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Dalhousie University

Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Book of Abstracts

Contents

T1-4 Mathematical Physics (DTP) | Physique mathématique (DPT) / 1946

Optimised explicit finite difference scheme for the KdV equation

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In this work, we consider the Korteweg-de Vries equation and its variants which are third order nonlinear partial differential equations. It originates from many physical phenomena, for example, the flow of liquids containing gas bubbles, in the study of the propagation of waves in an elastic tube filled with a viscous fluid and also for the description of shallow water waves on viscous fluid.

We start by designing implicit finite difference schemes that conserve the first three integrals: mass, momentum and energy. The derived schemes being implicit are difficult to implement and consume more computer time, hence quest for explicit finite difference schemes is highlighted since they are easy to implement and consume less computer time. Here we investigate explicit schemes for the Korteweg de Vries equations and it's variant.

With regards to these schemes, several numerical experiments are carried out to analyse their spectral properties. Their performance is compared with regards to dispersive and dissipative errors and their ability to conserve the first three integrals. In addition, an optimisation procedure is carried out to determine the optimum spatial step size that produces the minimum error. Graphical presentation of results obtained shed more light.

W4-5 Education Research-informed Physics Teaching (DPE) | L'enseignement de la physique enrichi par la recherche en éducation (DEP) / 1947

Measuring Scientific Literacy

Author: Ian Blokland[1]

Co-authors: Sheryl Gares [1]; Brian Rempel [1]

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In conjunction with a new interdisciplinary, experiential science course for non-science majors, we have developed the Augustana Interdisciplinary Scientific Literacy Evaluation (AISLE) to measure gains in scientific skills and attitudes. This presentation will outline the context of AISLE, its development criteria, calibration data, and upcoming analyses.

W4-3 Advances in Nuclear and Particle Physics Theory (DTP/PPD/DNP) | Progrès en physique nucléaire et en physique des particules théorique (DPT/PPD/DPN) / 1948

Chiral Gravitational Waves and Baryon Superfluid Dark Matter (I)

Author: Evan Mcdonough[1]

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In this talk I will discuss a recently proposed model of "Dark Baryon Superfluid" dark matter. This scenario begins with a unified model of dark-genesis and baryogenesis, involving strongly interacting dark quarks, and utilizing the gravitational anomaly of chiral gauge theories. In these models, both the visible and dark baryon asymmetries are generated by the gravitational anomaly induced by the presence of chiral primordial gravitational waves. A concrete model realizing this is an SU(2) gauge theory with two massless quarks. In this model, the dark quarks condense and form a dark baryon charge superfluid (DBS), in which the Higgs-mode acts as cold dark matter. I will elucidate the essential features of this dark matter scenario and discuss its phenomenological prospects. Talk based on JCAP 1805 (2018) no.05, 003 [arXiv:1801.07255.]

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 1949

Holography for fields with different spins in rotating black holes (I)

Author: Masoud Ghezelbash[1]

[1] *University of Saskatchewan*

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We find the explicit form of two-point functions for the conformal energy momentum operators as well as conformal spin-one operators on the near horizon of a near extremal Kerr black hole. We introduce the appropriate boundary actions for the spin-two and the vector fields near the horizon of near extremal Kerr black hole. We find the two-point function for the conformal energy-momentum operators and the spin-one operators in Kerr/CFT correspondence by finding the variation of the proper boundary actions. We find agreement between the two-point functions and the correlators of the dual conformal field theory to the Kerr black hole.

T3-4 Gravity and Cosmology (DTP/DHP) | Gravité et cosmologie (DPT/DHP) / 1950

What we have learned from the Cosmic Microwave Background (I)

Author: Mark Halpern[1]

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It is now 100 years since Planck received a Nobel Prize for describing blackbody radiation. It is 75 years since McKellar found a background temperature of molecules in space and 55 years from the recognized discovery of the cosmic microwave background. Measurements of the spectrum, and the the anisotropy of the intensity and polarization patterns of the CMB have told us about thermal equilibrium in the first weeks of the Universe, the geometry, baryon fraction and expansion history of the Universe and constrain neutrino masses, among many other things. I will describe these measurements and also the current experimental efforts to measure large angular scale odd-parity polarization patterns in a hope to understand cosmic inflation and perhaps GUT-scale physics.

W3-3 Fields and Strings II (DTP) | Champs et cordes II (DPT) / 1951

Renormalisation of non-perturbative calculations in scalar theories (I)

Author: Margaret Carrington[1]

[1] *Brandon University*

Corresponding Author: carrington@brandonu.ca

Non-perturbative techniques are needed to study strongly coupled systems. One powerful approach is the n-particle irreducible effective action. The technique provides a systematic expansion for which the truncation occurs at the level of the action. However, renormalisation using a standard counterterm approach is not well understood. At the 2PI level one must introduce multiple counterterms, and at higher orders there is no known way to renormalise an nPI theory using counterterms. On the other hand, renormalisation is much simpler using a renormalisation group approach. We present results from a calculation using a scalar theory with quartic coupling in 4 dimensions, at the 4 loop level.
The 2PI theory is renormalised using one bare coupling constant which is introduced at the level of the lagrangian. We discuss how the method can be generalised to higher order calculations.

: R1-5 History of Physics (DHP) | Histoire de la physique (DHP) / 1952

Two Hundred Years of Physics at Dalhousie (I)

Author: Manfred Jericho[1]

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Dalhousie University was established in 1818 through an act of the Nova Scotia Legislature. Proper function of the College, however, did not commence until 1838 and it ceased again in 1848 when the College reverted to a high school. A reorganization of Dalhousie took place in 1863 when an Act of the Legislature incorporated Dalhousie as a University. In 1877 the Dalhousie board appointed J.J. Mackenzie to the first chair of Physics (previously Physics was known as Natural Philosophy) in Canada. In 1879 J.J. MacKenzie died and the University found itself in great financial difficulty. George Munro, a rich business man and publisher in New York, offered to endow a chair for physics at $2000 per year. This beginning of Munro's benefactions brought George MacGregor to Dalhousie as first George Munro Professor of Physics (1879 - 1901). The department has always had high standards in both research and teaching and in this respect Howard Logan Bronson (FRSC), George Munro Professor and department head (1910 - 1945), deserves special mention. The department produced, with minimal funding from NRC, 32 master's theses and students, after obtaining Ph.Ds. at other institutions, occupied prominent positions in universities and industry. Seven of these were elected fellows of Royal Societies. The construction, in 1960, of the Dunn Science Building through the munificent benefaction of Lady Dunn launched the department into the big leagues. Installation of a helium liquefier allowed cutting edge research in condensed matter physics and the department was now accredited to grant Ph.Ds. The talk will present an overview of subsequent research directions and touch on some research accomplishments.

W3-1 Creating Authentic Physics Learning Experiences (DPE) | Créer d'authentiques expériences d'apprentissage en physique (DEP) / 1953

Impact of Reflective Writing and Labatorials on Student Understanding of Force and Motion in Introductory Physics

Authors: Calvin Kalman[1]; Mandana Sobhanzadeh [2]; Mark Lattery [3]

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We examine a way to deal with alternative student conceptions about force and motion in a university introductory physics course. The course combines Reflective Writing, an activity that engages students in textual material metacognitively, and Labatorials, an in-class active learning intervention. The analysis is based on both pre- and post- interview statements, to give a picture of the students'initial state and evolution in their understanding of force and motion. All interviewees mentioned reflective writing as one of the activities that helped them move from their knowledge about these two concepts at the beginning of the semester to their present ideas. Semi-structured interviews and student writing provide evidence of conceptual change

T3-7 Surface Sciences (DSS) I Science des surfaces (DSS) / 1954

Exploring surface phase, morphology, and charge distribution transitions of perovskites: a case study on SrTiO3

Authors: Omur E. Dagdeviren[1]; Peter Grutter[1]

[1] *McGill University*

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The structure and properties of perovskite substrates have attracted substantial interest due to material's popularity as a substrate for complex oxide epitaxy [1,2]. Strontium titanate (SrTiO3) is among the most popular perovskites, with film quality dependent on the structure of the substrate at the beginning of the growth process. Here, we examined the surface structure of SrTiO3 (100) single crystals as a function of annealing time and temperature in either oxygen atmosphere or ultra-high vacuum (UHV) for a variety of different preparation schemes using scanning probe microscopy, auger electron spectroscopy (AES), and low-energy electron diffraction (LEED) [1]. We find that the SrTiO3 surface evolves depending on the preparation scheme with respect to surface roughness, surface terminations, and surface reconstruction. Non-contact atomic force microscopy (NC-AFM) images, e.g., reveal a non-monotonic trend of surface roughness with respect to UHV annealing temperature. Interestingly, the surface roughness changes also as a function of the bias voltage applied to the surface. This can be explained by the effect of the electrostatic field induced by both the Nb-doping and oxygen deficiencies in the bulk or on the surface, with the latter being a function of the preparation history. As for surface termination, we observe for initially TiO2-terminated crystals the formation of terraces with half unit cell step heights between them with increasing UHV annealing temperatures, implying that multiple terminations are forming. This conclusion is corroborated by AES data, which expose an increase in Sr amount relative to Ti and O. Complementary LEED data reveals a structural phase transition from (1x1) termination to an intermediate c(4x2) surface reconstruction to ultimately a sqrt(13) x sqrt(13)-R33.7° surface phase by annealing the sample with oxygen flux, while the inverse structural phase transition from sqrt(13) x sqrt(13)-R33.7° to c(4×2) is observed when annealing in UHV. As a result, we suggest that careful selection of preparation procedure combined with applying an appropriate bias voltage during growth may be used to control outcomes of thin film growth.

[1] O. E. Dagdeviren *et al.*, Physical Review B **93**, 195303 (2016).

[2] O. E. Dagdeviren *et al.*, Advanced Materials Interfaces **4**, 1601011 (2017).

