report on progress in making devices for this purpose and on future directions of research.

[1]Linfield College Faculty/Student Collaborative Grant

D1.00008 Photoemission electron microscopy of graphene[1] , SEBASTIAN SALIBA, Department of Physics, Portland State University, Portland, OR 97201, JENNA WARDINI, Department of Physics, Oregon State University, Corvallis, OR 97331, J.P.S. FITZGERALD, ROBERT C. WORD, Department of Physics, Portland State University, Portland, OR 97201, JOSH KEVEK, Department of Physics, Cornell University, Ithaca, NY 14853, ETHAN MINOT, Department of Physics, Oregon State University, Corvallis, OR 97331, ROLF KOENENKAMP, Department of Physics, Portland State University, Portland, OR 97201 — A study of chemical vapor deposited graphene on copper foil is conducted using an aberration-corrected photoemission electron microscope (PEEM). We demonstrate the efficacy such a PEEM has in identifying multi-layer graphene, defects and cracking. A model is developed to describe the observed reduction in photoemission rate where electrons originate from the copper foil and scatter through the graphene. A survey of several multi-layer feature line profiles demonstrates the reduced photoemission rate as the number of graphene layers increases. A mean-free-path length of $l = 3.8 \pm 0.8$ nm is inferred assuming the layer spacing in graphene is $\Delta z = 0.35$ nm. The PEEM's high spatial resolution and surface sensitivity combined with no electron beam damage are promising for characterizing biosensors and other nanoscale graphene devices.

[1]This research was funded by the US Department of Energy Basic Science Office under contract DE-FG02-10ER46406.

D1.00009 Effect of Pair Annihilation and Neutrino Decoupling on Cosmological Perturbations , ELHAM ALIPOUR, KRIS SIGURDSON, University of British Columbia — The origin and evolution of the primordial perturbations is the key to understanding structure formation. Through their evolution, these primordial fluctuations have generated first the observed Cosmic Microwave Background (CMB) anisotropies and later the distribution of galaxies and dark matter in the Universe. One possibility for the origin of the primordial perturbations is that the fluctuations were generated during a period of inflation. As inflation ended the fluctuations would have been imprinted as initial conditions for the cosmological perturbations on scales far beyond the horizon. Assuming a growing adiabatic mode as the initial condition, we investigated the impact of electron-positron annihilation and neutrino decoupling on the evolution of primordial perturbations and in particular on the gravitational potential transfer function.

D1.00010 2D Bose gases near resonance , DMITRY BORZOV, MOHAMMAD MASHAYEKHI, JEAN-SEBASTIEN BERNIER, University of British Columbia, JUN-LIANG SONG, Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, FEI ZHOU, University of British Columbia — We explore 2D Bose gases at large scattering lengths near resonance by analyzing contributions of 3-body scattering events that are universal in 2D unlike the 3D case of Efimov physics dependable upon ultraviolet limit energy scale. Within our approach, we study competition between 2-body and 3-body forces for varying scattering length parameter beyond the dilute limit, and find that, as the role of 3-body processes becomes significant, chemical potential saturates and reaches maximum at the first critical value beyond which we get region of negative compressibility. For even larger scattering lengths the 3-body forces become dominant and eventually lead to the onset of instability at the second critical value.

D1.00011 Measuring the Magnetic Induction of Isolated CoFeB Nanowires by Off-Axis Electron Holography, AZADEH AKHTARI-ZAVAREH, Simon Fraser University (SFU), T. KASAMA, Technical U of Denmark, L.P CARIGNAN, École Polytechnique de Montréal (EPM), A. YELON, D. MÉNARD, EPM, R. HERRING, University of Victoria, R.E. DUNIN-BORKOWSKI, Research Centre Jülich, M.R. MCCARTNEY, Arizona State University, K.L. KAVANAGH, SFU — Soft, and high saturation magnetization CoFeB Ferromagnetic Nanowires with diameters of 40 nm and 170 nm, were studied by *Selected Area Electron Diffraction (SAED)* and Electron Holography (EH). Diffraction patterns obtained from the nanowires suggest that the wires are nanocrystalline rather than amorphous. Holograms Show the magnetization inside the wire is uniform over most of the wire length, except at the edge. Since the wires consist of soft magnetic nanocrystals, the magnetic anisotropy is likely dominated by the shape anisotropy. Numerical simulations suggest that the stray fields at the top of the wire are well reproduced by a truncated cone model, rather than a cylinder. The measured magnetic induction for wires with diameters near 170 nm is 1.45 T, which is somewhat smaller than the saturation magnetization extracted from static magnetometry measurements of thin films of CoFeB (about 1.67 T). For the 40 nm diameter wires the magnetic induction is ranging from an average of 0.5 T near the tip of the wires to 1.5 T in the middle of the wires. The smaller induction near the end of the wires is attributed to the presence of a significant *out-of-plane* magnetic component since their tips are generally pointed out of the plane of the sample holder.

D1.00012 Optical Trapping in Silicon-Based Photonic Crystal Microcavities[1], SEYED HAMED MIRSADEGHI, JEFF F. YOUNG, University of British Columbia — A Si-based photonic integrated circuit has been designed to optically trap gold nano-particles at precise, lithographically defined positions on a silicon wafer. The circuit consists of input/output grating couplers, waveguides and a photonic crystal resonant cavity, all designed to operate at wavelengths near 1.5 microns. The objective is to use this as a means of bringing together metal and semiconductor (tethered to the metal) nanoparticles with plasmonic and excitonic resonances coincident with the microcavity resonance, for cavity quantum electrodynamic experiments and applications. The optical trapping potential achievable at the main antinode of the resonant cavity was calculated using 3D FDTD simulations, assuming 10 mW of CW optical power is available to excite the input grating coupler. These calculations suggest that the optical trap depth is 40 kT at room temperature, for a 30 nm diameter gold sphere. Experimental characterization of test samples fabricated based on this design agrees well with simulations.

[1]Supported by UBC AMPEL Nanofabrication Facility,Univ. of Washington Microfabrication/Nanotechnology User Facility (a member of NSF National Nanotechnology Infrastructure Network) assisted by Lukas Chrostowski, NSERC, NRAS, CIFAR, Lumerical Solution Inc.

D1.00013 Nanoscale diffraction gratings and electron vortex beams in a scanning electron microscope, ALEXANDER SCHACHTNER, CARLY WRIGHT, BENJAMIN MCMORRAN, TYLER HARVEY, TYLER YAHN, JORDAN PIERCE, University of Oregon dept. of Physics — We use focused ion beam nanofabrication to manufacture forked diffraction gratings capable of producing electron beams with helical wavefronts and orbital angular momentum (OAM). A vast number of unique beam modes carrying OAM can be produced through manipulation of grating fork number or position. Generally these gratings are milled such that they produce a phase shift in the beam and are used with high energy electrons (300keV) in a TEM to investigate the quantum or magnetic properties of the electron or image magnetic materials. Our latest work focuses on manufacturing sub-100-nm pitch binary transmission gratings that produce only an amplitude modulation, which opens up imaging capability to lower energy electrons (5-30 keV) and thus expands their use to a wider range of commercially available SEMs. We use these amplitude gratings to show the relationship between the number/position of forks and OAM inherited by the beam. This work could lead to advances in imaging capability, and also creates a widely accessible and scalable demonstration of the quantum properties of the electron which can be leveraged by any science program with SEM access.

D1.00015 Geometric Optimization of Spin Current, JOSH MELANDER, Linfield College, SERGEI URAZHDIN, Emory University — Spintronics is the study of spin transport electronics. Already employed in data storage technologies, spintronics offers the opportunity to continue to shrink electronic devices past what traditional electronics are capable of. The application of spintronics requires highly optimized devices; more so than what is available currently. In this experiment we aim to optimize spin transport properties through the geometry of the device. More specifically, we investigate how the thickness of the sample affects the diffusion length of the spin current (SC). The sample device is a multilayer made up of FeMn(0.5)Pt(x)Py(5), where x is the thickness in nm, sputtered onto an oxidized silicon chip. SC is then induced by the Spin Hall Effect (SHE) which occurs when a current is passed through the Pt layer. The effect of SC on Py is measured by Brillouin light scattering (BLS) spectroscopy. Our data shows that spin diffusion length is dependent on the thickness of the sample and we are currently working to formulate a working model for it.

D1.00016 Probing interactions between collagen proteins via microrheology, MARJAN SHAYEGAN, Department of Chemistry, Simon Fraser University, NANCY R. FORDE, Department of Physics, Simon Fraser University — Collagen is the major structural protein of our connective tissues. It provides integrity and mechanical strength through its hierarchical organization. Defects in collagen can lead to serious connective tissue diseases. Collagen is also widely used as a biomaterial. Given that mechanical properties are related to the structure of materials, the main goal of our research is to understand how molecular structure correlates with microscale mechanical properties of collagen solutions and networks. We use optical tweezers to trap and monitor thermal fluctuations of an embedded probe particle, from which viscoelastic properties of the solution are extracted. We find that elasticity becomes comparable to viscous behavior at collagen concentrations of 5mg/ml. Furthermore, by simultaneously neutralizing pH and adding salt, we observe changes in viscosity and elasticity of the solution over time. We attribute this to the self-assembly process of collagen molecules into fibrils with different mechanical properties. Self-assembly of collagen under these conditions is verified by turbidity measurements as well as electron microscopy. By comparing results from these local studies of viscoelasticity, we can detect spatial heterogeneity of fibril formation throughout the solution.

D1.00017 Undergraduate Construction of Optical Tweezers, LAWRENCE HUBBELL, University of Oregon — I will present a poster on the construction of optical tweezers. This will demonstrate the full process one must go through when working on a research project. First I sifted through the internet for papers and information pertaining to the tweezers. Afterwards I discussed the budget with the lab manager. Next I made purchases, however some items, such as the sample mount, needed to be custom made. These I built in the machine shop. Once the tweezers were operational I spent some time ensuring that the mirrors and lenses were adjusted just right, so that the trap performed at full strength. Finally, I used video data of the Brownian motion of trapped silica microspheres to get a reasonable estimate of the trapping stiffness with such particles. As a general note, all of this was done with the intent of leaving the tweezers for future use by other undergraduates. Because of this extra effort was taken to ensure the tweezers were as safe to use as possible. For this reason a visible LASER was chosen over an infrared LASER, in addition, the LASER was oriented parallel to the surface of the table in order to avoid stray upwards beams.

D1.00018 Measurements of adsorbate binding on individual suspended carbon nanotubes[1] , HAO-CHUN LEE, BORIS DZYUBENKO, DAVID COBDEN, OSCAR VILCHES, Department of Physics, University of Washington — By measuring the resonance frequency shift of vibrating suspended single-walled nanotubes at controlled temperature and pressure we can accurately detect the adsorption of gases including He, Ar, Kr, Xe, O2, and N2. The binding energy can then be determined from the low-coverage part of the adsorption isotherms. We find that the adsorption isotherms generally resemble those on graphite but with weaker binding energies, allowing access to behavior at lower two-dimensional (2D) chemical potential than on graphite. For He-4 the binding energy is reduced by as much as a factor of two. For Ar the binding energy on all nanotubes measured is in the range 800 - 900 K, about three quarters of that on graphite. This enables us to investigate the 2D critical and triple points of Ar. Puzzlingly, we find that the devices fall into two classes: one with monolayer condensation at lower pressures and sudden 2D liquid-vapor transitions, the other with condensation at higher pressures and lacking sharp transitions even well below the 2D critical point.

[1]Work supported by NSF DMR-1206208.