T3-2 Thin Films, Magnetism and Solar Cells (DCMMP) | Films minces, magnétisme et piles solaires (DPMCM) / 1955

Dimensionality and length scale of defects in epitaxial SnTe topological crystalline insulator films

Authors: Omur E. Dagdeviren[1]; Peter Grutter[1]

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Revealing the local electronic properties of surfaces and their link to structural properties is an important problem for topological crystalline insulators (TCI) in which metallic surface states are protected by crystal symmetry. As a first step toward this goal, we have studied the epitaxial growth of SnTe films and characterized their structural and electronic properties by molecular beam epitaxy using scanning probe microscopy, non-contact atomic force microscopy, low-energy and reflection high-energy electron diffraction, X-ray diffraction, Auger electron spectroscopy, and density functional theory [1,2]. Initially, SnTe (111) and (001) surfaces are observed; however, the (001) surface dominates with increasing film thickness. The films grow island-by-island with the [011] direction of SnTe (001) islands rotated up to 7.5° from SrTiO3 [010]. Although films with a mosaic spread in the epitaxial alignment are generally undesirable, in this case they provide a route to creating periodic symmetry breaking defects that may be used to pattern topological states. Microscopy reveals that defects on different length scales and dimensions that affect the electronic properties, including point defects (0D); step edges (1D); grain boundaries between islands rotated up to several degrees; edge-dislocation arrays (2D out-of-plane) that serve as periodic nucleation sites for pit growth (2D in-plane); and screw dislocations (3D). These features cause variations in the surface electronic structure that appear in STM images as standing wave patterns and a non-uniform background superimposed on atomic features. The results indicate that both the growth process and the scanning probe tip can be used to induce symmetry breaking defects that may disrupt the topological states in a controlled way.

[1] O. E. Dagdeviren *et al.*, Advanced Materials Interfaces **4**, 1601011 (2017).

[2] O. E. Dagdeviren *et al.*, Physical Review B **93**, 195303 (2016).

T2-5 Instrumentation and Imaging (DAPI) | Instrumentation et imagerie (DPAI) / 1956

A New Pathway for Robust High-Resolution Imaging and Quantitative Force Spectroscopy in Vacuum: Tuned-Oscillator Atomic Force Microscopy

Authors: Omur E. Dagdeviren[1]; Peter Grutter[1]

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Since the first demonstration of atomic resolution in ultra-high vacuum more than twenty years ago, frequency modulation-based noncontact atomic force microscopy (FM-NC-AFM) has significantly matured and is now routinely applied to study problems that benefit from high-resolution surface imaging. In FM-NC-AFM, control of the tip's vertical position is accomplished by detecting a shift in the cantilever's resonance frequency upon approach to the sample. Consistently ensuring reliable distance control during extended data acquisition periods has nevertheless remained challenging, as most FM-mode-based control schemes employ three feedback loops that may interfere. As a consequence, sample throughput in FM-NC-AFM is often low compared to ambient condition AFM, where the easy-to-implement amplitude-modulation (AM) control scheme is predominantly used. Transfer of the AM methodology to high-resolution measurements in vacuum is, however, difficult as with AM-AFM, instabilities during approach are common; in addition, the lack of viscous air damping and the related significant increase of the cantilever's quality factor generates prolonged settling times that cause the system's bandwidth to become impractical for many applications. Here

we introduce a greatly simplified approach to NC-AFM imaging and quantitative tip-sample interaction force measurement that prevents instabilities while simultaneously enabling data acquisition with customary scan speeds by externally tuning the oscillator's response characteristics [1]. After discussing background and basic measurement principle, examples for its application to characterize layered materials, thin-films, and topological crystalline insulators are provided [2-4].A major advantage of this operational scheme is that it delivers robust position control in both the attractive and repulsive regimes with only one feedback loop, thereby carrying the potential to boost the method's usability.

[1] O. E. Dagdeviren *et al.*, Nanotechnology **27**, 065703 (2016).

[2] O. E. Dagdeviren *et al.*, Nanotechnology **27**, 485708 (2016).

[3] O. E. Dagdeviren *et al.*, Physical Review B **93**, 195303 (2016).

[4] O. E. Dagdeviren *et al.*, Advanced Materials Interfaces **4**, 1601011 (2017).

M2-5 Nuclear Structure I (DNP) | Structure nucléaire (DPN) / 1957

Determination of proton radii of neutron rich oxygen isotopes from charge-changing cross section measurements. (G)*

Author: Satbir Kaur[1]

Co-authors: Rituparna Kanungo [2]; Wataru HORIUCHI [3]; FREDERIC Ameil [4]; J. Atkinson [5]; AYYAD LIMONGE, Yassid [6]; Soumya BAGCHI [7]; D. CORTINA-GIL [8]; Iris Dillmann ; Alfredo Estrade [9]; Alexei EVDOKIMOV [10]; Fabio FARINON [11]; Hans GEISSEL [11]; G. GUASTALLA [11]; R. Janik [12]; Ronja KNOBEL [11]; J. KURCEWICZ [11]; Yuri LITVINOV [11]; Michele MARTA [11]; M. Mostazo [13]; Ivan MUKHA [13]; Chiara NOCIFORO [11]; Jin ONG [14]; Stephane PIETRI [11]; Andrej PROCHAZKA [11]; C. SCHEIDENBERGER [11]; Branislav SITAR [12]; Peter STRMEŇ [12]; Maya TAKECHI [11]; Junki TANAKA [15]; Isao Tanihata [16]; S. TERASHIMA [17]; Jossittwilliams VARGAS [13]; Helmut WEICK [11]; John Stuart WINFIELD [11]

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Charge radius is an important bulk property of the nucleus for investigating nuclear structure. The nuclei lying close to the boundaries of the nuclear chart (the drip lines) have revealed new features

like halo and skin. Another new phenomenon that has emerged in the neutron-rich region is the changing or vanishing of magic numbers [1,2]. The knowledge of proton radii is crucial for understanding the halo and skin formation and also the shell evolution in unstable nuclei. The systematic study of proton radii along an isotope chain, together with knowledge of the matter radii is important to deduce the neutron skin thickness in the neutron-rich nuclei. Furthermore, the proton radii are crucial to understand the spatial correlation between halo neutrons and its core nucleus. Proton radii also serve as a test of newly developed structure models including those based on $ab\ initio$ theory. Charge-changing cross section (σ_{cc}) is the total cross section for the change of the atomic number of the projectile nucleus. It is a new method to extract the proton radii of neutron-rich nuclei using the Glauber model analysis. The proton radii of ^{12-17}B [3] and ^{12-19}C [4] have been successfully determined using the charge-changing cross section measurements. The neutron-rich oxygen isotopes are particularly interesting nuclei, with a new magic number (N=16) at the neutron drip line [5]. The proton radii of neutron-rich oxygen isotopes have not been measured til date. We, therefore, performed an experiment at Fragment Separator (FRS) in Germany using relativistic beams of ^{16-24}O with energy around 900 MeV/u. In this talk, I will present the preliminary results of σ_{cc} measurements of ^{16-24}O.

References
[1] A. Ozawa et al., Phys. Rev. Lett. 84, 5493 (2000).
[2] R. Kanungo et al., Phys. Lett. B 528, 58 (2002).
[3] A. Estradé et al., Phys. Rev. Lett. 113, 132501 (2014).
[4] R. Kanungo et al. Phys. Rev. Lett. 117, 102501 (2016).
[5] C. R. Hoffman et al., Phys. Rev. Lett. 100, 152502 (2008).

T3-4 Gravity and Cosmology (DTP/DHP) | Gravité et cosmologie (DPT/DHP) / 1958

The CMB and the early universe (I)

Author: Edward Wilson-Ewing[1]

[1] *University of New Brunswick*

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I will explain how observations of the cosmic microwave background constrain theories of the early universe. I will then present some cosmological models whose predictions are in agreement with current observations, and explain how future observations may be able to differentiate between these models.

W3-6 Particle Physics VIII (PPD) I Physique des particules VIII (PPD) / 1959

Emulsion-based Measurement of the Production of Hadrons At a Test beam in Chicagoland [EMPHATIC] (G)

Author: Khalid Gameil[1]

[1] *University of British Columbia*

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Hadronic interaction uncertainty is a shared systematic uncertainty between many neutrino experiments. The reduction of this uncertainty would mean a furthering of the physics goals for these experiments. Hadronic interactions from the T2K and NuMI beamline can be separated into primary and secondary interactions. Primary hadronic interactions occur when high energy protons interact with a graphite target, producing hadrons that will then decay into neutrinos. Secondary interactions occur when the hadrons produced re-interact inside the target or surrounding material. Hadronic

interaction uncertainty is reduced by existing hadron production experiments (NA61/SHINE, HARP, and MIPP), however these measurements are dominated by an uncertainty in the proton interaction length. To reduce this uncertainty an accurate measurement of the quasi-elastic and elastic scattering cross sections for 120GeV/c and 30GeV/c protons on carbon is required. Secondary pions of the order of 10GeV/c and lower also contribute to the hadronic interaction uncertainty. A previous hadron emulsion experiment (HARP) has taken data below the 10GeV/c limit, however a more accurate measurement is needed. The EMPHATIC group has taken data using the Fermilab test beam on carbon, aluminum, and steel targets for hadrons ranging from 2GeV/c to 120GeV/c. By using emulsion and silicon strip detectors an accurate measurement of both the vertex and scattering angle is obtainable, as well as significantly reducing the detection material. In addition, two upstream gas Cherenkov detectors and three downstream aerogel detectors are used for particle identification. A silicon telescope, consisting of silicon strips and pixel detectors, is used for timing information and additional tracking surrounds the emulsion target. A moving table was constructed to increment the emulsion target position for each spill to maintain a track density of 104 particles per cm2. Preliminary results from these measurements will be presented.

CAP President's report | Rapport du président de l'ACP / 1960

Test Abstract for 2018 Congress

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This is a test abstract so can learn Indico programming.