D1.00019 Strain control and the triple point of the metal-insulator transition in vanadium dioxide nanobeams[1] , JAE-HYUNG PARK, JIM COY, SERKAN KASIRGA, ZAIYAO FEI, CHUNMING WANG, BRAD SMITH, ELI BINGHAM, DAVID COBDEN, Department of Physics, University of Washington — We have developed an apparatus for applying controlled strain to suspended nanostructures while carrying out optical measurements. This platform enables us to study phenomena which are very sensitive to strain, such as the metal-insulator transition (MIT) occuring in vanadium dioxide nanobeams. The relationship between the metallic (R) phase and the two insulating (M1 and M2) phases involved in the MIT in vanadium dioxide remains unclear. Due to the different lattice constants of these phases, control of the strain along the nanobeam allows us to study the transitions between them methodically as a function of temperature and nanobeam length. One of our findings is that the triple point of the three phases occurs at zero strain.

[1]Supported by DoE grant DE-SC0002197.

D1.00020 NOνA Far Detector Module Fiber QA Test Analyses , AMANDA BOWERS, Linfield College, NOVA COLLABORATION[1] — In an effort to better understand the fiber-optic technology used to read out information regarding neutrino interactions in the NOvA far detector, various tests are performed at multiple stages of the detector module production. These fiber tests are used to check for and find sources of damaged fibers that may yield faulty readings. Analyses were performed specifically on the Stringing Fiber Test, closed fiber test, and visual inspection test both with and without a card. Cross-analyses were also performed to consolidate the data from these various tests and draw conclusions regarding the location and source of damaged fiber. The goal is to minimize the number of future tests that need be performed on a module while maintaining a high confidence level in the acceptance and rejection of modules to be installed at the detector site.

[1]NUMI Off-Axis Electron Neutrino Appearance at the University of Minnesota

D1.00021 Charmonium Hybrid Masses From QCD Sum-Rules , TIMOTHY RICHARDS, JASON HO, BRENDAN BULTHUIS, DEREK HARNETT, University of the Fraser Valley, ROBIN KLEIV, TOM STEELE, University of Saskatchewan — Over the past decade or so, more than a dozen new charmonium-like resonances, the so-called XYZ resonances, have been discovered due largely to work done by the Belle and BaBar collaborations. Few of these resonances fit neatly into a conventional charmonium interpretation as there are significant discrepancies between predicted and observed masses and widths. As such, there has been considerable speculation that some of these new states may lie outside of the constituent quark model. Hybrids, hadrons with explicit quark and gluon degrees of freedom, represent one such possibility. Using QCD sum-rules, we predict charmoniun hybrid masses for a variety of J^{PC} quantum numbers, and comment on possible phenomenological implications.

D1.00022 On the Formation of Luminescent MgZnO Ceramics with the Hexagonal and the Cubic Phase , LEAH BERGMAN, JOHN MORRISON, JESSE HUSO, MICHELLE HUSO, HUI CHE, DINESH THAPA, University of Idaho — Mg(x)Zn(1-x)O is a promising alloy family with UV-tuneable bandgaps, which can have the hexagonal or cubic structure depending on the composition x. ZnO has the hexagonal wurtzite structure and a bandgap of ~ 3.4 eV, while MgO has the NaCl cubic structure and a bandgap of ~ 7.4 eV. Mg(x)Zn(1-x)O can yield bandgaps spanning the range 3.4 eV to 7.4 eV that are achieved via the choice of composition x. We present studies of the optical and material properties of sintered ceramics with two alloy compositions, $x = 0.1$ and $x = 0.6$, to investigate both the wurtzite and the cubic phases. To study the alloying dynamics, the properties as a function of annealing temperature in the range of 600-1100C were investigated. For the low Mg composition ceramic sample it was found that a threshold temperature around 900C is required in order to initiate the formation of the solid solution of MgZnO with the wurtzite structure. The formation of the high Mg composition ceramic sample was found to have a sequence of phases: initially the alloy formed with the wurtzite structure at around 900C, then a transition into the NaCl cubic structure took place at the high temperature regime. Due to such formation, the cubic phase ceramics inherently include defects within the wurtzite structure.

D1.00023 Measuring the spin relaxation time of donor-bound electrons in InP , PASQUAL RIVERA[1], University of Washington, EMMA LORENZEN[2], Knox College, TODD KARIN[3], RUSSELL BARBOUR[4], KAI-MEI FU[5], University of Washington — Neutral donor-bound electrons and excitons in bulk semiconductors provide a system that may have interesting prospects for quantum information processing (QIP). In GaAs, the donor-bound exciton system exhibits extremely high optical homogeneity with spin relaxation times similar to that of negatively charged quantum dots. The complex excited state structure, however, makes full coherent optical control of the spin state challenging. In this work we investigate the spin relaxation properties of donor-bound electrons in InP, a material which exhibits a simpler excited-state structure and a higher exciton binding energy than GaAs. Current progress towards measuring the T1 via polarization-induced optical pumping will be presented.

[1]Washington NASA Space Grant Consortium
[2]NSF REU
[3]Graduate Student
[4]Post-Doctoral Researcher
[5]Principal Investigator

D1.00024 Electrical Conductivity of Sr_xVMoO_{6-y}(x=0.0, 0.1, 0.2) Double Perovskite Solid Oxide Fuel Cell Anode[1]

, NICHOLAS CHILDS, Montana State University Physics Department, ADAM WEISENSTEIN, Montana State University Mechanical Engineering Department, CAMAS KEY, Montana State University Physics Department, STEPHEN SOFIE, Montana State University Mechanical Engineering Department, RICHARD SMITH, Montana State University Physics Department — Solid Oxide Fuel Cells (SOFCs) are suited for high efficiency power generation, fuel flexibility, high temperature electrolysis, closed loop regenerative systems, oxygen generation, and carbon dioxide reduction. These capabilities make the SOFC highly versatile for: primary/secondary power systems, advanced life support, and in-situ resource utilization which may all be desired for a forthcoming lunar return and Mars Exploration. A promising anode material for a SOFCs is the double perovskite $Sr_{2-x}VMoO_{6-y}$(x=0.0-0.2), due to its stability, electronic, and ionic conduction. Anodes of this material were prepared via a tape casting technique. Electrical conductivity was studied in reducing atmospheres at temperatures up to 800 °C. V and Mo valence states were indentified before and after annealing in a hydrogen environment. Samples exhibited metallic conduction with electrical conductivity of $\sim 10^4$S/cm in a reducing atmosphere at 25 °C. A highly insulating $SrMoO_4$ phase forms upon room temperature exposure to air. The $SrMoO_4$ phase can be reduced above 400 °C resulting in an increase in conductivity.

[1]Montana NASA EPSCoR grant NNX09AP73A

D1.00025 Fabrication of hybrid GaP/diamond resonators for quantum information processing

, NICOLE THOMAS, University of Washington — Long spin coherence time and coupling of spin to optical transitions make nitrogen vacancy centers in diamond promising candidates for stationary qubits for quantum information processing. Their integration into photonic networks may allow for the measurement-induced entanglement of different spins through photon interference. One possible chip-based photonic entanglement network could consist of ring resonators for the enhancement of light emitted by the nitrogen vacancy centers, optical switches and waveguides. GaP is an ideal material choice for the fabrication of photonic networks in that it is transparent at the wavelength range of interest, provides a high refractive index for efficient waveguiding and electro-optic tuning capabilities for switching. We present two approaches to the fabrication and testing of hybrid GaP/diamond nanophotonic structures: (1) direct growth of GaP on diamond by molecular beam epitaxy and (2) transfer for a 200 nm thick GaP sheet from a bulk GaP/AlGaP/GaP sample to diamond. Disk resonators were fabricated via electron beam lithography and an anisotropic dry etch, and the resonator quality factor is measured.

D1.00026 Generation of coherent blue light in rubidium vapor: An advanced undergraduate laboratory

, SHANNON MAYER, University of Portland, MARCUS KIENLEN, NOAH HOLTE, HUNTER DASSONVILLE, Pacific University, KURT IVERSEN, RYAN MCLAUGHLIN, University of Portland, ANDREW DAWES, Pacific University — We describe an experiment for generating and characterizing coherent blue light in a rubidium vapor using two grating-feedback diode lasers. The lasers, operating at 780.2 nm and 776.0 nm respectively, provide step-wise excitation from the 5S ground state to the 5D excited state in rubidium. Cascade decay through the 6P state can produce a coherent beam of light at 420 nm. In this experiment, carried out in two different laboratories with different equipment, we investigate the spatial coherence and spectral characteristics of the blue beam under a variety of experimental conditions. This experiment provides advanced undergraduate physics students with a unique opportunity to investigate nonlinear optical phenomena in the laboratory. The equipment is similar to that used for saturated absorption spectroscopy in rubidium and can therefore be easily performed in laboratories with apparatus for that experiment.

D1.00027 Investigating and manipulating color centers in yttrium aluminum garnets[1]

, CHRIS VARNEY, AUTUMN PRATT, FARIDA SELIM, Department of Physics and Astronomy, Washington State University — Rare-earth-doped yttrium aluminum garnets (YAG) are important photonic materials with numerous applications in many fields such as lasers, phosphors, and scintillators. Color centers forming from point defects and impurities play a significant role on the optical properties of YAG crystals. In this work, color centers in undoped and RE doped YAG crystals were identified by absorption measurements in the UV-VIS- NIR range. Photo- and radio-luminescence measurements were carried out to study their emission. Growth atmosphere, annealing and UV excitation were utilized to alter the charge state of color centers and manipulate their absorption and luminescence characteristics.

[1]This work has been supported by National Science Foundation under grant number (DMR-1006772).

D1.00028 Women in Physics in Canada

, JANIS MCKENNA, University of British Columbia — Here we are in the 21st century in Canada, where most of us would say that young girls and boys have equal access to education, opportunities, and careers of their own choice. In Canada, women currently outnumber men in full-time university enrollment, in Medical Schools and in Law Schools. 48% of the Canadian work force is female, yet women make up only 21% of working professionals in science, engineering and technology. Canada-wide in Physics, the situation is such that only 20% of our BSc graduates are women, and 19% of our PhD graduates are women. It is evident that the "leaky pipeline" in Physics leaks most at a young age, before BSc graduation. High school physics statistics in BC indicate that while most of the grade 12 science and math disciplines have roughly equal numbers of young men and women enrolled, this is not the case for high school physics, where province-wide, only 30% of Physics 12 students are women. (Biology is also skewed, but in the other direction: 62% of Biology 12 students are women) This poster will present current statistics and will hopefully be a wake-up call for us all to consider participating in more outreach in science, and especially physics, in our high schools.

D1.00029 Developing a Research Tool to Gauge Student Metacognition[1]

, ALISTAIR MCINERNY, ANDREW BOUDREAUX, SEPIDEH RISHAL, KELCI CLARE, Western Washington University — Metacognition refers to the family of thought processes and skills used to evaluate and manage learning. A research and curriculum development project underway at Western Washington University uses introductory physics labs as a context to promote students' abilities to learn and apply metacognitive skills. A required "narrative reflection" has been incorporated as a weekly end-of-lab assignment. The goal of the narrative reflection is to encourage and support student metacognition while generating written artifacts that can be used by researchers to study metacognition in action. We have developed a Reflective Thinking Rubric (RTR) to analyze scanned narrative reflections. The RTR codes student writing for Metacognitive Elements, identifiable steps or aspects of metacognitive thinking at a variety of levels of sophistication. We hope to use the RTR to monitor the effect of weekly reflection on metacognitive ability and to search for correlations between metacognitive ability and conceptual understanding.

[1]Research supported by Western Washington University, NASA SPACE Grant

D1.00030 Proportional reasoning competence among different student populations , KING WONG, Westen Washington University, WESTERN WASHINGTON UNIVERSITY, RUTGERS UNIVERSITY, AND NEW MEXICO STATE UNIVERSITY COLLABORATION — A collaborative project between Western Washington University, Rutgers University, and New Mexico State University seeks to understand student's competence level on proportional reasoning. We have been collecting and analyzing data from introductory physics and science education courses using a set of assessment tasks. We utilize the notion of constructs to categorize student thinking according to repetitive patterns. Results suggest that, when students confront ratio and proportion problems, they often experience a gap between the mechanics of the mathematical operations and the conscious understanding of what they are doing. In this poster we will share results of our findings from different courses, institutions, and student populations. Supported by NSF grants DUE-1045227, DUE-1045231, DUE-1045250..

Friday, October 19, 2012 6:00PM - 7:00PM –

Session E1 Northwest Section Business Meeting SFU Harbour Centre 1700 Labatt Hall - Chair: Erich Vogt, TRIUMF

6:00PM E1.00001 Business Meeting –

Friday, October 19, 2012 7:00PM - 8:30PM –

Session F1 Banquet SFU Harbour Centre 1400-1430 Segal Centre - Chair: Andrew DeBenedictis, Simon Fraser University

7:00PM F1.00001 DINNER –

7:45PM F1.00002 Big Bangs: Applying Geophysics to the Study of Active Volcanoes , GLYN WILLIAMS-JONES, Simon Fraser University — Although considerable progress has been made in the quantitative characterisation of volcanic eruptions, significant questions remain about the physicochemical processes that control volcanic activity. Improving this understanding is essential to accurate forecasting of eruptions, and will only be achieved through the integration of multi-temporal, and multi-spatial geochemical, geophysical and remote sensing data sets. Volcanoes present short and long term variations in their magmatic, hydrothermal, and/or hydrogeological systems that can be detected on the surface and since magma is rarely directly accessible on the surface, investigation of the dynamic behaviour of these systems is particularly suited to geophysical monitoring. Emplacement and movement of magma will often result in volume change, rock fracturing or pressure variations that can be readily detected by seismic and geodetic networks, while variations in mass, density and flow direction of the magma, magmatic gases and fluids will be expressed through the generation of local disturbances of potential-fields, such as gravity, magnetic or electrical fields. While, the source generating the potential-field signal is a nonunique solution, when the models are informed by independent data sets such as seismicity or geochemistry, it becomes possible to limit the models to a reasonable number of possibilities. Although a network of seismometers and geodetic sensors is still the ideal method for monitoring volcanic activity, the required capital investment means that only a small number of active volcanoes are thoroughly monitored. Fortunately, recent advances in the miniaturisation and standardisation of sensors and wireless communication systems will likely make these monitoring networks more widely available. Furthermore, the application of new geophysical techniques, such as muon tomography show enormous potential for expanding our knowledge of the subsurface structures of volcanoes and may even eventually be used for monitoring. However, it is only through the integration of a wide variety of geophysical, geochemical and remote sensing techniques that we can constrain the rates at which key magmatic processes occur and interpret the associated surface signals that may indicate changes in volcanic activity.

Saturday, October 20, 2012 8:25AM - 12:00PM –

Session G1 Plenary Session II SFU Harbour Centre 1900 Fletcher Challenge Theatre - Chair: Brian Milbrath, Pacific Northwest National Laboratory

8:25AM G1.00001 Welcome –

8:30AM G1.00002 Next-Generation Muon g-2 , DAVID HERTZOG, University of Washington — The Brookhaven muon g-2 experimental result—now more than 3 standard deviations greater than the Standard Model prediction—continues to generate significant theoretical interest. It represents one of the strongest hints of new physics. What could this be, and perhaps more importantly, is it real? To answer this, an even more precise experiment is being designed at Fermilab using the unique complex of accelerators associated with the so-called Intensity Frontier campaign. The E989 experiment will re-employ the original BNL storage ring, but otherwise much of the measurement equipment, beam delivery, and key elements related to muon storage, will be new. I will describe this exciting effort, including the latest thinking on how to move the very large superconducting coils across the country.

9:06AM G1.00003 Obliquely Incident Solitary Wave onto a Vertical Wall , HARRY YEH, Oregon State University — When a solitary wave impinges obliquely onto a reflective vertical wall, it can take the formation of a Mach reflection (a geometrically similar reflection from acoustics). The mathematical theory predicts that the wave at the reflection can amplify not twice, but as high as four times the incident wave amplitude. Nevertheless, this theoretical four-fold amplification has not been verified by numerical or laboratory experiments. We discuss the discrepancies between the theory and the experiments; then, improve the theory with higher-order corrections. The modified theory results in substantial improvement and is now in good agreement with the numerical as well as our laboratory results. Our laboratory experiments indicate that the wave amplitude along the reflective wall can reach 0.91 times the quiescent water depth, which is higher than the maximum of a freely propagating solitary wave. Hence, this maximum runup 0.91 h would be possible even if the amplitude of the incident solitary wave were as small as 0.24 h. This wave behavior could provide an explanation for local variability of tsunami runup as well as for sneaker waves.

9:42AM G1.00004 Minerva: Big Exoplanet Science from Small Telescopes , NATE MCCRADY, University of Montana — The Kepler mission has identified over 2300 candidate planets in the past two years, adding to the over 500 confirmed exoplanets from radial velocity (RV) surveys. One of the most striking results of these surveys is that the number of planets increases rapidly with decreasing size. There may in fact be more Earth-like planets in the Galaxy than stars. There must be terrestrial planets around nearby stars, though few have yet been discovered. Finding these planets requires high precision RV observations and high cadence transit observing to densely sample the orbital phase. Minerva will surmount these obstacles with a dedicated observatory for detection of super-Earths and close-in Earth-like planets. Our array of four 0.7-m telescopes will operate in two modes: jointly with a high precision fiber-fed spectrometer capable of detecting the RV signal of an Earth orbiting a low mass star, and independently for photometric transit detection surveys.

10:18AM G1.00005 BREAK —

10:48AM G1.00006 Atom trap loss, elastic collisions, and technology[1] , JAMES BOOTH, Physics Department, BCIT — The study of collisions and scattering has been one of the most productive approaches for modern physics, illuminating the fundamental structure of crystals, surfaces, atoms, and sub-atomic particles. In the field of cold atoms, this is no less true: studies of cold atom collisions were essential to the production of quantum degenerate matter, the formation of cold molecules, and so on. Over the past few years it has been my delight to investigate elastic collisions between cold atoms trapped in either a magneto-optical trap (MOT) or a magnetic trap with hot, background gas in the vacuum environment through the measurement of the loss of atoms from the trap. Motivated by the goal of creating cold atom-based technology, we are deciphering what the trapped atoms are communicating about their environment through the observed loss rate. These measurements have the advantages of being straightforward to implement and they provide information about the underlying, fundamental inter-atomic processes. In this talk I will present some of our recent work, including the observation of the trap depth dependence on loss rate for argon-rubidium collisions. The data follow the computed loss rate curve based on the long-range Van der Waals interaction between the two species. The implications of these findings are exciting: trap depths can be determined from the trap loss measurement under controlled background density conditions; observation of trap loss rate in comparison to models for elastic, inelastic, and chemical processes can lead to improved understanding and characterization of these fundamental interactions; finally the marriage of cold atoms with collision modeling offers the promise of creating a novel pressure sensor and pressure standard for the high and ultra-high vacuum regime.

[1]This work has been supported by the Natural Sciences and Engineering Reseach Council of Canada and by the BCIT School of Computing and Academic Studies.

11:24AM G1.00007 Inspire Curiosity, Promote Understanding, Explode Soda , SANDRA EIX, Science World British Columbia — Pyrotechnical demonstration shows, summer camps,and larger-than-life exhibits. Is this a theme park or an educational institution? We'll explore what informal science education has to offer, and ponder why and how a science centre does what it does best. Be forewarned: this presentation may involve audience participation and rubber chickens.

Saturday, October 20, 2012 12:00PM - 1:15PM —

Session G2 SPS Undergraduate Luncheon SFU Harbour Centre 1400-1430 Segal Centre - Chair: Tom Olsen, Society of Physics Students

12:00PM G2.00001 SPS Undergraduate Luncheon —

Saturday, October 20, 2012 1:30PM - 5:50PM —

Session H1 Atomic, Molecular, and Optical Physics SFU Harbour Centre 1700 Labatt Hall - Chair: Daniel Steck, University of Oregon

1:30PM H1.00001 Casting Light on Antimatter with ALPHA Project at CERN: Fundamental Physics with Trapped Antihydrogen[1] , MAKOTO FUJIWARA, TRIUMF — Testing fundamental symmetries plays an important role in our understanding of Nature. Experiments at CERN's Antiproton Decelerator facility aim to make precision tests of matter-antimatter symmetry, in particular CPT (charge, parity, time reversal), by comparing the properties of hydrogen with those of its antimatter counterpart, antihydrogen. Demonstration of trapping of antihydrogen atoms by the ALPHA collaboration, and subsequent observation of their long-time confinement, have opened up new experimental possibilities in antimatter physics. Most recently, ALPHA has succeeded in demonstrating the first spectroscopic measurement on anti-atoms, via microwave resonance. I this talk, I will discuss how to make and trap antihydrogen atoms. I will also discuss the prospects of fundamental symmetry tests with antihydrogen, including the possibility of measuring the gravitational interaction of antimatter.

[1]Supported in part by NSERC, TRIUMF/NRC

2:06PM H1.00002 Microwave Spectroscopy of Trapped Antihydrogen , MOHAMMAD DEHGHANI ASHKEZARI, Simon Fraser University — Theory predicts that, under CPT[1] symmetry, the laws of physics make no distinction between matter and anti-matter. We have every reason to believe that equal amounts of both were produced in the early universe, following the Big Bang. However, our observable universe is overwhelmingly made up of matter. ALPHA is an international project located at CERN and involves ~ 30 physicists from 15 different institutions. The primary goal of the collaboration is to investigate this gaping discrepancy between theoretical expectations and reality by precise comparison of matter and anti-matter, in particular hydrogen and antihydrogen. A critical milestone was reported in November 2010, the first-ever stable and reproducible magnetic confinement of neutral antihydrogen atoms. Shortly after, in June 2011, ALPHA announced the long-time (1000 s) trapping of antihydrogen, opening the door to precision spectroscopy. In March 2012, the first proof-of-principle spectroscopic measurement performed on trapped antihydrogen atoms using microwave radiation[2]. Detailed aspects of this measurement is presented in this talk.

[1]Charge conjugation, Parity inversion, and Time reversal.
[2]C. Amole, et al., (ALPHA collaboration), Nature **483**, 439 (2012).

2:18PM H1.00003 Yttrium ionization scheme development for Ti:Sa laser based RILIS

ANDREA TEIGELHOEFER, JENS LASSEN, ZEINAB ABBOUD, PIERRE BRICAULT, HENNING HEGGEN, PETER KUNZ, RUOHONG LI, THOMAS QUENZEL, SEBASTIAN RAEDER, TRIUMF — Resonant ionization laser ion sources (RILIS) are popular ion sources if intense, radioactive ion beams (RIBs) with minimal isobaric contamination are required. The intensity of the ion beam depends strongly on the applied resonant laser ionization scheme. Based on the all solid state laser system TRIUMF's RILIS (TRILIS) is using, the off-line development towards an efficient ionization scheme for yttrium is presented. Several continuous wavelength scans have been performed to compare different nonresonant ionization schemes and to identify suitable Rydberg or autoionizing states for resonant ionization schemes.

2:30PM H1.00004 Terahertz imaging of inhomogeneous electrodynamics in single-layer graphene embedded in dielectrics

ZACHARY THOMPSON, MICHAEL PAUL, JOESEPH TOMAINO, Oregon State University, JOSHUA KEVEK, Cornell University, TRISTAN DEBORDE, ETHAN MINOT, YUN-SHIK LEE, Oregon State University, OREGON STATE UINVERSITY TEAM, CORNELL UNIVERSITY COLLABORATION — We investigate electron transport properties in large-area, single-layer graphene embedded in dielectric media, using free-space terahertz (THz) imaging and time-domain spectroscopy. Sandwiched between a thin polymethyl methacrylate (PMMA) layer and a Si substrate, graphene layers of different growth recipes exhibit distinctive spatial inhomogeneity of sheet conductivity. The non-contacting, non-destructive THz probe reveals that the PMMA layer induces a small, yet noticeable reduction in conductivity.