W4-1 Energy Storage 4 (DCMMP) | Accumulation d'énergie 4 (DPMCM) / 1961

On the Design of Organic Molecules for Redox Flow Batteries (I)

Author: Susan Odom[1]

[1] *University of Kentucky*

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The development of charge-storage materials for use in redox flow batteries (RFBs) requires possession of a diverse property set that will lead to high capacities, voltages, and lifetimes for large-scale stationary storage application. High capacities require high solubilities in all states of charge. High voltages stem from large differences in redox potentials. Long lifetimes require stability far greater than the timescales at which many chemists are used to operating, who rarely have the need to isolate a charged species at high concentration in diverse environments for a decade or more. None of these properties may be compromised in realizing a commercial battery, on top of which low cost and scalability are paramount. Given the demands in materials design, cost, and scale, it's a small wonder that the variety of redox couples utilized in commercial redox flow batteries are few. While the challenge of meeting these requirements may at first seem daunting, to the right organic chemist, an opportunity is presented. The flexibility in design and tunability of properties of organic materials presents a cornucopia of choices to evaluate as electrolyte candidates. The most challenging question is "Where do we begin?"In this presentation, I will focus on the design and characterization of organic molecules as candidates for charge-storage species in non-redox flow batteries, covering both aqueous and nonaqueous electrolytes, with focused results in the latter environment. I hope to

provide a general represent of accomplishments as well as examples of the many remaining opportunities in this nascent field of research and development.

W4-3 Advances in Nuclear and Particle Physics Theory (DTP/PPD/DNP) | Progrès en physique nucléaire et en physique des particules théorique (DPT/PPD/DPN) / 1962

QCD Sum-Rules Analysis of Meson-Hybrid Mixing in Vector Heavy Quarkonium (G)

Author: A. Palameta[None]

Co-authors: J. Ho ; D. Harnett ; T. Steele

We use QCD Laplace sum-rule to explore meson-hybrid mixing in vector heavy quarkonium. Our cross-correlator calculation supplements perturbation theory with non-perturbative corrections proportional to the four-dimensional and six-dimensional gluon condensates and the six-dimensional quark condensate. After forming the Laplace sum-rule we use experimentally determined hadronic masses to build several single- and multi-resonance models of the $c\overline{c}$ and $b\overline{b}$ mass spectra. These models and the QCD Laplace sum-rule are then used to probe resonances for meson-hybrid mixing. Observations and results of the analysis will be presented.

W3-8 Nuclear Structure II (DNP) | Structure nucléaire II (DPN) / 1963

Ab initio calculations for exotic nuclei (I)

Author: Matteo Vorabbi[1]

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One of the recently developed approaches capable of describing both bound and scattering states in light nuclei simultaneously is the No-Core Shell Model with Continuum (NCSMC). This technique represents a state-of-the-art $ab\ initio$ approach and combines the No-Core Shell Model (NCSM) description of short-range correlations with the clustering and scattering properties of the Resonating Group Method. Recent NCSMC calculations of the exotic structure of the ^{9}He nucleus will be presented. The properties of this system were investigated by analyzing the n+^{8}He continuum and using chiral interactions as the only input. Our analysis produced an unbound ^{9}He nucleus with two resonant states found above the n+^{8}He breakup threshold. In particular, no positive parity ground state was found, indicating the break-up of the parity-inversion mechanism found in the ^{11}Be and ^{10}Li nuclei of the same $N = 7$ isotonic chain. Finally, recent calculations for elastic proton-nucleus scattering will be presented too. The differential cross section and the analyzing power for several light target nuclei were computed using a microscopic optical potential constructed from new $ab\ initio$ nonlocal densities obtained within the NCSM framework.

M1-3 Theory, Modelling, and Forecasting I (DASP) I Théorie, modélisation et prévisions I (DPAE) / 1964

Kinetic simulations of needle probes on cubeSats

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CubeSats are increasingly popular among the space physics commuinty, as an afordable means of deploying large numbers of instruments in space, thus providing better monitoring and coverage of space environment. Needle probes consisting of thin cylindrical probes of length ranging from a few to several centimeters, have been used on a number of cubeSats, because of the relative simplicity with which they can be used to infer plasma density. The interest in this type of probes is motivated by the dependence of their characteristic on plasma density and temperature, whereby the collected current in the electron saturation region is approximately proportional to the density and the square root of the potential, with only a week dependence on temperature. As a result, when operated in fixed-bias mode, these probes can provide the electron density from the slope of the current square as a function of bias voltage. One concern with the use of such probes on cubeSats, however, has to do with their impact on the satellite bus (the ground) potential. Indeed with probes mounted on larger spacecraft, the probe bias and collected current generally has negligible effect on the bus floating potential. With the much smaller CubeSats, however, the ion collection capacity of the bus is limited. The relatively large positive biases and resulting collection of negative current, have to be balanced with an equal positive collected current from the rest of the satellite. The concern that this may only be possible by reducing the spacecraft potential to the point that positively biased probes with respect to the bus, may have a potential comparable to, or less than that of surrounding plasma. In this talk simulation results are presented, showing the effect on the bus floating potential, associated with needle probes operating in the electron saturation region. It is shown that under certain conditions, the bus floating potential can become significantly more negative than it would be in the absence of probes, and that active means of controlling the bus floating potential may be required.

W2-5 COMP Special Session (DPMB) | Session spéciale de l'OCPM (DPMB) / 1965

Seeing is Believing: New Imaging Physics to Transform Asthma Patient outcomes (I)

Author: Grace Parraga[1]

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My laboratory is focused on developing a deep understanding of chronic lung disease using novel imaging methods, in patient-based research. The overarching goal of my team's research is to discover, validate and clinically translate magnetic resonance imaging (MRI) biomarkers while generating the evidence to support the clinical use of lung MRI to change asthma and COPD patient outcomes.

I completed my BSc and MSc at Western University and a PhD at the University of Washington in Seattle, Washington. Upon completing post-doctoral studies (funded by MRC Canada) at the University of Basel, (Switzerland), I joined F. Hoffman La Roche AG as a Scientist in Pharmaceutical Research and Development (Switzerland). In September 2004, I returned to academic research at Robarts Research Institute and Western University.

In this invited lecture I will provide an overview of the past 20 years of hyperpolarized noble gas developments including MRI and polarizer physics innovations. I will discuss these in the context of the burden of chronic lung disease and how these physics tools are being used in medical imaging applications in patients. I will review the most recent findings using 129Xe MRI in patients with lung disease and the tricks and tools needed for clinical translation.

My lab's work has been extensively published with more than 80 peer-reviewed papers in the last 5 years in the highest impact medical physics, imaging and respiratory/physiology journals; 15 contributions were highlighted in Editorials, Journal Covers or Editoral podcasts because of their significance and impact. My lab is currently funded by the Heart and Stroke Foundation (Canada), Canadian Institutes of Health Research as well as the Natural Science and Engineering Research Council (Canada) Discovery, Research Tools and Accelerator awards.

M2-2 Theory, Modelling and Forecasting II (DASP) | Théorie, modélisation et prévisions II (DPAE) / 1966

Exploring the use of the Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) and other empirical ionospheric electron density models at high latitudes (I)

Author: David Themens[1]

Co-authors: P.T. Jayachandran [1]; Ben Reid [1]

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In this study, we begin by presenting an overview of the methodology behind existing empirical ionospheric electron density models, including the E-CHAIM and International Reference Ionosphere (IRI). Several limitations have been identified in the methodology used to parameterize the IRI (Themens et al., 2014, 2016, and 2017a), particularly in its application at high latitudes. Using these validation studies to inform the approach used in E-CHAIM, we managed to avoid several of the IRI' s short comings and have demonstrated substantial quantitative improvements in performance over the IRI (Themens et al., 2017b, and 2018). We will here explore those improvements and examine the limits of empirical approaches in their ability to represent "weather-like"time scales. To this end, we have manual scaled a year of ionosonde data from several Canadian High Arctic Ionospheric Network (CHAIN) ionosondes and will assess the representativeness of climatologies at high latitudes. In so doing, we will demonstrate that, while empirical models struggle appreciably in the representation of smaller time scales (two hours or less), it is well within their capacity to capture variabilities on 2-7 day timescales using measured geomagnetic indices as drivers. We also demonstrate that in the absence of a storm-time correction, empirical models may exhibit biases in their representation of monthly median variability at high latitudes due to the dominance of negative storm responses in these regions.

T4-4 Films, surfaces and composites (DCMMP) | Films, surfaces et composites (DPMCM) / 1967

Unusual resistive hysteresis cycles in VO2 thin films on quartz substrates

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Vanadium oxide (VO2) thin films have been studied extensively because of their thermochromic properties, i.e. reversible optical change as a function of temperature. These reversible optical changes, also accompanied by electrical changes make these films interesting from application point of view. Many applications such as smart windows, sensing devices, variable reflectance mirrors and many others can be envisiioned. VO2 undergoes a reversible insulator-to-metallic (MIT) phase transition at a temperature of ˜ 68° C. This phase change is accompanied by a change of the optical and electrical properties. The electric resistance decreases to a few ohms and the film changes from transparent to opaque in the IR region after a phase transition occurs.
Sputtering technique was used to deposit pure vanadium thin films on glass and quartz substrates. Subsequently, the films were annealed at 500℃ in a vacuum chamber in the presence of oxygen gas for 1 hour to oxidize the films to obtain stoichiometric VO2. Both electrical and optical changes during the transition insulator to metal (MIT) were studied. All the fabricated films exhibit efficient thermochromic changes. The films deposited on quartz substrates were found to show an unusual hysteresis in their resistivity in the first few cycles. XRD and XPS studies were done to understand this unusual behaviour of VO2 films on quartz substrates.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 1968

POS-40 Propriétés thermochromes des couches minces de VO2 et de VO2 dopées de tungstène (W) par une nouvelle technique.

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Le dioxyde de vanadium (VO2) est un matériau thermochrome de la famille des oxydes de métaux de transition (OMT) qui présente un intérêt scientifique et industriel majeur. En effet, les couches minces de VO2 sont des semi-conducteurs transparents dans la région infrarouge (IR) à température ambiante et passent à un état métallique hautement réfléchissant autour de la température de transition (Tt) de 68℃. Cette transition de phase réversible dans les couches minces du VO2 s'accompagne de changements de ses propriétés optiques et électriques. Il est possible de réduire cette température de transition en dopant le VO2 avec le tungstène (W).
Dans ce travail, le vanadium est déposé sur le substrat de verre par la technique de pulvérisation cathodique par un magnétron à fréquence radio (RF) en introduisant un débit de gaz argon (50 SCCM). Les films de vanadium sont recuits dans un four (à 500℃) en présence d'un faible débit de gaz oxygène pour former les couches minces du VO2. Ces échantillons du VO2 sont étudiés par les méthodes de caractérisation électriques, optiques, morphologiques et structurales.
Le dopage de tungstène est fait en déposant une couche très mince de W au-dessus de la cible de vanadium à travers un masque. Le vanadium dopé de W est déposé sur le verre par la même méthode de pulvérisation. Les couches minces de vanadium dopé de W obtenues sont ensuite oxydées en W-VO2 par le même processus de recuit. Enfin, ces couches minces ont été caractérisées de la même façon que les couches minces du VO2 non dopées.
On a étudié la corrélation entre le pourcentage de dopage de W et la température de transition. Les résultats initiaux indiquent la possibilité de faire diminuer la température de transition. Ces résultats seront présentés et discutés.