2:42PM H1.00005 Terahertz Transmission Ellipsometry of Vertically-Aligned Multi-Walled Carbon Nanotubes

MICHAEL PAUL, NICK KUHTA, JOE TOMAINO, ANDY JAMESON, LOUIS MAIZY, TAL SHARF, Oregon State University, NALIN RUPESINGHE, KEN TEO, Aixtron Ltd., SANDEEP INAMPUDI, VICTOR PODOLSKIY, University of Massachusetts Lowell, ETHAN MINOT, YUN-SHIK LEE, Oregon State University, OREGON STATE UNIVERSITY TEAM, AIXTRON LTD COLLABORATION, UNIVERSITY OF MASSACHUSETTS LOWELL COLLABORATION — We demonstrate time-resolved terahertz transmission ellipsometry of vertically-aligned multi-walled carbon nanotubes. The angle-resolved transmission measurements reveal anisotropic characteristics of the terahertz electrodynamics in multi-walled carbon nanotubes. The anisotropy is, however, unexpectedly weak: the ratio of the tube-axis conductivity to the transverse conductivity, $\sigma_z/\sigma_{xy} = 2.3$, is nearly constant over the broad spectral range of 0.4 – 1.6 THz. The relatively weak anisotropy and the strong transverse electrical conduction indicate that THz fields readily induce electron transport between adjacent shells within multi-walled carbon nanotubes.

2:54PM H1.00006 Exploring asymmetry in the optical dispersion of dyes in solution near an absorption resonance

AMELIA VANENGEN SPIVEY, Physics Department, University of Puget Sound, Tacoma, Washington — Dispersion is the dependence of the refractive index of a material on wavelength. Dispersion is problematic in ultrafast optics experiments, which use broad-spectrum laser pulses lasting hundreds of femtoseconds or less. Together with nonlinear effects, dispersion can cause undesirable changes (such as temporal spreading or pulse splitting) to a propagating ultrafast laser pulse. Temporal spreading of ultrafast laser pulses during propagation is primarily governed by the group velocity dispersion (GVD) coefficient. Therefore, modeling ultrafast pulse propagation in a material requires accurate knowledge of the GVD coefficient in the material. This talk presents experimental measurements of the GVD coefficient of dyes in solution using a white light Michelson interferometer. In particular, we probe the dependence of the GVD on wavelength near the absorption resonance in the dye. We find the wavelength dependence of the GVD to be asymmetric about the absorption resonance. On the low-wavelength side of the resonance, the dye contribution to the GVD is negligibly small. However, on the high-wavelength side, the dye contribution to the GVD can be significant and is highly wavelength dependent. This effect is consistent with a simple Lorentz model of dispersion and can be modeled accurately using the linear absorption spectrum of the dye.

3:06PM H1.00007 Quantum resonances in selective rotational excitation of molecules with a sequence of ultrashort laser pulses[1]

SERGEY ZHDANOVICH, CASEY BLOOMQUIST, The University of British Columbia, JOHANNES FLOSS, ILYA AVERBUKH, The Weizmann Institute of Science, JOHN HEPBURN, VALERY MILNER, The University of British Columbia — The periodically kicked rotor is a paradigm system for studying classical and quantum chaos. In the quantum regime, the dynamics of the kicked rotor exhibit such phenomena as suppression of classical chaos, Anderson localization in angular momentum and quantum resonances in the accumulation of rotational energy. Even though these effects have been studied with ultracold atoms in optical fields and Rydberg atoms in microwave fields, they have never been observed in a real rotational system. In this work we study the effect of quantum resonance in the rotational excitation of a diatomic molecule. By using femtosecond pulse shaping and rotational state-resolved detection, we measure the rotational distribution of molecules interacting with a train of pulses. We show enhancement of population transfer from the ground to the excited rotational states at resonance, and demonstrate selective rotational excitation of two nitrogen isotopes. We utilize fractional quantum resonances for separating para- and ortho-nitrogen, paving the way to novel methods of coherent control of molecular rotation.

[1] CFI, BCKDF, NSERC, ISF, DFG, Minerva Foundation

3:18PM H1.00008 BREAK –

3:38PM H1.00009 XUV Frequency Combs via Femtosecond Enhancement Cavities

ARTHUR MILLS, University of British Columbia — We report on recent developments in tabletop extreme ultraviolet (XUV) sources based on high harmonic generation (HHG) in femtosecond enhancement cavities (fsEC). The XUV frequency comb is produced via HHG at the full repetition rate of the mode-locked oscillator (typically > 50 MHz), inside a passive enhancement cavity with an enhancement of a few hundred. Several technical challenges have recently been resolved, which have led to an increase in the generated photon flux in the XUV (10^{14} photons/sec), and a substantial improvement in the operating time of these sources. XUV sources based on fsECs are now able to perform direct frequency comb spectroscopy with MHz precision in atomic systems at wavelengths down to 60 nm. Ongoing research is aimed at determining the ultimate frequency stability of these new XUV frequency comb sources. XUV fsEC sources are also promising for some applications that are typically performed with XUV light at advanced light sources. These applications include electronic structure of quantum material systems, such as angle-resolved photoemission spectroscopy (ARPES), size metrology of nano-aerosol particles, and potentially velocity map imaging for studies of chemical physical problems. In this talk, we present a brief introduction to XUV frequency comb sources and the technical challenges that have been overcome to achieve the current performance levels. We will also discuss our progress on ARPES experiments with a fsEC XUV source and our efforts toward increasing the energy resolution of the produced harmonics. Finally, we describe ongoing efforts to further increase the maximum photon energy and photon flux generated, and subsequently delivered to an experiment by fsEC XUV sources.

4:14PM H1.00010 Coherent anti-Stokes Raman spectroscopy in the presence of strong resonant signal from background molecules

, MARTIN BITTER, VALERY MILNER, University of British Columbia — Laser spectroscopy based on femtosecond coherent anti-Stokes Raman scattering (fs CARS) often involves simultaneous excitation of multiple resonances covered by the broad spectral bandwidth of ultrashort pulses. Determining the chemical composition of a mixture of molecular species with close vibrational frequencies typically requires Fourier analysis of the detected time-resolved fs CARS signal. Here we propose and demonstrate an alternative method of separating vibrational responses from two molecular species with neighboring vibrational modes (here, oxygen and carbon dioxide). We utilize ro-vibrational coupling as a mechanism of suppressing the strong vibrational response from the dominating molecular species (O_2). Coherent ro-vibrational dynamics leads to long "silence windows" of zero CARS signal from oxygen molecules. In these silence windows, the detected signal stems solely from the minority species (CO_2) enabling background-free detection and characterization of the O_2/CO_2 mixing ratio. In comparison to a Fourier analysis, our technique does not require femtosecond time resolution or time-delay scanning.

4:26PM H1.00011 Spin orbit coupling in a dilute gas Bose-Einstein condensate[1]

, CHRIS HAMNER, JIAJIA CHANG, PETER ENGELS, Washington State University — The recent implementation of Raman dressing in cold atom systems opens the door for novel investigations of quantum dynamics. It provides an intriguing new tool to dynamically change the dispersion relation with unprecedented tunability. In suitable parameter regimes this scheme also allows for the generation of 1D spin orbit coupling analogous to the spin orbit coupling in complex condensed matter systems. In our experiments we have implemented spin orbit coupling for a ^{87}Rb BEC and study its influence on hydrodynamics properties. We present results of recent and ongoing research.

[1]We acknowledge funding from NSF and ARO.

4:38PM H1.00012 Dynamics of Feshbach molecules in an ultracold three-component mixture[1]

, ALEXANDER KHRAMOV, ANDERS HANSEN, WILLIAM DOWD, ALAN JAMISON, SUBHADEEP GUPTA, University of Washington, Seattle, WA 98195 — Feshbach resonances are an integral tool in ultracold atomic physics, allowing for tunable two-body interactions and the synthesis of molecular dimers. The two lowest energy states of the ^{6}Li atom exhibit a broad Feshbach resonance at 834 Gauss which can be used to link pairs of atoms into shallow dimers. We study ultracold mixtures of ^{6}Li atoms near the Feshbach resonance, immersed in a bath of ^{174}Yb. We observe dynamics of Li_2 Feshbach molecule formation and decay, as modified by a non-resonant component, and find remarkable molecule stability even in the absence of Fermi statistics. We also extract the reaction rate coefficients of the dominant chemical processes. This work opens various new possibilities for studies of strongly interacting Fermions, as interrogated by a second species.

[1]Supported by the National Science Foundation and the Air Force Office of Scientific Research.

4:50PM H1.00013 Spontaneous nucleation of topological defects in trapped Yb^+ ion-crystals

, SARA EJTEMAEE, PAUL. C. HALJAN, Simon Fraser University — Laser-cooled arrays of trapped ions, also known as ion crystals, are currently being investigated for quantum information processing. They are also interesting as a mesoscopic "condensed-matter" system to study classical and quantum few-body phase transitions. Following a recent theoretical proposal, we are performing experiments to investigate the non-equilibrium dynamics of the linear-zigzag phase transition in a system of trapped $^{174}Yb^+$ ions. We use strong transverse confinement to align the trapped ions into a linear crystal. Gradually reducing the trap anisotropy induces a structural phase transition from linear to a two-dimensional zigzag configuration. Alternatively, rapidly quenching the anisotropy across the phase transition can lead to crystal structures containing spontaneously nucleated topological defects. We describe our recent experimental results on the formation and lifetime of these structural defects.

5:02PM H1.00014 Atom Interferometry with Bose-Einstein condensates to measure α[1]

, BENJAMIN PLOTKIN-SWING, ALAN JAMISON, SUBHADEEP GUPTA, University of Washington — The most precise measurement of the fine structure constant, α, comes from the electron $g-2$ measurement. This result relies on high orders of perturbation theory in QED. A complementary measurement of α with less dependence on theory would allow for extremely stringent tests of QED. Atomic recoil measurements, which measure h/m for a given atomic species, are a promising direction for such a measurement. We will report on our progress toward a Bose-Einstein condensate (BEC) interferometer to measure the atomic recoil of ytterbium (Yb) with high precision. Use of a BEC allows for long interrogation times and a robust signal. Using Yb eliminates magnetic fields as a potentially damaging systematic while allowing comparison of results for different isotopes. We have established key components of the interferometer with a ^{174}Yb BEC: diffraction with short laser pulses for momentum-state beam-splitting and with long pulses as mirrors. We are working on acceleration pulses to achieve large momenta in the different interferometer arms, necessary for a sub-ppb measurement of α.

[1]This work is supported by NSF and NIST.

5:14PM H1.00015 Quantum dynamics in a trapped ultra-cold Bose gas

, DORNA NIROOMAND, LYDIA ZAJICZEK, JEFFREY MCGUIRK, Simon Fraser University — We study spin dynamics in a trapped Rb gas near quantum degeneracy. Although the system is not degenerate, the dynamics are dominated by quantum properties of particles. We use an optical technique, based on the ac Stark effect, to imprint desired spin structures in these trapped atomic samples. These spin structures can lead to generation of instabilities, such as the Castaing instability, in which a strong longitudinal spin gradient is unstable to transverse perturbations. We report experimental results on observing the Castaing instability.

5:26PM H1.00016 Measuring geometric quantum discord using DQC1[1]

, GINA PASSANTE, University of Washington, OSAMA MOUSSA, RAYMOND LAFLAMME, Institute for Quantum Computing, University of Waterloo — DQC1 is a model of quantum computation that utilizes a single qubit accompanied by a register of completely mixed states. While this model is able to outperform current classical methods without substantial entanglement, it does contain non-classical correlations as measured by the quantum discord. We describe an efficient algorithm to experimentally measure a near relative of the quantum discord, the geometric quantum discord, of a DQC1-state. We provide an analytical expression that indicates the geometric quantum discord of a $(1+n)$-qubit DQC1-state decreases exponentially with n. This is in contrast to the quantum discord, which is independent of n for the same state. In addition, we present experimental results using a four-qubit liquid-state nuclear magnetic resonance quantum information processor.