T4-1 Energy Storage 2 (DCMMP) | Accumulation 2 (DPMCM) / 1969

Development of Utility Friendly Safe Olivine Based ESS in Esstalion Technologies. (I)

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Development of Utility Friendly Safe Olivine Based ESS in Esstalion Technologies.

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One of the promising approaches for striking a balance of realizing sustainable society and maximizing utility's profit is to apply energy storage system (ESS). There're many use cases proposed (1), such as reserve, regulation, peak shaving, time shift, load following, smoothing, and minimum

emission. To answer these demands, the development of a battery with high rate of charging and discharging, a longer cycle life and safe is imperative.
Esstalion Technologies Inc. was established in 2014 as a joint venture company between Sony Corporation and Hydro-Québec.(2) . By September 2017, Sony Corp. has sale of its battery business to electronic parts maker Murata Manufacturing Co.
We are the first corporate joint venture between battery manufacturer and utility.
Since then, we've developed utility friendly ESS based on lithium ion battery technology for grid scale utilization.
Since we put our importance on safety and long-life, our core technology is olivine based material which is patented by Hydro Québec and commercialise by Sony as Fortelion. (3)
We've started in field testing using 1.2 MWh ESS in 2016.
In Esstalion, we try to bring innovation by gathering "multi-wisdom"in ONE ESSTALION team, doing the new material research, BMS/EMS development and ROI calculation etc.
We propose a brief review of our technologies and we will show an example of our efforts to enhance the key properties of the Li-ion battery.
(1) Pacific Northwest National Laboratory, Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems
(2) Press Release, Establishment of Esstalion Technologies, Inc., a joint venture between Hydro-Québec and Sony, 2014
(3) News Release, Sony Launches High-power, Long-life Lithium Ion Secondary Battery
Using Olivine-type Lithium Iron Phosphate as the Cathode Material, 2009

T3-7 Surface Sciences (DSS) I Science des surfaces (DSS) / 1970

Water-repellent coatings via electrodeposition

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The way that water wets a surface can be controlled by manipulating surface energies and/or surface topography. Although these factors can be controlled very well on the lab scale for certain kinds of materials, it is very challenging to achieve good control on compositionally heterogeneous surfaces such as stainless steel. Here, we show that mildly alkaline electrolytes can be used to produce zinc electrodeposits that, when capped with stearic acid to prevent oxidation, can improve the water repellent properties of stainless steel. The electrolyte composition and the applied potential during deposition influence the growth morphologies of crystallites within the electrodeposit. The capped electrodeposits display an impressive degree of water repellency, including extremely poor water droplet adhesion. We discuss physical and chemical factors that contribute to the water-repellent behaviours of these electrodeposits, and describe their potential applications to mitigate icing and corrosion in harsh offshore environments.

M1-5 Nuclear Astrophysics (DNP) | Astrophysique nucléaire (DPN) / 1971

Investigating key reactions of nuclear astrophysics interest using the DRAGON recoil separator (I)

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Gaining insight into the astrophysical processes that govern nucleosynthesis in stellar scenarios requires a detailed understanding of the involved nuclear reactions. Radiative capture cross sections at typical temperatures of environments like novae, X-ray burst or supernovae are in many cases vanishingly small, thus making the reaction rates extremely challenging to access experimentally.
The DRAGON ({\bf D}etector of {\bf R}ecoils {\bf A}nd {\bf G}ammas {\bf O}f {\bf N}uclear reactions) recoil separator has been designed to recreate nuclear fusion reactions on radioactive as well as on stable nuclei of astrophysical interest in the laboratory, and to directly measure absolute cross sections of radiative capture reactions on protons and alpha particles.
In order to take advantage of the radioactive beams delivered by the TRIUMF-ISAC facility, which are often too short-lived to be used as target material for normal kinematics measurements, the reaction rates require to be studied in inverse kinematics. Ion beams at energies of 0.15 to 1.5 MeV/u impinge on the windowless gas target and γ-rays from the de-excitation of the compound nucleus are detected in the high-efficiency BGO array surrounding the target.
With 8 out of 10 radioactive beam experiments performed over the last one and a half decades, DRAGON still holds the record for the number of direct radioactive beam measurements of radiative capture.

In this presentation I will give an overview of the DRAGON recoil separator and outline its capabilities before presenting results of the most recent experiments; among them the direct measurement of the long debated strength of the $E_{c.m.}$ = 456 keV key astrophysical resonance in the ^{19}Ne(p,γ)^{20}Na reaction. The latter bypasses the production of ^{19}F observed in the ejected shells of oxygen-neon novae, and is further expected to play an important role in Type-I X-ray bursts during the "breakout" from the hot CNO cycles into a new set of thermonuclear reactions, known as the rp process.

M3-4 Cold and Trapped Atoms, and Tests of Fundamental Symmetries I (DNP/DTP/PPD/DAMOPC) | | Atomes froids et piégés, et tests de symétries fondamentales I (DPN/DPT/PPD/DPAMPC) / 1972

Final results from the QWeak experiment: The Weak charge of the proton and new mass scale limits on possible physics beyond the Standard Model. (I)

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The QWeak collaboration completed a two year long, high precision measurement of the parity violating asymmetry in the elastic scattering of 1.1 GeV, longitudinally polarized electrons from protons. At low momentum transfer the measured asymmetry is directly related to the Weak charge of the proton $Q_W^p = 1 - 4sin^2\theta_W$. The Standard Model makes a firm prediction for the size of the Weak charge, based on the "running" of the Weak mixing angle $sin^2\theta_W$, away from the Z^0-pole, toward lower energies. The QWeak measurement provides a sensitive test for new physics beyond the Standard Model, with a mass scale sensitivity up $\Lambda/g = 7.5$ TeV. I will provide an overview of the experiment, including the measurement methodology and associated systematic effects. I will then present our final results for the proton Weak charge, the Weak mixing angle, and an extraction of the vector Weak quark couplings C_{1u} and C_{1d}, using a combination of the ^{133}Cs APV and QWeak measurements. I will also discuss the QWeak mass reach for new beyond-the-Standard-Model physics and briefly discuss our sensitivity to a few models.

T3-5 Hadronic Physics (DNP) | Physique hadronique (DPN) / 1973

Recent Results from GlueX (I)

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The GlueX experiment is located in the recently constructed experimental Hall D at Jefferson Lab (JLab), and provides a unique capability to search for hybrid mesons in high-energy photoproduction, utilizing a 9 GeV linearly polarized photon beam. Commissioning of the Hall D beamline and GlueX detector was recently completed and the data collected in the spring of 2017 officially began the GlueX physics program. The statistical precision of this initial dataset surpasses the previous world data on polarized photoproduction in this energy domain by orders of magnitude. First results from this dataset will be presented along with the plan for acquiring higher statistics datasets to begin the search for hybrid mesons at GlueX.

W1-4 Translational Research in Medical Physics Symposium (DPMB/DAPI) | Symposium de recherche translationnelle en physique médicale (DPMB/DPAI) / 1974

Creating Research that Translates to Widespread Clinical Use (I)

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After twenty years of working in Radiation Therapy productization, this talk looks at numerous research projects that were attempted translations to commercial and clinical use, with examples of failures, successes and many projects in between. Some common characteristics of successful projects can be identified, and a process for cultivating products is shown. Examples from a career working for 2 large companies (Varian, Siemens), 2 small start-ups, and a National Lab will be used to illustrate the meta-research analysis concepts, which features early work on some now-known products.

R1-7 Neutrons (DNP) | Neutrons (DPN) / 1975

The ultra-cold neutron facility at TRIUMF (I)

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Neutrons converted to low energies of several hundreds of neV are referred to as ultra-cold neutrons (UCN). Their unique storage properties and resulting long observation times make them an ideal tool to study fundamental properties. Results obtained from measurements of the neutron lifetime and experiments searching for a neutron electric dipole moment (EDM) have profound consequences for the evolution of the Universe after the Big Bang as well as our understanding of the Standard Model in general. Experimental sensitivity of these measurements will greatly benefit from higher statistics, eg. improved UCN production.
The Canadian-Japanese TUCAN collaboration anticipates to build a strong UCN source based on a unique combination of a spallation target and a superfluid helium converter to establish a leading UCN user facility at TRIUMF. A major milestone has been reached in fall 2017 with the first successful production of UCN in Canada.
The presentation shall give an overview and status update of the TRIUMF UCN facility, report on first results from UCN production and introduce plans for a neutron EDM measurement with an anticipated sensitivity level of at least 1e-27 ecm.

T3-5 Hadronic Physics (DNP) | Physique hadronique (DPN) / 1976

Exclusive Backward-Angle Meson Electroproduction – Unique access to u-channel physics

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Exclusive meson electroproduction at different squared four-momenta of the exchanged virtual photon, Q^2, and at different four-momentum transfers, t and u, can be used to probe QCD's transition from hadronic degrees of freedom at long distance scale to quark-gluon degrees of freedom at short distance scale. Backward-angle meson electroproduction was previously ignored, but is anticipated to offer complimentary information to conventional forward-angle meson electroproduction studies on nucleon structure. The results of our pioneering study of backward-angle ω cross sections through the exclusive $p(e,e'p)\omega$ reaction will be presented. The experiment was performed as part of E01-004 in Jefferson Lab Hall C, with central Q^2 values of 1.60 and 2.45 GeV^2, and W=2.21 GeV. The extracted cross sections were separated into transverse (T), longitudinal (L), and LT, TT interference terms. The data set has a unique coverage of $u \sim 0$, opening up a new means to study the transition of the nucleon wave function through backward-angle experimental observables. Plans to extend these studies to the π^0 and ϕ channels will also be presented.