[1]This research was performed at the Institute for Quantum Computing at the University of Waterloo.

5:38PM H1.00017 The Quantum Gunslinger: A Gedanken Experiment , MICHAEL DEVINE, None — Presented is the Quantum Gunslinger, a gedanken experiment that explores, in a purely classical setting, the assumptions and conclusions of John Bell's seminal paper "On the Einstein Podolsky Rosen Paradox." The Quantum Gunslinger can be easily implemented as a carnival game. If a player's score violates a CHSH inequality, then the player wins a beable. If the player's score violates a Leggett Inequality, then the player wins a large ball wound from surplus string. Find out why the game operator will either quickly go out of business for giving away prizes too easily, or be forced out of business on charges of fraud.

Saturday, October 20, 2012 1:30PM - 4:50PM – Session H2 Biological and Applied Physics SFU Harbour Centre 1315 Scotiabank Lecture Room - Chair: Michael Schick, University of Washington

1:30PM H2.00001 Biological membranes at large length scales: Biological applications and computational modeling , LUTZ MAIBAUM, Department of Chemistry, University of Washington — Biological membranes, such as the plasma membrane surrounding cells, perform an astonishing variety of essential functions: they provide structural support, regulate trafficking, and control endocytosis and fusion events, among others. Some of these capabilities are due to a membrane's elastic properties: at typical length scales of hundreds of nanometers, it can be thought of as a two-dimensional fluid sheet that exhibits significant fluctuations. This mesoscopic picture can be used to model several biological processes, including the formation of cellular protrusions due to interactions between the cytoskeleton and the cell membrane. We show that a membrane can bundle polymerizing actin filaments, thereby enabling the formation of tubular structures that resemble filopodia observed in motile cells. To study this and similar processes that involve the cell membrane over large length scales, we have developed a new computational model that correctly captures the effects of bending rigidity and fluidity. We show that our model exhibits an elastic response to perturbations that is consistent with the Canham-Helfrich description of lipid bilayers, while also providing a computationally efficient way to capture the effects of shape fluctuations.

2:06PM H2.00002 Membranes, mechanics, and intracellular transport , RAGHUVEER PARTHASARATHY, The University of Oregon, Department of Physics — Cellular membranes are remarkable materials – self-assembled, flexible, two-dimensional fluids. Understanding how proteins manipulate membrane curvature is crucial to understanding the transport of cargo in cells, yet the mechanical activities of trafficking proteins remain poorly understood. Using an optical-trap based assay involving dynamic deformation of biomimetic membranes, we have examined the behavior of Sar1, a key component of the COPII family of transport proteins. We find that Sar1 from yeast (*S. cerevisiae*) lowers membrane rigidity by up to 100% as a function of its concentration, thereby lowering the energetic cost of membrane deformation. Human Sar1 proteins can also lower the mechanical rigidity of the membranes to which they bind. However, unlike the yeast proteins, the rigidity is not a monotonically decreasing function of concentration but rather shows increased rigidity and decreased mobility at high concentrations that implies interactions between proteins. In addition to describing this study of membrane mechanics, I'll also discuss some topics relevant to a range of biophysical investigations, such as the insights provided by imaging methods and open questions in the dynamics of multicellular systems.

2:42PM H2.00003 Effect of Sterol Structure on Chain Ordering of an Unsaturated Phospholipid: A 2H-NMR Study of POPC/Sterol Membranes , MEHRAN SHAGHAGHI, Physics Department, Simon Fraser University, JENIFER THEWALT, Physics & MBB Departments, Simon Fraser University, MARTIN ZUCKERMANN, Physics Department, Simon Fraser University — The physical properties of biological membranes are considerably altered by the presence of sterols. In particular, sterols help to maintain the integrity of the cell by adjusting the fluidity of the plasma membrane. Cholesterol is in addition an important component of lipid rafts which are hypothesized to compartmentalize the cell membrane surface thereby making it possible for certain proteins to function. Using 2H-NMR spectroscopy, we studied the effect of a series of different sterols on the chain ordering of POPC, an unsaturated phospholipid present in eukaryotic cell membranes. We were able to assigned specific roles to the structural differences between the sterols by comparing the manner in which they affect the average lipid chain conformation of POPC.

2:54PM H2.00004 Frequency Mapping of Rat Spinal Cord at 7T[1] , EVAN CHEN, ALEXANDER RAUSCHER, PIOTR KOZLOWSKI, ANDREW YUNG, None, UBC MRI RESEARCH CENTER TEAM, ICORD AT VGH TEAM — The spinal cord is an integral part of the nervous system responsible for sensory, motor, and reflex control crucial to all bodily function. Due to its non-invasive nature, MRI is well matched for characterizing and imaging of spinal cord, and is used extensively for clinical applications. Recent developments in magnetic resonance imaging (MRI) at high field (7T) using phase represents a new approach of characterizing spinal cord myelin. Theory suggests that microstructure differences in myelinated white matter (WM) and non-myelinated gray matter (GM) affect MR phase, measurable frequency shifts. Data from pilot experiments using a multi-gradient echo (MGE) sequence to image rat spinal cords placed parallel to main magnetic field B0 has shown frequency shifts between not only between WM and GM, but also between specific WM tracts of the dorsal column, including the fasciculus gracilis, fasciculus cuneatus, and corticospinal tract. Using MGE, frequency maps at multiple echo times (TE) between 4ms and 22ms show a non-linear relationship between WM frequency, contrary to what was previously expected. These results demonstrate the effectiveness of MGE in revealing new information about spinal cord tissue microstructure, and lays important groundwork for in-vivo and human studies.

[1]Research supported by NSERC funding

3:06PM H2.00005 Combined Fat Imaging/Look Locker for mapping of lipid spin-lattice (T1) relaxation time[1] , ANNIE JIHYUN PARK, ANDREW YUNG, PIOTR KOZLOWSKI, STEFAN REINSBERG, University of British Columbia — Tumor hypoxia is a main problem arising in the treatment of cancer due to its resistance to cytotoxic therapy such as radiation and chemotherapy, and selection for more aggressive tumor phenotypes. Attempts to improve and quantify tumor oxygenation are in development and tools to assess the success of such schemes are required. Monitoring oxygen level with MRI using T1 based method (where oxygen acts as T1 shortening agent) is a dynamic and noninvasive way to study tumor characteristics. The method's sensitivity to oxygen is higher in lipids than in water due to higher oxygen solubility in lipid. Our study aims to develop a time-efficient method to spatially map T1 of fat inside the tumor. We are combining two techniques: Fat/Water imaging and Look Locker (a rapid T1 measurement technique). Fat/Water Imaging is done with either Dixon or Direct Phase Encoding (DPE) method. The combination of these techniques poses new challenges that are tackled using spin dynamics simulations as well as experiments in vitro and in vivo.

[1]Natural Sciences and Engineering Research Council (NSERC), Canadian Cancer Society

3:18PM H2.00006 BREAK –

3:38PM H2.00007 How Tongue Size and Roughness Affect Lapping , M.J. HUBBARD[1], K.M. HAY[2], Pacific Lutheran University Tacoma, WA — The biomechanics of domestic cat lapping (Felis catus) and domestic dog lapping (Canis familiaris) is currently under debate. Lapping mechanics in vertebrates with incomplete cheeks, such as cats and dogs, is a balance of inertia and the force of gravity likely optimized for ingestion and physical necessities. Physiology dictates vertebrate mass, which dictates vertebrate tongue size, which dictates lapping mechanics to achieve optimum liquid ingestion; with either touch lapping, scooping, or a hybrid lapping method. The physics of this optimized system then determines how high a column of liquid can be raised before it collapses due to gravity, and therefore, lapping frequency. Through tongue roughness model variation experiments it was found that pore-scale geometrical roughness does not appear to affect lapping or liquid uptake. Through tongue size model variation experiments it was found that there is a critical tongue radius in the range of 25 mm to 35 mm above which touch lapping is no longer an efficient way to uptake liquid. Vertebrates with incomplete cheeks may use a touch lapping method to ingest water if their tongue radius is less than this critical radius and use an alternative ingestion method if their tongue radius is larger.

[1]Undergraduate student at Pacific Lutheran University. Graduating spring of 2013 with a B.S. in Physics (math and music minors). Interests include fluids, biomechanics, and modeling wave-like phenomenon.

[2]Assistant Professor of Physics at Pacific Lutheran University. Ph.D. in Physics with fluid physics emphasis (Oregon State University). Interests include rock fracture fluid flow and animal-fluid dynamic interactions.

3:50PM H2.00008 Rayleigh-Taylor Instability in Disintegration of Liquid Globule due to Constant Acceleration , MAZIYAR JALAAL, Department of Mechanical Engineering, The University of British Columbia, Vancouver, BC, Canada, KIAN MEHRAVARAN, School of Engineering, The University of British Columbia, Kelowna, BC, Canada. — Fragmentation of droplets is of fundamental importance in several applications, from volcanic eruption to combustion engines. In the current study, the fragmentation of an initially spherical droplet accelerated by a constant body force is examined in 3D. A finite volume-volume of fluid (FV-VOF) numerical technique is employed for direct numerical simulation (DNS) of the two-phase system. The numerical code uses a combination of octree spatial discretization and a multilevel Poisson solver. It is shown that the fragmentation has four main steps: 1-Deformation of the initially spherical droplet and bag formation. 2-Bursting of the bag generating upper and lower tori. 3-Deformation and breakup of the tori. 4-Disintegration of remaining ligaments and drops. The role of Rayleigh-Taylor instability (RTI) at each step is studied in detail. It is showed RTI is the prevailing mechanism in bursting of the bag, flattened core and tori. Stability analyses are also provided based on the linearized Navier-Stokes equations, and the most amplified wave numbers were compared with the observations in DNS. Reasonable agreement is observed between the numerical and analytical solutions.

4:02PM H2.00009 Particle dynamics in a virtual harmonic potential[1] , MOMCILO GAVRILOV, YONGGUN JUN, JOHN BECHHOEFER, Dept. of Physics, Simon Fraser University, Burnaby, BC, Canada — The recently developed Anti-Brownian ELectrokinetic (ABEL) trap is a device for trapping and manipulating single fluorescent particles in solution. The ABEL trap acquires an image of a Brownian particle in order to estimate its position and then apply an electrical force to bring it to the desired position. This feedback system allows us to explore properties of a single molecule in its natural environment. Although the ABEL trap has been used in a number of biophysical studies, there is no complete theory to describe how the ABEL trap actually works. In this talk, we will present the first complete theory of the ABEL trap that takes into account parameters such as the particle's diffusion constant, feedback frequency, camera exposure time, observational noise, response delay, and feedback gain. The theory predicts successfully the power spectrum density of particle motion for given trap parameters. We will present the case of an imposed harmonic virtual potential, comparing theoretical predictions to simulation and experimental results.

[1]This work was funded by NSERC (Canada).

4:14PM H2.00010 Studying biomechanics at the single-molecule level with optical tweezers , NAGHMEH REZAEI, NANCY FORDE, ANDREW WIECZOREK, Simon Fraser University — Lasers have found significant roles in today's world. One of their applications is trapping microscopic objects, which has helped scientists to understand mechanical processes involved in protein and DNA mechanics, structure, and interaction kinetics. We use the optical trapping technique to study mechanical properties of short proteins that play a vital role in providing structural support for the body. Elastin and collagen are two important structural proteins: we study their mechanical response to an applied force, and try to understand how it relates to their biological roles. The goals are to reveal how changes chemical compositions at the molecular scale affect mechanical properties, and relate these to macroscopic changes that can lead to serious and sometimes lethal diseases.

4:26PM H2.00011 A Density Functional Theory of Transfer Free Energy in Protiens[1] , ERIC MILLS, STEVEN PLOTKIN, Dept of Physics & Astronomy, University of British Columbia — The cell environment in which proteins fold and function is crowded with biological molecules, at densities of ∼300g/L. Treating these molecules explicitly in a MD simulation introduces enormous computational cost, so accurate ways of modelling their contribution to protein behaviour is desirable. I will discuss existing models of transfer free energy (Auton and Bolen, Biochemistry 43, 1329) and solvation (Luchko et al, J Chem Thry Cmp it 6, 607) and propose a new approach, which uses classical density functional theory (Emborsky et al, Fluid Phase Equil 306, 15) to calculate the effect of these solutes on protein folding in a way that is efficient, yet accurate. The theory developed will be applied to both post-processing approaches and implicit solvent models.

[1]Project supported by NSERC.

4:38PM H2.00012 Solvation effects on like-charge attraction , SHAHZAD GHANBARIAN ALAVIJEH, JOERG ROTTLER, Department of Physics and Astronomy, The University of British Columbia — We present results of molecular dynamics simulations on electrostatic interaction between two parallel charged rods in the presence of divalent counterions. Such polyelectrolytes have been considered as a simple model for understanding electrostatic interaction in biomolecules such as DNA. Since there are correlations between the free charge carriers, the phenomenon of like charge attraction appears for specific parameters. We explore the effects of the nonlocal dielectric function of water on this peculiar phenomenon. The behavior of the force between the charged rods in a simulation model with full representation of water molecules are completely different from a model in which water is modeled as a continuum dielectric with $\epsilon_r = 72$. After calculating counterion-rodion pair correlation functions, we find that the presence of water molecules changes the distribution of counterions in the system and explains the difference in the behavior of the force in two models.

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Session H3 Particle Physics II SFU Harbour Centre 2270 Sauder Industries Policy Room - Chair: Gordon Watts, University of Washington

1:30PM H3.00001 Searches for New Physics at the Energy Frontier , BERND STELZER, Simon Fraser University — CERN's Large Hadron Collider (LHC) is recently performing at record luminosities and energies that enables a program systematically addressing some of the most fundamental questions of nature. On July 4th, 2012 the ATLAS and CMS experiments at the LHC announced observation of a new particle one that is consistent with the legendary Higgs boson, linked to the question of origin of mass. Both collaborations, ATLAS and CMS, have since analyzed datasets up to 11/fb that push searches for new physics to higher and higher sensitivity. I will present a summary of the latest Higgs results and highlight some of the key searches for Physics beyond the Standard Model of particle physics.

2:06PM H3.00002 Search for Resonances Decaying into Top Quark Pairs Using Fully Hadronic Decays in pp Collisions with ATLAS at $\sqrt{s}$ = 7 TeV , STEPHEN SWEDISH, University of British Columbia, ATLAS COLLABORATION — A search for a new top quark pair resonance at the CERN Large Hadron Collider with the ATLAS detector is performed on 4.66 fb^{-1} of data collected at $\sqrt{s} = 7$ TeV. The search uses a new method for tagging jets that correspond to highly energetic top quark decays that tests the agreement of calorimetric energy depositions with the three-prong top quark decay hypothesis. The top quark plays an important role in many theories of physics beyond the Standard Model which often predict the existence of a new massive boson that couples dominantly to top quarks. The search reveals no evidence of a new top quark pair resonance, and the result is used to exclude Kaluza-Klein gluons as predicted by the Randall-Sundrum model with masses between 1.02 and 1.62 TeV, and to set cross-section limits on the leptophobic Z' boson.

2:18PM H3.00003 Search for high-mass resonances decaying to lepton pairs with the ATLAS detector[1] , SIMON VIEL, University of British Columbia / TRIUMF, ATLAS COLLABORATION — We present a search for high-mass $\ell^+\ell^-$ resonances in pp collisions at a centre-of-mass energy of 7 TeV recorded by the ATLAS experiment in 2011. No statistically significant excess above the Standard Model expectation is observed in a dataset corresponding to an integrated luminosity of approximately 5 fb^{-1}. Consequently, upper limits are set on the cross-section times branching ratio of resonances decaying to muon pairs as a function of the resonance mass. In particular, a Sequential Standard Model Z' is excluded for masses below 2.22 TeV, and a Randall-Sundrum Kaluza-Klein graviton with coupling $k/\overline{M}_{Pl} = 0.1$ is excluded for masses below 2.16 TeV, both at the 95% C.L. Results using data recorded by the ATLAS experiment in 2012 at a centre-of-mass energy of 8 TeV will also be presented.

[1]The author acknowledges support from the Vanier Canada Graduate Scholarship program, and the Natural Sciences and Engineering Research Council of Canada.

2:30PM H3.00004 Search for supersymmetry in final states with three leptons and missing transverse momentum in $\sqrt{s}$ = 7 TeV pp collisions with the ATLAS detector , SAM KING, University of British Columbia, ATLAS COLLABORATION — A search for the direct production of weak gauginos in final states with three leptons and missing transverse momentum is presented. An integrated luminosity of 4.7 fb^{-1} of $\sqrt{s} = 7$ TeV proton-proton collision data delivered by the Large Hadron Collider and recorded with the ATLAS detector has been analyzed. Consistency with Standard Model expectations was observed in three signal regions that are either depleted or enriched in Z-boson decays. Upper limits at 95% confidence level have been set in the parameter spaces of the phenomenological minimal supersymmetric Standard Model and simplified models.

2:42PM H3.00005 Determination of the Jet Energy Scale at ATLAS using Z+Jet Events , JAMIE HORTON, MIKE VETTERLI, Simon Fraser University, ATLAS COLLABORATION — A correct energy calibration for jets is essential to the success of the ATLAS experiment. In this talk the missing transverse energy projection fraction method, an in-situ jet energy calibration currently being being used in the ATLAS detector will be discussed. In particular preliminary results using this method in events where a Z-boson balances a jet in transverse momentum will be shown. The response derived from these events can be used to complement a response derived in gamma-jet events for low transverse momentum, as well as a method for separating the responses for jet initiated by quarks and gluons. These quark and gluon responses will allow for a selection specific jet energy calibration to be derived for individual physics analysis based on the composition of the jets being observed.

2:54PM H3.00006 Exploring the CP nature of the Higgs within the context of the Type III Two Higgs Doublet Model , PETER WINSLOW, UBC/TRIUMF, SEAN TULIN, University of Michigan — We investigate the possibility that the newly discovered boson at the LHC belongs to a set of new bosons originating in a general type III two Higgs doublet model. New sources of CP violation from the scalar potential which mix the electrically neutral scalar and pseudo-scalar states lead to the Higgs acquiring a pseudo-scalar admixture. This mixing is tightly constrained by electric dipole moments, electroweak oblique parameters, and vacuum stability. However, within a small region of parameter space, a sizeable pseudo-scalar admixture cannot be excluded and allows for a large enhancement in the Higgs to di-photon signal rate. We discuss how the LHC Higgs data can provide complementary information in constraining the CP nature of the Higgs boson.

3:06PM H3.00007 BREAK —

3:26PM H3.00008 Bring the Higgs to Rest , JACOBUS VAN NIEUWKOOP, Simon Fraser University, ATLAS COLLABORATION — In the Standard Model of Physics, the Higgs boson can decay to a pair of W bosons which decay leptonically. At ATLAS, we have developed a discriminator that classifies events as signal-like or background-like based on their kinematics. This discriminator requires the calculation of the matrix element (derived from Feynman rules) for both signal and background hypotheses. One assumption that we made is that the Higgs is at rest in the transverse plane of the detector. However, this is often not the case due to next-to-leading order effects like initial state radiation. In order to improve our sensitivity we attempt to boost the Higgs into its transverse rest frame. Since the neutrinos pass through ATLAS undetected, we do not have direct access to the Higgs 4-momenta. My talk will describe how we used multivariate techniques to estimate the transverse momentum of the Higgs.

3:38PM H3.00009 Search for a light Higgs Boson at Babar , ROCKY SO, University of British Columbia, BABAR COLLABORATION — Babar collided electrons and positrons at a centre of mass energy of 10GeV at the Stanford Linear Accelerator Center. A light CP-odd Higgs boson is expected in extensions to the Standard Model such as Next to Minimal Supersymmetry. The Babar Collaboration searched for a light Higgs boson (A0) produced in radiative decays of an Y meson. We saw no evidence of the A0 decaying into various final states with a sample of 122 million Y(3S), 99 million Y(2S), and 23 million Y(1S) collected at the PEP II B-factory. We exclude some of the parameters space of Next to Minimal Supersymmetry. Some searches are published and a few is still in the analysis stage. I will present work done by the collaboration as well as my work in progress for the A0 to hadrons.

3:50PM H3.00010 The Topological Casimir Effect , MOOS VAN CASPEL, CHARLES CAO, ARIEL ZHITNITSKY, University of British Columbia — The conventional Casimir effect manifests itself as a quantum-mechanical force between two plates, that arises from the quantization of the electromagnetic field in the enclosed vacuum. In this talk the possibility is discussed of an extra, topological term in the Casimir energy at finite temperatures. This topological Casimir effect emerges due to the nontrivial topological features of the gauge theory and becomes apparent when examining, for example, periodic boundary conditions. Here the extra term is explicitly calculated for the simplest example of such a system: two large plates in the x-y plane, with an integer-valued topological flux in the z-direction. By dimensional reduction, this system is closely related to 2D Maxwell theory, which is well understood. We find that the topological term is extremely small compared to the conventional Casimir energy, but that the effect could possibly be amplified by an external magnetic field.

4:02PM H3.00011 Physical Implications of Topological Casimir Effect , CHUNJUN CAO, MOOS VAN CASPEL, ARIEL ZHITNITSKY, University of British Columbia — Casimir effect is typically known as the presence of an attractive force between two neutrally charged and perfectly conducting parallel plates in vacuum. It was known that an extra term in the Casimir energy emerges from non-trivial topological features of the gauge fields, but this effect is greatly suppressed in the typical setup of Casimir effect experiments. Nevertheless, I will show in this presentation that in the presence of a non-zero external magnetic field, this topological effect is greatly enhanced, making it possible to be measured in experiments.

4:14PM H3.00012 Long range order in gauge theories: Deformed QCD as a toy model[1] , EVAN THOMAS, University of British Columbia — I present some recent work (arXiv:1208.2030) on long range order in gauge theories, using a "deformed" QCD model. I first introduce the theory and the formulation of topological objects, mainly monopoles and domain walls. I then present our numerical calculation and results related to the interaction between a monopole and a nearby domain wall. Finally, I discuss how this can help us understand some recent lattice QCD results which indicate that topological charge in real QCD may be exclusively spread along extended objects rather than localized in point-like instantons.

[1]This research was supported in part by the Natural Sciences and Engineering Research Council of Canada.

Saturday, October 20, 2012 1:30PM - 5:26PM – Session H4 Condensed Matter II SFU Harbour Centre 1520 Barrick Gold Lecture Room - Chair: Brad Johnson, Western Washington University

1:30PM H4.00001 Conductance Quantization in Graphene Nanostructures[1] , GEORGE KIRCZENOW, Department of Physics, Simon Fraser University, Burnaby, BC, Canada, V5A1S6 and Canadian Institute for Advanced Research, Nanoelectronics Program. — Electrical conductances quantized in integer multiples of the fundamental quantum $2e^2/h$ are the hallmark of ballistic quantum transport in nanostructures such as semiconductor quantum point contacts, gold atomic wires, and carbon nanotubes. However, there have been only a few reports of conductance quantization being observed in graphene nanostructures, and the observed behavior presented significant puzzles: Lin *et al.* [Phys. Rev. B **78**, 161409(R) (2008)] and Lian *et al.* [Appl. Phys. Lett. **96**, 103109 (2010)] observed conductance quantization in graphene nanoribbons. However, surprisingly, the conductance steps that they found were orders of magnitude smaller than the ballistic conductance quantum $2e^2/h$. Tombros *et al.* [Nature Physics **7**, 697 (2011)] reported observing conductance quantization in *integer* multiples of $2e^2/h$ in a graphene nanoconstriction with curved boundaries. However, the curvature implies the presence of large numbers of atomic-scale steps along the boundaries. In this respect a graphene constriction differs from semiconductor constrictions whose boundaries, being defined electrostatically, are atomically smooth, and this smoothness is widely believed to be crucial for the observation of conductance quantization. In this talk I will review these experiments and the explanations that we have proposed[2] of the quantized conductance phenomena that have been observed in graphene nanostructures.