T1-1 Energy Storage 1 (DCMMP) | Accumulation d'énergie 1 (DPMCM) / 1977

Ultrafast time resolution in AFM measurements of charge transport in sustainable energy materials (I)

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One of the Grand Challenges for humanity in the 21st Century is sustainable energy generation and storage. This translates to major opportunities for AFM to help addressed relevant materials issues if ultrafast time resolution in the localized measurement of electronic properties can be achieved. In this presentation, I will give an overview of our recent successes at characterizing surface potentials using AFM-based techniques on time scales down to ps. The high spatial resolution of AFM in principle then allows the identification of rate limiting structures/defects, allowing the fundamentally important correlation of structure and processing with properties.

We have combined a UHV AFM system with a fs laser excitation system tunable in the optical spectrum. By developing a new pump-probe method we can measure ultrafast decay times using AFM/EFM as a spatial detector. We have applied this technique to organic and organometallic perovskite as well as GaAs to measure ultrafast charge carrier decay times as well as mobility. We will also discuss the fundamental time limits achievable using the AFM probe as a detector in pump-probe experiments. [see DOI: 10.1063/1.4975629]

A major challenge in the widespread deployment of sustainable energy sources such as solar and wind is maintaining grid stability. Distributed energy storage in electrical vehicle batteries connected to the grid is an option. A major issue inhibiting wide spread deployment is low charging rates. This is related to the poor current understanding of what determines mobility of Li ions in cathode materials. We have used a newly developed AFM/EFM technique to spatially determine variations in Li transport mechanism in LiFePO4, a model cathode material. We applied voltage pulses to the sample and observed the resultant fast time decay of the electrostatic forces due to the mobility of Li ions using a time averaging technique. By performing these experiments as a function

of temperature we obtain spatially resolved activation barriers for Li transport. By combining our ultrafast AFM techniques with SEM, TOF-SIMS and EBSD as well as comparison to DFT calculations we show that ionic transport in these materials must be regarded as a collective effect due to the significant contributions by ion-ion and ion-polaron interactions to the measured activation energies. (Collaborators: A. Mascaro, Z. Wang, P. Hovington, Y. Miyahara, A. Paollela, V. Gariepy, Z. Feng,T. Enright, C. Aiken, K. Zaghib, K. Bevan)

T3-6 Developing Scientific Practices in the Laboratory (DPE) | Exercice de la science en laboratoire (DEP) / 1978

Engaging Students in Authentic Scientific Practices in Physics Lab Courses (I)

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Physics is an empirical science. Therefore, learning physics must include learning how to design and conduct experiments, analyze and interpret data, and revise models and apparatus. Physics lab courses at the introductory and upper-division levels are one of only a few opportunities for students to engage in these authentic physics practices. For many students, instructional labs are the only opportunity. However, these courses do not always have the students reach the desired learning goals. Our work looks to improve lab experiences by improving students' competency with modeling of physical and measurment systems, troubleshooting skills, documentation practices, and views of the nature of experimental physics.

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 1979

Jordan frame no-hair for scalar-tensor black holes: a new proof

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We present a no-hair theorem for spherical black holes in scalar-tensor gravity. Contrary to the existing theorems, which are all proved in the Einstein conformal frame, this proof is performed entirely in the Jordan frame. The theorem is limited to spherical symmetry (instead of axisymmetry), but it holds for non-constant Brans-Dicke coupling.

[Based on V. Faraoni, Phys. Rev. D 95, 124013 (2017)]

DTP Poster Session & Finals: Poster Competition and Mingle Session with Industrial Partners/Employers (1) | Session d'affiches DPT et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (1) / 1980

POS-44 Three new roads to the Planck scale

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We propose three new heuristic derivations of the Planck scale which are based on basic principles or phenomena of relativistic gravity and quantum physics. The Planck scale quantities obtained are within one order of magnitude of the "standard"ones. The phenomena contemplated are the pair creation of causal bubbles so small that they can be treated as particles, the scattering of a matter wave off the background curvature of spacetime that it induces, and the Hawking evaporation of a black hole in a single burst at the Planck scale.

[Based on V. Faraoni, Am. J. Phys., 85, 865 (2017)]

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 1981

POS-1 Investigation of Emission Enhancement in Dual-Pulse and Resonance-Enhanced Laser-Induced Breakdown Spectroscopy

Authors: Robert Valente[1]; Paul Dubovan[1]

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Laser-induced breakdown spectroscopy (LIBS) is an elemental analysis technique in which a high powered laser is used to create a plasma on the surface of a sample. The light emitted from this plasma through a de-excitation process is then collected and used to spectrally analyze the sample. Two techniques that can improve the signal-to-noise ratio of LIBS spectra are dual-pulse LIBS, which utilizes a second laser that couples into the plasma created by the first laser pulse; and resonance-enhanced LIBS, which is similar to dual-pulse LIBS except that the second laser pulse has its wavelength tuned to match a known atomic transition in the sample in order to improve the coupling to the plasma. This enhancement can be useful for applications where a single pulse LIBS signal would be too weak to produce accurate or even detectable measurements, such as in handheld LIBS.

Presented here are measurements utilizing these two techniques on steel and neodymium samples. The first pulse was provided by a 1064 nm Nd:YAG laser and the second pulse was provided by a tunable OPO laser (both having 10 ns pulse duration). Time resolved LIBS spectra were acquired using an echelle spectrometer with a time-gated intensified CCD providing sub-nanosecond timing resolution. LIBS emission enhancement due to the second laser pulse was measured as a function of laser power, OPO wavelength, interpulse delay time, and gaseous environment present in the chamber. These tests were conducted to determine optimal parameters for signal enhancement. Additionally, attempts to replicate these measurements in a vacuum chamber will be discussed.

T3-3 Particle Physics IV (PPD) | Physique des particules IV (PPD) / 1982

*** Moved from M3-6 *** Searches for new physics at ATLAS (I)

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Throughout Run II ATLAS has maintained an extensive, varied program of searches for physics beyond the Standard Model. Searches for supersymmetry cover strong and electroweak production as well as R-parity violating scenarios, while Exotic analyses search for heavy bosons, dark matter mediators, exotic Higgs production, and much more. This talk will show highlights of the Run II search results so far and lay out plans for analyses in the full dataset and beyond.

W3-4 Soft matter and molecular dynamic (DPMB/DCMMP) | Matière molle et dynamique moléculaire (DPMB/DPMCM)) / 1983

Escherichia coli's RfaH studied by all-atom Monte Carlo simulation (G)*

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RfaH is a compact two-domain multi-functional protein from the bacteria $Escherichia\ coli\ (E.coli)$. Its C-terminal domain (CTD) has been shown experimentally to be able to undergo a complete conformational change from an α-helix bundle to a β-barrel structure. The α-helix bundle to β-barrel fold switch accounts for the observed dual role of RfaH, whereby it regulates transcription as well as enhances translation. We employ all-atom Monte Carlo simulations to investigate the stabilities of the two structural forms of RfaH and the character of transition between them. Our simulations reveal that the stand-alone α-helix CTD is relatively unstable despite the stabilizing interactions with the N-terminal domain (NTD). Moreover, we observe the stability of the stand-alone β-barrel conformation to be always higher than the α-helix bundle structure. Thus, we conclude that the α-helix bundle to β-barrel fold switch of the CTD in RfaH is thermodynamically favoured in our model.

T2-3 Ground-based and in Situ Observations II (DASP) l Observations terrestres et In situ II (DPAE) / 1984

STEVE, the mysterious subauroral optical structure (I)

Authors: Bea Gallardo-Lacourt[1]; Toshi Nishimura[2]; Eric Donovan[1]; William Archer[3]; Gareth Perry[1]; Megan Gillies[1]; Emma Spanswick[1]; Jun Liang[1]; MacDonald Elizabeth[4]; David Knudsen[1]

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There has been an exciting recent development in auroral research associated with the discovery of a new subauroral phenomenon called STEVE (Strong Thermal Emission Velocity Enhancement). Although STEVE has been documented by amateur night sky watchers for decades, it is a new upper atmosphere phenomenon. Observed first by amateur auroral photographers, STEVE appears as a narrow luminous structure across the night sky over thousands of kilometers in the east-west direction. In this paper, we present the first statistical analysis of the properties of 28 STEVE events

identified using THEMIS ASI and the REGO database. We found that STEVE occurs about one hour after substorm onset at the end of a prolonged expansion phase. On average, the AL index magnitude is larger and the expansion phase has longer duration for STEVE events compared to SAIDs or Substorm. The average duration for STEVE was about one hour and its latitudinal width was ˜20km, which corresponds to ˜ ¼ of the width of narrow auroral structures like streamers. STEVE typically has an equatorward displacement from its initial location of about 50 km and a longitudinal extent of 2145 km. We also analyzed STEVE's seasonal dependence and found that more events were observed during equinox. Finally, we did not find evidence of solar cycle dependence for the events of STEVE analyzed in this study.
In addition, we use data from Meridian Scanning Photometers (MSP, NORSTAR and FESO) that measure brightness of H-β proton auroral emission at 4861Å. This dataset help us to locate STEVE relative to typical auroral arcs. We analyzed in total 12 events in which THEMIS or REGO have a good conjunction with MSP instruments from December 2007 up to May 2017. Our observations suggests that Steve is always located equatorward of the proton aurora (˜5˚mlat on average), and thus is not a traditional electron auroral arc, a feature which is always poleward of the peak in proton auroral brightness.