[1]Work supported by NSERC, CIFAR, Compute Canada and WestGrid.

[2]S. Ihnatsenka and G. Kirczenow, Phys. Rev. B **80**, 201407(R) (2009); Phys. Rev. B **83**, 245442 (2011); Phys. Rev. B **83**, 245431 (2011); Phys. Rev. B **85**, 121407(R) (2012); Phys. Rev. B **86**, 075448 (2012).

2:06PM H4.00002 Proposal for better control of single molecule magnets for quantum information storage[1] , FATEMEH ROSTAMZADEH RENANI, GEORGE KIRCZENOW, Simon Fraser University — A molecular nano-magnet (MNM) is a single molecule that contains transition metal atoms that endow it with a stable magnetic moment. Transistors based on MNMs are potential candidates for spintronic devices and information storage. Knowledge of the orientation of the molecule's easy axis relative to leads is important for potential spintronic applications of MNMs but it has not been experimentally controllable. Our calculations reveal the possibility of determining the easy axis orientation experimentally by means of current measurements: We find the lowest unoccupied molecular orbital (LUMO) of the Mn_{12}-benzoate MNM to be on ligands, unlike the highest occupied molecular orbital which is on the Mn_{12} magnetic core. Therefore, we predict transport via the LUMO not to be subjected to Coulomb blockade. We predict gate controlled switching between Coulomb blockade and coherent resonant tunnelling in transistors based on such MNMs. We propose that this effect can be used to identify specific experimentally realized MNM transistors in which the easy axis is approximately parallel to the direction of the current flow.

[1]This work was supported by CIFAR and NSERC.

2:18PM H4.00003 A continued fraction approach to calculating Auger electron spectra , ANAMITRA MUKHERJEE, MONA BERCIU, University of British Columbia — We present a novel real space approach to calculating few body lattice Green's functions for the Anderson impurity model. Using this we compute the two hole impurity Green's function for the impurity coupling to a one dimensional bath. We show that the geometry of the impurity-bath coupling can introduce new features in the impurity spectral function that survive even when the impurity-bath hybridization is weak. We compare these results with the spectral function for the corresponding periodic Anderson model and identify the parameter regime where the impurity spectral function is a faithful representation of the two hole (Auger) spectra of the periodic system. We comment on the generalization of the method to calculating three hole spectral functions and their application to Auger electron spectra in partially filled band.

2:30PM H4.00004 Birefringent fermions and their phase transitions on square lattices

, NAZANIN KOMEILIZADEH, MALCOLM KENNETT, Simon Fraser University — We introduce a tight-binding model for spinless fermions on a square lattice, which when half-filled has low energy excitations with a Dirac-like dispersion. In the vicinity of these Dirac points there are unusual gapless excitations with the feature that there are two different "speeds of light." This is a consequence of a broken chiral symmetry in the model, which occurs in the kinetic energy term, and hence leaves the spectrum gapless in the vicinity of the Dirac points. This chiral symmetry breaking is fundamentally different from spontaneous chiral symmetry breaking that leads to mass generation in field theoretic models. We investigate the effects of interactions in this model and present the associated phase diagrams and phase transitions when there are nearest neighbour and next nearest neighbour interactions.

2:42PM H4.00005 Failure of the Holstein model to describe strong electron-phonon coupling[1]

, CLEMENS P.J. ADOLPHS, MONA BERCIU, Department of Physics and Astronomy, University of British Columbia, Vancouver, Canada — The coupling of electrons to phonons and the properties of the resulting quasiparticle, the polaron, are important for understanding many materials, including strongly correlated systems like the cuprates and the manganites. For some materials, the effective electron-phonon (el-ph) coupling λ is well known. For others, like the cuprates, estimates range from very small ($\lambda \sim 0.3$) to extremely large ($\lambda \sim 5$). Here, we point out an inconsistency in the widely used theoretical models. Both the Holstein and the Fröhlich model assume that lattice distortions are sufficiently small to allow treating the el-ph coupling as linear. At strong coupling, however, it is well established that a small polaron forms, with potentially considerable lattice distortions, invalidating the original assumption. We use the momentum average approximation to study the effect of higher-order coupling terms in the Holstein model. We show that they have drastic consequences on the properties of the polaron when compared to the linear model and that these effects cannot be captured by a linear model with renormalized parameters. Since linear models fail to describe strongly coupled systems, estimates of λ based on those models have to be reevaluated.

[1]This work was supported by NSERC, CIFAR and QMI.

2:54PM H4.00006 Hop dynamics in glasses

, ANTON SMESSAERT, JÖRG ROTTLER, The University of British Columbia — Although glassy materials are widely used, we still know little about the underlying physics of the glass state. One key challenge is the non-equilibrium nature, which manifests in time-dependent material properties. A link between this "aging" and structural changes is still missing. Elementary structural relaxation events, called "hops," have been identified as particles leaving the shell of their immediate neighbors. We present first results of molecular dynamics simulations with a new algorithm that enables us to track these hops throughout the system. Using a standard polymer glass model, we show a complete "map" of the hop-dynamics in the bulk. This data allows us to explore the correlations between relaxation events. Our map of hop-events is also useful in the study of dynamical heterogeneities (DH), a concept that arose from the discovery of "faster" and "slower" moving groups of particles in glasses. Current research aims at connecting their growth to the glass transition, but their observation and study has proven to be challenging. The hop-detection gives us a coarse-grained picture of the dynamics and we can identify DH as spatio-temporal accumulations of hops. This makes a direct study of DH possible and we present preliminary results based on a cluster analysis.

3:06PM H4.00007 Electron-phonon coupling in 1D edge-shared cuprates probed by resonant soft x-ray scattering[1]

, STEVEN JOHNSTON, University of Britsh Columbia, W.S. LEE, SLAC National Accelerator Laboratory, Stanford University, B. MORITZ, Northern Illinois University, JEROEN VAN DEN BRINK, IFW-Dresden, Z.-X. SHEN, Stanford University, T.P. DEVEREAUX, SLAC National Accelerator Laboratory, Stanford University — Resonant inelastic x-ray scattering (RIXS) is a powerful probe for studying excitations in strongly correlated systems. With continued advancements of the technique, the overall energy resolution has improved to the point of uncovering low-energy bosonic excitations near the elastic line. In this talk we present evidence for coupling to an optical oxygen phonon in the RIXS spectrum of the quasi-1D edge shared cuprate $Ca_{2+x}Y_{2-x}Cu_5O_{10}$ at the oxygen K-edge. This mode is identified as a compressive mode polarized perpendicular to the chain direction which modulates the Cu-O charge transfer energy which sets the size exchange interaction. By comparing to small cluster calculations we extract a sizable electron-phonon coupling strength and infer an interplay between the electronic, magnetic, and lattice degrees of freedom.

[1]This work is supported by FOM (The Netherlands) and the U. S. Department of Energy, Office of Basic Energy Science, Division of Materials Science and Engineering.

3:18PM H4.00008 BREAK –

3:38PM H4.00009 Ultrafast Dynamics of Polaron Formation[1]

, SUSAN DEXHEIMER, Washington State University — The formation of localized electronic states reflects the fundamental physics of coupling between electronic and lattice dynamics, as first noted by Landau who in 1933 described the process of polaron formation as "the electron 'digs its own hole' and is trapped there." Localization of electronic states plays a critical role in determining the properties of a wide range of materials: polaron formation has a profound impact on charge transport properties of electronic materials, and formation of self-trapped excitons, or exciton-polarons, dramatically changes optical properties and energy transport mechanisms. I will present femtosecond time-resolved studies of the dynamics of the localization process, focusing on the formation and evolution of self-trapped excitons and polarons. The experiments are carried out in quasi-one-dimensional materials in which the strength of the electron-phonon coupling that drives the dynamics can be systematically tuned by varying the material composition. Experiments using femtosecond vibrationally impulsive excitation, in which the system is excited with an optical pulse short compared to the periods of the relevant vibrational modes, allow us to time-resolve the coupled electronic and lattice dynamics as the system evolves from the initially photoexcited delocalized electronic state to form a self-trapped exciton, revealing rapid dynamics involving both optical and acoustic phonon modes. Polaron dynamics are probed using time-resolved terahertz spectroscopy, in which short pulses of far-infrared light are used to monitor the fast photoinduced carrier response, and show localization on the time scale of a single vibrational period of the lattice.

[1]Work supported by the National Science Foundation, DMR1106379.

4:14PM H4.00010 Specification, design and commissioning of an ultra-low-vibration facility for Scanning probe microscopy experiments

, BENJAMIN MACLEOD, YAN PENNEC, VINCENT WONG, GRAEME ADAMSON, The University of British Columbia — Scanning probe microscopes are perhaps best known for being able to image individual atoms in real space. A practical complication of this extreme spatial sensitivity is that these instruments are also extremely sensitive to mechanical vibrations; to approach ultimate levels of performance, these microscopes must therefore be operated in an environment with an extremely low level of mechanical vibrations. In this work, the specification, design and commissioning of a new ultra-low-vibration facility recently completed at the University of British Columbia is presented. Based on the pneumatically-suspended inertial slab concept used at NIST's Gaithersburg facility[1] this system will be used as a highly stable platform for a 50mK Scanning Tunneling Microscope system.

[1]Hal Amick, Bea Sennewald, Norman C. Pardue, Clayton Teague, and Brian Scace, Noise Control Engineering Journal 46, 39-47 (1998).

4:26PM H4.00011 Optical pump wavelength dependence in visible-pump visible-probe spectroscopy of noble metals

, DEREK G. SAHOTA, Department of Physics, Simon Fraser University, CALVIN LOBO, Department of Physics, McMaster University, KONRAD DUCH, Faculty of Mathematics, University of Waterloo, J. STEVEN DODGE, Department of Physics, Simon Fraser University — We have developed a femtosecond visible-pump visible-probe reflectometer with individually tunable pump and probe photon energies. The spectrometer has been used to study optically thick films of the noble metals Au and Cu over a wide variety of pump fluences and photon energies. Through comparison between experimental measurements and two-temperature model (TTM) simulations, we estimate an electron-phonon coupling constant, g, of $2.37 \pm 0.11 \times 10^{16}$ Wm^{-3}K^{-1} for Au and $1.19 \pm 0.13 \times 10^{17}$ Wm^{-3}K^{-1} for Cu, consistent with previous studies. The variation of the optical pump parameters allows a more accurate determination of the electron-phonon coupling constant. The relaxation rate, τ, of the thermally excited electrons is shown to be strongly dependent on the peak electron temperature of the excited sample, and only weakly dependent on the pump photon energy. The static dielectric constant is found to significantly underestimate the dependence of the differential reflectivity on the pump photon energy.