M2-5 Nuclear Structure I (DNP) | Structure nucléaire (DPN) / 1985

Recent mass measurements at TITAN (I)

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TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN) is located at the Isotope Separator and Accelerator (ISAC) facility, Vancouver. Titan is a multiple ion trap system capable of performing high-precision mass measurements and in-trap decay spectroscopy. In particular TITAN has specialised in fast Penning trap mass spectrometry of short-lived exotic nuclei using its Measurement Penning Trap (MPET). In order to reach the highest possible precision, ions can be charge bred into higher charge states by an Electron Beam Ion Trap (EBIT), reducing the required excitation time for a needed precision. Thus using highly charged ions, TITAN is capable of performing mass measurements of short lived heavy species with high precision. Although ISAC can deliver high yields for some of the most exotic species, many measurements suffer from a strong isobaric background. This background often prevents the high precision measurement of the exotic species of interest. To overcome this limitation an isobar separator based on the Multiple-Reflection Time-Of-Flight Mass Spectrometry (MR-TOF-MS) technique has been installed recently at TITAN, similar to other ion trap on-line facilities. At TITAN the mass selection is achieved using dynamic re-trapping of the species of interest after a time-of-flight analysis in an electrostatic isochronous reflector system. Additionally the MR-TOF-MS enables mass measurements of very short-lived nuclides that are weakly produced, complementing TITAN's existing mass measurement program of short-lived exotic nuclei.
In this way TITAN is able to expand its mass measurements towards even more exotic isotopes produced at very low production yields. Results from recent high-precision mass measurements of super-allowed beta decays emitters, as well as mass measurements for nuclear structure and nuclear astrophysics will be shown employing singly and highly charged ions with MPET and the new MR-TOF-MS.

T1-2 Special CAP Plasma Physics Session: in Memory of Prof. Akira Hirose (DPP) l Session spéciale en physique des plasmas: À la mémoire du prof. Akira Hirose (DPP) / 1986

Simulation-based interpretation of Langmuir probe measurements (I)

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Owing to their relative simplicity, Langmuir probes are the instrument of choice to infer the density and temperature in space and laboratory plasma experiments. The interpretation of probe characteristics, that is, the collected current as a function of bias voltage, is practically always based on theoretical models amenable to analytic solutions, and capable of producing fast solutions under real-time experimental conditions. Several theoretical probe models have been developed over the years corresponding to plasma conditions under various limiting cases including collisionless unmagnetized plasma, low or high density plasma, strongly collisional plasma, and strongly magnetized plasma. Analytic models also assume isolated probes in a spatially uniform background, far from any other material object. Unfortunately these analytic models, while useful as fast and effective interpretation tools, cannot account for physical processes or experimental conditions which affect the measurements of characteristics in actual experimental conditions. Ideally, a preferred solution would rely on computer models capable of accounting for actual non-ideal measurement conditions, such as weakly magnetized plasma, Debye lengths comparable to size of the probe, plasma inhomogeneity, and the proximity of objects responsible for deflecting or obstructing particle to be collected. Such numerical models however, require considerable computing resources, which renders them inapplicable under real-time experimental conditions. This is the case in laboratory experiments, as well as in satellite on-orbit conditions. A solution would consist of using computer models, capable of accounting for the actual conditions under which lab or space measurements are made, to compute probe characteristics, and create a library of solutions over expected ranges of plasma parameters. Given this solution library, it would be possible to infer plasma parameters such as the density and temperature, directly from measured characteristics by using an adapted multivariate regression algorithm. In this talk, preliminary results are presented using solution libraries constructed from a combination of synthetic results obtained analytically, and numerically from kinetic simulations. The applicability of the method is discussed, with a particular attention to space-borne Langmuir probe measurements.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 1987

POS-63 Multisequence algorithm for coarse-grained biomolecular simulations: Exploring the sequence-structure relationship of proteins

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Many biologically motivated problems naturally call for the investigation and comparison of molecular variants, such as determining the mechanisms of specificity in biomolecular interactions or the mechanisms of molecular evolution. We consider a generalized ensemble algorithm for coarse-grained simulations of biomolecules which allows the thermodynamic behavior of two or more sequences to be determined in a single multisequence run. By carrying out a random walk in sequence space, the method also enhances conformational sampling. Escape from local energy minima is accelerated by visiting sequences for which the minima are shallower or absent. We test the method on an intermediate-resolution coarse-grained model for protein folding with 3 amino acid types and explore the potential for large-scale coverage of sequence space by applying it to sets of more than 1,000 sequences each. The resulting thermodynamic data is used to analyze the structures and stability properties of sequences covering the space between folds with different secondary structures. Besides demonstrating that the method can be applied to a large number of sequences, the results allow us to carry out a more systematic analysis of the biophysical properties of sequences along mutational pathways connecting pairs of different folds than has been previously possible.

T4-6 DASP General Contributions II (DASP) | DPAE: contributions générales II (DPAE) / 1989

Search for Vertical Stratification of Element Abundances in Chemically Peculiar stars

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A portion of upper main-sequence stars, called chemically peculiar (CP) stars, show significant abundance anomalies mainly due to atomic diffusion of chemical elements within the stellar atmospheres of these stars. Slowly rotating CP stars may have hydrodynamically stable atmospheres where a competition between the gravitational and radiative forces launches the mechanism of atomic diffusion that can be responsible for the abundance peculiarities observed in CP stars. Recently, Project VeSElkA (Vertical Stratification of Elements Abundance) was initiated with the aim to detect and study the vertical stratification of element abundances in atmospheres of CP stars. The first results from abundance analysis of several slowly rotating (Vsin(i)<40 km/s) CP stars observed recently with ESPaDOnS are presented here. Signatures of vertical abundance stratification for several chemical elements have been found in stellar atmospheres of HD22920, HD41076, HD95608, HD116235, HD148330 and HD157087.

W4-5 Education Research-informed Physics Teaching (DPE) | L'enseignement de la physique enrichi par la recherche en éducation (DEP) / 1990

Grade Inflation due to Selective Averaging

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When assessing student performance, some educators choose to discard the worst tests written by the student. The mean of the remaining tests is taken as opposed to the mean of all tests written. Naturally, this process will result in some expected grade inflation. In our paper we provide a model for the expected grade inflation in the case when the student's test-writing ability changes over time. Furthermore, we provide results on the grade inflation when the educator decides to use nested selective averaging processes. The Physics Laboratory post-tests' grades have been analyzed in our model.

M3-2 General Contributions I (DASP) l Contributions générales 1 (DPAE) / 1992

Coordinated space weather observations at the SANAE IV base in Antarctica

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The proposed ionising influence of cosmic rays on atmospheric aerosols, clouds and atmospheric electrical properties has resulted in several attempts to obtain convincing correlations. Several theoretical studies on such possible indirect influence is still poorly understood while the observational evidence remains controversial and incomplete. This study examines the Heliospheric-Magnetospheric-Atmospheric responses during a recent fortuitous cosmic rays Forbush decrease (FD) that occurred on 16-17 July 2017. The varied instrumentation located on SANAE IV in Antarctica provided us an opportunity to test the different theories applied to cosmic ray influence. Various ground based instruments located in South Africa, belonging to South Africa National Space agency, are used to coordinate FD-atmospheric connection hypothesis. A synthesis of multiple observations indicates that there is a plausible link between cosmic ray ionisation and polar aerosols, but clouds.

R2-2 Electrochemical Energy Storage (DAPI) | Stockage d'énergie électrochimique (DPAI) / 1993

Withdrawn talk is being given in W4-1 session Transport properties of electrolytes containing esters for high power Li-ion cells (G)

Author: Eric Logan[1]

Co-authors: Erin Tonita [1]; Kevin L. Gering [2]; Jing Li [1]; Luc Beaulieu [3]; Jeff Dahn [1]

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Li-ion batteries that can charge rapidly without sacrificing lifetime are crucial for the further development of electric vehicles (EVs) and for better customer acceptance. Measuring transport properties such as ionic conductivity and viscosity are simple and effective techniques for screening electrolyte suitability for fast charge applications. The use of low-viscosity esters as co-solvents in traditional carbonate-based electrolytes has been proposed to improve both high-rate and low temperature cycling performance in Li-ion cells. In this work, a novel automated method to measure viscosity is used in combination with ionic conductivity measurements to investigate the transport properties of electrolytes containing different ester co-solvents. Finding methyl acetate (MA) to have the most desirable properties of the esters considered, the impact of MA on viscosity and conductivity when added to electrolytes containing ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethyl carbonate (DMC) was studied.
Electrolytes containing solvent blends EC:EMC:MA and EC:DMC:MA, with compositions 30:(70-x):x (wt. %), and LiPF6 concentrations between 0 and 2 mol/kg were considered. Over all conditions, the addition of MA decreases the viscosity of the electrolyte, leading to a corresponding increase in conductivity. Additionally, it was found that these ester-containing electrolytes roughly obey a simple expression for conductivity based on Stokes'Law. A Walden analysis is performed which shows that all electrolytes considered have approximately the same iconicity independent of salt concentration and temperature, leading to the conclusion that the characteristic decrease in conductivity seen at high concentrations of LiPF6 is primarily driven by high viscosity. Conductivity and viscosity data are also compared to a statistical-mechanics model for electrolyte properties, the Advanced Electrolyte Model (AEM). The AEM can calculate many macroscopic transport properties of electrolytes, and it shows excellent agreement with experiment for MA-containing electrolytes. Charge-discharge cycling results for Li-ion cells containing MA in the electrolyte show remarkably improved performance at high charge rates compared to a solely carbonate-based electrolyte.

M2-3 Particle Physics II (PPD) | Physique des particules II (PPD) / 1994

The SuperCDMS SNOLAB Dark Matter Experiment (I)

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SuperCDMS SNOLAB is a dark matter experiment currently under construction and slated for installation in SNOLAB in 2019. SuperCDMS SNOLAB will use cryogenic silicon and germanium detectors to search for nuclear recoils produced by dark matter particles interacting in the detectors. These nuclear recoils will produce both phonon excitations and ionization (electron/hole pairs) in the detector, which can be read out by sensitive elements on the surface of the detector. Applying a voltage across the detector can amplify the ionization signal into a large phonon signal through the conversion of the charge carriers' kinetic energies into phonon vibrations, greatly lowering the energy threshold of the experiment. This low energy threshold will give SuperCDMS SNOLAB world-leading sensitivity for dark matter particles with masses below ˜10 GeV/cˆ2. SuperCDMS SNOLAB can also search for hypothesized dark photons that produce electrons in the detectors through an analog of the photoelectric effect. In this talk I will review the scientific program of SuperCDMS SNOLAB, its current status, and the latest science results from this unique detection technology.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 1995

POS-26 The effect of 1,3-Dimethyl-2-imidazolidinone (DMI) as an additive in Lithium-ion cells.

Author: Roby Gauthier[1]

Co-authors: David Hall [1]; Jeff Dahn [1]

[1] *Dalhousie University*

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Improving the energy density, cost and lifetime of current lithium-ion batteries is vital for the electric vehicle industry and for grid energy storage. It is known that the composition of the electrolyte solution in lithium-ion batteries can dramatically affect their performance. For that reason, it is common to add a small amount of additives to the electrolyte solution to limit impedance growth, decrease the cell voltage drop during storage, and extend the cycling lifetime of the cells or to reduce the formation of gases inside them. In this work, a new electrolyte additive named 1,3-dimethyl-2-imidazolidinone (DMI), a molecule with a structure and a dipole moment similar to the better-known ethylene carbonate (EC) molecule, has been evaluated in cells with or without the co-additive vinylene carbonate (VC). This work combines a variety of experimental and theoretical methods, including differential capacity analysis (dQ/dV) and density functional theory (DFT) calculations, to explore the chemical effects of DMI in full lithium-ion pouch cells. It is found theoretically that DMI doesn't reduce or oxidize inside the voltage operational window of lithium-ion cells. In fact, the reduction and oxidation potentials of DMI are found to be -0.63 V vs Li/Li+ and 4.57 V vs Li/Li+, respectively. Furthermore, our experimental data suggest that the electrochemical impedance of cells with DMI as an additive strongly depends on the cathode composition. This effect is unusual, in that it is not typically seen for other additives, such as VC. This significant difference in impedance for different cathode composition is interesting in the sense that it could be used to study and better understand the physical and chemical properties of the cathode electrolyte interface (CEI), which is much less studied than its anode analogue, the solid electrolyte interface (SEI). Adding the co-additive VC increase the electrochemical impedance and decrease the cell voltage drop during storage.

T4-8 Novel Approaches to Promoting Engagement in Physics Classes (DPE) | Nouvelles approches pour promouvoir l'engagement dans les classes de physique (DEP) / 1996

ChromaStar: A model star and exo-planet for the classroom

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ChromaStar is a responsive physical model star and exo-planet life zone equipped with a suite of virtual astronomical instruments. It runs in a web-browser on any commonplace personal computing device and allows for PER-based methods and lab assignments when teaching astronomy from the High School to the upper University level. Advanced students can access the code through the browser's developer console. I will provide sample demonstrations with the apparatus. See www.ap.smu.ca/OpenStars .

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 1997

POS-50 Spectroscopic Techniques in Determining the Elemental Composition of Fish Otoliths

Author: Christopher Heath[1]

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The migration patterns of fish have been shown to be reflected in the elemental composition of certain bone-like structures (otoliths) within the fish. These follow a radial growth pattern with characteristic ring structures forming annually, giving a method for aging the fish. Elemental analysis of the salts present in the otolith can then be used with locational data to give a mapping of the otoliths structural changes over time. These changes are correlated to the dominant features of the water the fish was in as its otolith developed. The current technique for this type of analysis is time consuming and costly, typically utilizing an inductively coupled plasma mass spectrometer (ICP-MS). The focus of this poster is to explore methods for using laser-induced breakdown spectroscopy (LIBS) on fish otoliths to develop a rapid, cost efficient method for migration tracking, with an emphasis on transitions from salt to fresh water bodies. LIBS is a point-sampling elemental analysis technique that uses the spectral radiation produced by a sample after laser ablating it to form a plasma. This poster will discuss our work on methods of sample preparation, including cross sectioning and plating techniques used to mount the otoliths. We will describe our experiments to optimize the signal-to-noise ratio and repeatability of our measurements. A central topic of this discussion will be if a statistically significant elemental difference can be determined between the innermost and the outermost structure of the otolith using LIBS. The exploration of novel algorithmic approaches to analyzing spectroscopic data in collaboration with modern chemometric techniques will be discussed. Lastly, we will address computerized autonomous methods for calculating the area under a peak in noisy LIBS data and classification models that can be applied when working with the data sets generated in the LIBS experiments.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 1998

POS-35 Tracking Liquid Electrolyte Changes Throughout Lithium-ion Cell Lifetime

Authors: David Hall[None]; Jeff Dahn[1]; Lauren Thompson[2]; Leah D. Ellis[None]; Michael Bauer[None]; Sam Buteau[None]

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Liquid electrolytes are essential to all battery systems, yet little is known of the changes that occur during the lifetime of a cell. It is certain that dramatic changes to the electrolyte of a Li-ion cell occur during operation because sometimes cells opened at the end of life appear "dry"(i.e. no liquid remaining) even though they were filled with substantial liquid electrolyte upon construction. These electrolyte changes contribute strongly to reducing cell lifetime.

This presentation will discuss the changes to the electrolyte composition during Lithium-ion battery cell life. Data from systematically cycled NMC/graphite cells having various electrolyte compositions and tested at various temperatures and voltages will be included. Results from traditional analysis techniques such as Gas Chromatography-Mass Spectrometry (GC-MS), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) will be presented with emerging analysis techniques such as Fourier-transformed Infrared spectroscopy (FTIR), and Li-ion cell Differential Thermal Analysis (Li-ion DTA). Observations include increased electrolyte degradation reactions at high upper cut-off voltages as well as increased salt (LiPF6) consumption. The results of these studies indicate the situations where electrolyte degradation is most severe and point to methods to mitigate against these problems. These solutions will lead to Li-ion batteries with longer lifetime.

W3-2 Energy Storage 3 (DCMMP) | Accumulation d'énergie 3 (DPMCM) / 1999

Gauging Li-ion Cell Health by Monitoring Irreversible Volume Expansion (G)*

Author: Alex Louli[1]

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An in-situ technique for monitoring the pressure evolution of volumetrically constrained Li-ion pouch cells has previously been introduced by Louli et al.[1] When constrained, changes in cell volume cause a pressure response that is measured. A reversible pressure change is observed due to the reversible electrode volume expansion and contraction during charge and discharge of the cell.[1] Here, it is shown that in addition to this reversible pressure evolution, pouch cells with silicon-containing negative electrodes exhibit an irreversible pressure growth over the course of tens of cycles, and that large irreversible pressure growth correlates with poor lifetime. It is hypothesized that this is caused by the growth of the solid electrolyte interphase (SEI), resulting in irreversible capacity loss as well as volume growth which is manifest in the irreversible pressure growth measurements. Li(Ni1-x-yCoxAly)O2/SiO-graphite, LiCoO2/Si Alloy-graphite and Li(Ni1-x-yCoxAly)O2/nano Si-C pouch cell chemistries were tested in this work. The lifetime of these cells are ranked and shown to agree with the ranking of irreversible pressure growth. Impedance measurements are also presented to further rationalize the apparent correlation between lifetime, irreversible pressure growth and SEI growth. We propose that in-situ pressure measurements can be used as a non-destructive technique to gauge SEI growth and thus rank the performance of Li-ion cells.

1. A. J. Louli, Jing Li, S. Trussler, Christopher R. Fell, and J. R. Dahn, Volume, Pressure and Thickness Evolution of Li-Ion Pouch Cells with Silicon-Composite Negative Electrodes, J. Electrochem. Soc., 164 (2017).

W4-1 Energy Storage 4 (DCMMP) | Accumulation d'énergie 4 (DPMCM) / 2000

Transport properties of electrolytes containing esters for high power Li-ion cells (G)

Author: Eric Logan[1]

Co-authors: Erin Tonita [1]; Kevin Gering [2]; Jing Li [1]; Luc Beaulieu [3]; Jeff Dahn [1]

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Li-ion batteries that can charge rapidly without sacrificing lifetime are crucial for the further development of electric vehicles (EVs) and for better customer acceptance. Measuring transport properties such as ionic conductivity and viscosity are simple and effective techniques for screening electrolyte suitability for fast charge applications. The use of low-viscosity esters as co-solvents in traditional carbonate-based electrolytes has been proposed to improve both high-rate and low temperature cycling performance in Li-ion cells. In this work, a novel automated method to measure viscosity is used in combination with ionic conductivity measurements to investigate the transport properties of electrolytes containing different ester co-solvents. Finding methyl acetate (MA) to have the most desirable properties of the esters considered, the impact of MA on viscosity and conductivity when added to electrolytes containing ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethyl carbonate (DMC) was studied.
Electrolytes containing solvent blends EC:EMC:MA and EC:DMC:MA, with compositions 30:(70-x):x (wt. %), and LiPF6 concentrations between 0 and 2 mol/kg were considered. Over all conditions, the addition of MA decreases the viscosity of the electrolyte, leading to a corresponding increase in conductivity. Additionally, it was found that these ester-containing electrolytes roughly obey a simple expression for conductivity based on Stokes'Law. A Walden analysis is performed which shows that all electrolytes considered have approximately the same iconicity independent of salt concentration and temperature, leading to the conclusion that the characteristic decrease in conductivity seen at high concentrations of LiPF6 is primarily driven by high viscosity. Conductivity and viscosity data are also compared to a statistical-mechanics model for electrolyte properties, the Advanced Electrolyte Model (AEM). The AEM can calculate many macroscopic transport properties of electrolytes, and it shows excellent agreement with experiment for MA-containing electrolytes. Charge-discharge cycling results for Li-ion cells containing MA in the electrolyte show remarkably improved performance at high charge rates compared to a solely carbonate-based electrolyte.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2001

POS-25 Impedance Growth in Lithium-Ion Pouch Cells

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The widespread adoption of electric vehicles over gas-powered transport is essential to our sustainable future. Consequently, the lithium-ion batteries used for electric cars are receiving more and more attention. Lithium-ion cells with LiNi0.8Co0.15Al0.05O2 (NCA) positive electrodes have been observed to lose capacity during their lifetime as a result of impedance growth.1,2 Understanding the origin of the impedance growth is important to improving the lifetime of these cells, which in turn can help make electric vehicles more desirable to consumers and speed the adoption of sustainable transport.