4:38PM H4.00012 High Resolution Photoluminescence Spectroscopy of Doped ZnO nanowires

, SENTHIL KUMAR ESWARAN, FAEZEH MOHAMMADBEIGI, DENG ZHIWEI, IAN ANDERSON, SIMON WATKINS, Department of Physics, Simon Fraser University — ZnO is a material with a very promising optical properties for visible and ultraviolet optoelectronics applications. The control of doping in single crystal epitaxial material is challenging both for n- and p-dopants due to the large n-type background doping typically present. In this paper we discuss recent efforts to dope ZnO nanowires with various n and p-type dopants using the metalorganic chemical vapor deposition growth technique (MOCVD). The nanowire geometry has the advantage of producing near perfect single crystals decoupled from the highly mismatched sapphire substrate. In this way we are able to observed remarkable narrow PL linewidths as low as 0.17 meV in an ensemble of wires. Careful addition of the group III impurities Al and In results in the unambiguous identification of several sharp line bound exciton features. The addition of n-dopants has strong effects on the nanowire morphology, resulting a in a large increase in the lateral growth rate. Antimony is claimed to produce p-type material by several groups, however we show that careful backdoping of single crystals with antimony results in the appearance of a new donor bound exciton transition, providing confirmation of recent channeling measurements, as well as theoretical predictions that Sb prefers to reside on the Zn sublattice.

4:50PM H4.00013 THz conductivity measurement of MnSi

, LALEH MOHTASHEMI, AMIR FARAHANI, Simon Fraser University, ERIC KARHU, THEODORE L. MONCHESKY, Dalhousie University, J. STEVEN DODGE, Simon Fraser University — We present measurements of the low-frequency optical conductivity of a thin film of MnSi, using time-domain terahertz spectroscopy. At low temperatures and low frequencies, we extract the DC resistivity, scattering life time and plasma frequency from a Drude fit. We obtain a value of $\omega_p \simeq 1.0$ eV, which can be used to estimate the renormalization coefficient through comparison with band theory. At higher temperatures, a deviation from Drude behavior is observed, suggesting a loss of quasi-particle coherence. In the region of low temperatures and high frequencies, we see evidence for a crossover to the anomalous power law dependence observed by Mena *et al.*[1] As the temperature increases, the anomalous frequency dependence becomes more pronounced, and the plasma frequency inferred from a Drude fit increases dramatically. Above T≈ 50 K, $\sigma_2(\omega)$ develops a negative slope that is inconsistent with both a Drude model and the anomalous power law observed earlier, indicating a sharp pseudogap in the conductivity spectrum.

[1]F.P. Mena *et al.* Phys. Rev. B. **67**, 241101(R) (2003).

5:02PM H4.00014 Superfluid density in 2D organic superconductors: evidence for d-wave pairing

, SONIA MILBRADT, Department of Physics, Simon Fraser University, ANDREW BARDIN, Centre for Organic Photonics and Electronics, School of Mathematics and Physics, University of Queensland, COLIN TRUNCIK, WENDELL HUTTEMA, PAUL CARRIERE, Department of Physics, Simon Fraser University, BEN POWELL, Centre for Organic Photonics and Electronics, School of Mathematics and Physics, University of Queensland, PAUL BURN, SHIH-CHUN LO, Centre for Organic Photonics and Electronics, School of Chemistry and Molecular Biosciences, University of Queensland, DAVID BROUN, Department of Physics, Simon Fraser University — Organic superconductors are an exciting "playground" for low dimensional physics, with a clean, layered structure that exhibits a variety of electronic phases including superconductivity. The interactions responsible for pairing, and the symmetry of the pair wavefunction, continue to be open issues in these materials. To gain further insights, we have carried out microwave spectroscopy of two BEDT-TTF-based superconductors. Penetration depth measurements reveal a strong, linear temperature dependence of superfluid density, indicating line nodes in the order parameter and providing strong evidence for d-wave pairing. Measurements of the microwave conductivity allow us to extract the quasiparticle scattering rate, both above *and* below T_c. In the normal state, the scattering is strong, at several times the thermal energy. Below T_c there is a rapid drop in scattering, with a T^3 temperature dependence characteristic of d-wave quasiparticles scattering from antiferromagnetic spin fluctuations.

5:14PM H4.00015 A Method for Determining Paper Processing Parameters Using Terahertz Spectroscopy

, ANTHONY STEIGVILAS, IAN BUSHFIELD, PAYAM MOUSAVI, Simon Fraser University, STEPHANE SAVARD, FRANK HARAN, Honeywell Process Solutions, STEVE DODGE, Simon Fraser University — To ensure consistency, paper manufacturing requires knowledge of the thickness, areal density, and moisture content of a paper sheet as it is produced. We use terahertz time-domain spectroscopy (THz-TDS) to estimate these three parameters. We model the paper as an effective medium composed of water, fibre and air, and include scattering losses. We then estimate model parameters from fits of the effective medium theory to the measured transmission amplitude using maximum-likelihood estimation. We will discuss the accuracy and precision of the resulting parameter estimates, and compare them to current paper parameter sensor technology.

Saturday, October 20, 2012 1:30PM - 4:50PM –

Session H5 Physics Education SFU Harbour Centre 1600 Canfor Policy Room - Chair: Joss Ives, University of the Fraser Valley

1:30PM H5.00001 Promoting Students' Proportional Reasoning Using Invention Tasks

, ANDREW BOUDREAUX, Western Washington University — To many students, introductory physics may seem a fast-moving parade of abstract, mysterious quantities. Most such quantities are rooted in proportional reasoning. Using ratio, physicists construct the force experienced by a unit charge and characterize motion with the change in velocity for a unit time. While physicists reason about these ratios without conscious effort, students may resort to memorized algorithms and struggle to match the appropriate algorithm to the situation encountered. Dan Schwartz and colleagues at Stanford University have developed invention instruction as a means to prepare students for future learning. Invention tasks present open-ended situations in which students must invent a procedure or quantity in order to make meaningful comparisons. Through creative thinking and struggle, students are primed to make sense of the accepted scientific solution. A collaboration between Western Washington University, Rutgers, and New Mexico State has developed sequences of invention tasks to promote proportional reasoning. Central to our work is the development of assessments to gauge student learning. This talk presents an overview of the coordinated research and curriculum development project together with selected examples.

2:06PM H5.00002 Measuring the Effectiveness of Simulations in Preparing Students for the Laboratory

, MARK PAETKAU, DAN BISSONNETTE, COLIN TAYLOR, Thompson Rivers University — For the past few years we have been using online simulations to help students prepare for their Introductory Physics labs. We have created online animations allowing students to simulate the lab before arriving, which, ideally, more effectively prepares students for the lab. To test whether the simulations are more effective than traditional pen-and-paper questions as pre-lab exercises, we attempted to measure the "level-of-preparedness" of our students. Using our preparedness measure, we compare the preparedness for the two forms of pre-lab exercises. A statistically significant change in "preparedness" is found with the use of online simulations over the pen-and-paper pre-labs.

2:18PM H5.00003 Student Performance on Conceptual Questions: Does Instruction Matter?[1]

, PAULA HERON, University of Washington — As part of the tutorial component of introductory calculus-based physics at the University of Washington, students take weekly pretests that consist of conceptual questions. Pretests are so named because they precede each tutorial, but they are frequently administered after lecture instruction. Many variables associated with class composition and prior instruction could, in principle, affect student performance. Nonetheless, the results are often found to be "essentially the same" in all classes. Selected questions for which we have accumulated thousands of responses, from dozens of classes representing different conditions with respect to the textbook in use, the amount of prior instruction, etc., serve as examples. A preliminary analysis suggests that the variation in performance across all classes is essentially random. No statistically significant difference is observed between results obtained before relevant instruction begins and after it has been completed. The results provide evidence that exposure to concepts in lecture and textbook is not sufficient to ensure an improvement in performance on questions that require qualitative reasoning.

[1]Supported in part by the US National Science Foundation.

2:30PM H5.00004 Examining student understanding in quantum mechanics[1]

, GINA PASSANTE, PAUL EMIGH, PETER SHAFFER, University of Washington — A solid understanding of quantum mechanics is an important component to an undergraduate physics degree. While many quantum mechanics students can successfully solve complicated mathematical problems, they are often unable to answer qualitative or conceptual questions and have trouble with some very important foundational concepts. The Physics Education Group at the University of Washington is working to develop a set of tutorials to supplement traditional instruction and improve students understanding of many important quantum mechanical concepts. Preliminary findings and examples will be presented.

[1]This work has been supported in part by the National Science Foundation.

2:42PM H5.00005 Science Rocks! Summer Program

, CARA BOERNER, University of the Fraser Valley — In this talk I will discuss the University of the Fraser Valley's Science Rocks! summer program. The success of the program will be discussed as well as how the program has been adapted over the years. I will also talk about me own experience with the program as I have been a facilitator for the last two years and how it has benefited the facilitators as much as the children who are taking part in the program. I will also be looking at how this program is largely science based and how that affects all parts of the day that the children are present for.

2:54PM H5.00006 The AIP Career Pathways Project: Learning the Effective Practices of Physics Departments Preparing Graduates with the Bachelor's Degree for STEM Careers[1]

, THOMAS OLSEN, KENDRA REDMOND, ROMAN CZUJKO, American Institute of Physics, College Park, MD — Forty percent of students graduating with the bachelor's degree in physics seek employment immediately upon graduation. The AIP Career Pathways Project, funded by NSF, seeks to learn by site visits the effective practices of departments in preparing these students to successfully secure positions in STEM and to make these practices known by presentations, publications, and workshops. This talk will review AIP Statistical Resources data on the careers of physicists with the bachelor's degree, provide preliminary insights from the site visits, provide some advice for graduates seeking employment, and describe the upcoming workshops.

[1]Supported by NSF DUE-1011829

3:06PM H5.00007 BREAK –

3:26PM H5.00008 Onward and Upward in the Physics Studio

, NEIL ALBERDING, Simon Fraser University — Since the fall of 2005 we have been offering a two-semester, Calculus-based first-year physics course at Simon Fraser University's Surrey campus. This course includes lecture, laboratory and laboratory components of the course in 6 hours of class time per week. During the following years we've evolved our methods of presenting the material, the equipment and our facilities have evolved. In addition other colleges in the lower mainland have started offering the same or similar courses. In this presentation we'll discuss what we find works, doesn't work, what difficulties we have encountered and our attempted solutions.

4:02PM H5.00009 Applying results from Physics Education Research in a large first-year service course[1]

, DARIA AHRENSMEIER, Simon Fraser University — First-year service courses are among the most challenging teaching appointments, due to factors such as lack of motivation, lack of academic preparation, and huge class size. I will describe how the Labatorial Project at the University of Calgary strives to apply results from Physics Education research on inquiry-based learning, addressing misconceptions, peer instruction etc. to the small group sections of these courses. After a brief overview of the design and implementation of the labatorials for a first-year course for engineering students, I will focus on the aspects of change management and sustainability: how one initial change led to a sequence of related modifications, from the lectures to the exams and TA training, accompanied by a natural process of faculty professional development.

[1]Work done in collaboration with Mike Potter, Robert I. Thompson, and W.J.F. Wilson, University of Calgary.

4:38PM H5.00010 Undergraduate and Graduate Opportunities in Nuclear Science at Simon Fraser University , CORINA ANDREOIU, J.-C. BRODOVITCH, J.M. D'AURIA, K. STAROSTA, Simon Fraser University, SFU NUCLEAR SCIENCE MINOR TEAM — The Departments of Chemistry and Physics at Simon Fraser University offer a Nuclear Science Minor at undergraduate level. The program, which is unique in Canada, attracts students from all departments of the Faculty of Science, and, occasionally, from other departments such as engineering and business. Students graduating with this minor have the opportunity to get employment in academia and a variety of industries ranging from nuclear power to nuclear medicine, safety, accelerators, etc. At the graduate level, the Nuclear Science group in the Department of Chemistry attracts students to its in-house program and also in collaboration with TRIUMF, Canada's Laboratory for Nuclear and Particle Physics. The graduate program offer a rich plethora of topics in experimental nuclear science ranging from understanding the matter at subatomic level and its role in astrochemistry to applications of nuclear science in radiation measurements and monitoring, nuclear instrumentation, etc. The academic components of the program, its goals and future developments are presented in this paper along with enrolment statistics for the last ten years.