In this study impedance growth was observed to contribute to capacity loss in pouch cells with NCA positive electrodes and graphite, graphite-SiO, or graphite-SiC negative electrodes. The positive electrode was observed to have drastic impedance growth during cycling while the negative electrode impedance was small in comparison. The impedance growth for NCA pouch cells was controlled by cycling in the limited voltage range of 3.0 V –3.8 V, while impedance growth was still observed for cells cycled only at high voltage (3.8 V –4.2 V). Additionally, the magnitude of impedance was highest near 4.2 V. The cathode material undergoes irreversible impedance growth in the high voltage region. Differential capacity vs. voltage (dQ/dV) for the NCA material shows a peak at 4.2 V vs Li/Li+, which may correspond to the impedance growth at high voltage. Similar experiments are also presented for pouch cells with LiNi0.8Mn0.1Co0.1O2 (NMC811) or LiNi0.5Mn0.3Co0.2O2 (NMC532) positive electrodes. Understanding the dQ/dV peak at 4.2 V vs Li/Li+ for these positive electrode materials may be important for preventing capacity loss from impedance growth during long term cycling.

1. Abraham, D. P.; Knuth, J. L.; Dees, D. W.; Bloom, I.; Christophersen, J. P. Performance Degradation of High-Power Lithium-Ion Cells—Electrochemistry of Harvested Electrodes J. Power Sources 2007, 170, 465–475
2. Seung-Taek Myung, Filippo Maglia, Kang-Joon Park, Chong Seung Yoon, Peter Lamp, Sung-Jin Kim, and Yang-Kook Sun. Nickel-Rich Layered Cathode Materials for Automotive Lithium-Ion Batteries: Achievements and Perspectives, ACS Energy Letters, 2017, 2, 196-223.

T3-5 Hadronic Physics (DNP) | Physique hadronique (DPN) / 2002

Blinded by the Light: Calibration of a Cherenkov Detector (G)*

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Quantum chromodynamics (QCD), the fundamental theory of the strong interaction, tells us that when quarks are close together (high energy) the interaction is feeble but when they are far apart (low energy) the strong force is intense. Currently, QCD can accurately describe the high energy regime, but calculations are difficult in the non-perturbative, low energy regime. At Jefferson Lab (JLab), 12 GeV electrons impinge upon a variety of targets in experimental Hall C, making it a prime location to probe how QCD transitions from the high energy to low energy regime.

There are two spectrometers in Hall C called the High Momentum Spectrometer and the Super High Momentum Spectrometer (SHMS). The SHMS features a suite of detectors used to track and identify particles to extract meaningful quantities from the experiment. One such detector is a gas Cherenkov used for identification of charged particles based off their velocity. If a particle passes through the detector faster than the speed of light in the media, characteristic Cherenkov radiation (photons) will be produced. The detector is outfitted with photomultiplier tubes which collect this light and convert it to an electrical signal, which is measured. Lighter particles of equal momenta produce more light, allowing us to distinguish between different species.

In this presentation I give a general overview of the JLab accelerator facility and the experimental Hall C. This will include a description of the detector stack in the SHMS and the role the HGC plays. I will then talk about the HGC specifically, how it was designed and the theory behind Cherenkov radiation. Next the calibration procedure will be shown, demonstrating how the detector is gain-matched and capable of performing particle separations. Afterwards I will show how the efficiency of the HGC is determined. Lastly I will show some simulations of the HGC and how they compare to the experimental data.

T4-5 Neutrinoless Double Beta Decay (DNP) | Double désintégration bêta sans neutrinos (DPN) / 2003

Neutrinoless double beta decay search using liquid xenon (I)

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The use of enriched liquid Xe-136 (LXe) offers significant advantages to search for double beta decay processes. A discovery of the neutrinoless mode (0vbb) would reveal new properties of neutrinos including first measurement of its mass scale, evidence that they are their own antiparticles, and a first observation of lepton number violation.

The Enriched Xenon Observatory (EXO) employs a time projection chamber filled with LXe to search for 0vbb, which allows an efficient and monolithic detector, ideal to identify and separate background arising from gamma rays. The EXO-200 is a 100-kg class detector in operation at the WIPP mine in New Mexico, USA. Its latest search for 0vbb is among the world's best, with sensitivity to the 0vbb half-life of 3.7x10^25 yr at the 90% confidence level. To further reject backgrounds, this search introduced a boosted decision tree trained on multiple topological variables. Rooted in the success of EXO-200, nEXO is a tonne-scale detector being designed to reach a sensitivity near 10^28 yr.

In this talk, the latest results with EXO-200 as well as projections for nEXO, the next generation experiment, will be discussed.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2004

POS-14 Metallic Li and Na Anodes for Next Generation Li and Na Metal Batteries

Author: Yang Zhao[1]

Co-authors: Xiaoting Lin [1]; Hossein Yadegari [1]; Andrew Lushington [2]; Qian Sun [2]; Ruying Li [2]; Xueliang Sun [2]

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Metallic Li is considered as the promising anodes for next generation Li-metal batteries including Li-S, Li-air and all solid-state batteries. However, it is still a crucial problem of Li dendrite growth and large volume change during the stripping/plating process. In our study, the advanced atomic/molecular layer deposition (ALD/MLD) is used to deposit protective coatings on Li metal with excellent coverage and controllable thickness to stabilize the SEI layer and longer the life time

[1].
Herein, we demonstrated MLD alucone (Al-EG and Al-GLY) as protective layers for Li metal anode with improved stability and life time, leading to the better performances than ALD Al2O3 [2]. Furthermore, the conductive carbon paper (CP) is proposed as an "interlayer"for Li metal anode with super long-life time under high current density [3].
Na metal anode also shows the great potential for the Na metal batteries [4], which facing the similar problems of dendritic Na growth. Here, we demonstrated the successful application of both ALD Al2O3 and MLD alucone protective coatings on Na metal anode in ether and carbonate-based electrolyte, respectively, to achieve long lifetime Na metal anode with suppressed dendrite growth [5].
To further reduce the dendrite growth and minimize the volume change, the 3D skeleton (carbon paper with N doped carbon nanotube) has been design with excellent electrochemical performance under high current density and high capacity [6]. To address the practical problems in Na-O2 batteries, the CP is used as "interlayer"to avoid the corrosion of Na metal and reduce the dendritic Na growth [7].
In conclusion, we developed the different approaches, including ALD and MLD protective layers, interlayers, and 3D skeleton design, for Li and Na metal anodes with enhanced electrochemical performances and reduced dendrite growth. Meanwhile, the ideas have been also applied to solve the practical issues for testing Li and Na metal batteries.
[1] X. Meng, X. Sun, Advanced Materials, 2012, 24, 1017; Y. Zhao, X. Sun, ACS Energy Letters, 2018, in press (review paper)
[2] Y. Zhao, X. Sun, Small Methods, 2018, DOI: 10.1002/smll.201703717; A. Lushington, X. Sun, submitted
[3] Y. Zhao, X. Sun, Nano Energy, 2018, 43, 368
[4] H. Yadegari, X. Sun, Advanced Materials, 2016, 28, 7065
[5] Y. Zhao, X. Sun, Advanced Materials, 2017, 29, 1606663; Y. Zhao, X. Sun, Nano Letters, 2017, 17, 5653
[6] Y. Zhao, X. Sun, Small, 2018, DOI: 10.1002/smll.201703717
[7] X. Lin, X. Sun, submitted

DPE Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (2) | Session d'affiches DPE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (1) / 2005

POS-57 Bloom Where You're Planted: Exposing Undergraduate Students to Local Research Excellence

Authors: Kevin Douglas[1]; Terry Bridges[1]; Ryan Ransom[1]; Robert Stutz[1]

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Okanagan College capitalizes on its long-standing relationship with the Dominion Radio Astrophysical Observatory, bringing students to the facility every semester. These field trips expose students to cutting-edge research, and reinforces the concepts learned in their classes. The realization that world-class research is being performed in the local community engages students tremendously. We present examples of the unanimously positive experiences of several OC students, and seek to discover other colleges which benefit from such partnerships in other parts of Canada.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2006

POS-24 Applying State-of-the-art Machine Learning Methods to Analyse Electrolyte composition of Lithium-ion Cells using Fourier-Transform Infrared Spectroscopy

Authors: Samuel Buteau[1]; Scott Young[2]; Samuel Hames[3]; Lauren Thompson[4]; Leah Ellis[4]; David Hall[1]; Jeff Dahn[1]

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Lithium-ion cells are complex electrochemical system and various physical properties can be measured, giving valuable insights into their behavior, state-of-health, degradation mechanisms, etc.. However, many such insights remain unexploited because of the difficulty of relating the raw data to the variables of interest. This is a setting well suited to Machine Learning. This talk will take as example the task of determining the composition of an unknown electrolyte, simply by using the Fourier-Transform Infrared (FTIR) spectrum. Some samples of known composition were measured, to build a calibration set, which was used to approximate the relationship between FTIR spectrum and electrolyte concentration.
Machine Learning methods have made significant leaps forward in recent years, achieving impressing results in image recognition, audio signal analysis, natural language processing, and even video game artificial intelligence. State-of-the-art methods in this emerging field of "deep learning"are however known to require huge amounts of data to achieve good results. This talk will demonstrate that this need not be so, by presenting a successful application of state-of-the-art complex neural networks to the problem of electrolyte analysis. A special emphasis will be given to the techniques developed to ensure the robustness of the resulting model, allowing the application of these techniques to more problems in the future. The resulting model will be compared to alternative techniques such as inductively coupled plasma optical emission spectrometry (ICP-OES) and Gas chromatography–mass spectrometry (GC-MS), thus validating it as a tool for the analysis of electrolytes from aged Lithium-ion cells, requiring no special sample preparation and using no harsh or expensive solutions.

R2-1 Theoretical modeling of materials 2 (DCMMP) I Modélisation théorique de matériaux 2 (DPMCM) / 2007

Ab-initio modeling of thermoelectric materials: a new route towards higher efficiency (I)

Author: Jesse Maassen[1]

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Today roughly 60% of the energy humans produce is lost as waste heat. Thermoelectrics (TE) can convert this heat source into useful electrical power, and thus have the potential to impact our energy future. The key challenge is to increase the TE conversion efficiency, which depends on the TE material properties. The past decade has seen remarkable progress in TE materials, but that have originated from experimental trial-and-error. This creates an opportunity for predictive materials modeling to theoretically explore and discover promising TE materials to help guide experimental efforts and accelerate innovation.

In this talk, I will give a brief introduction to TEs and present our recently developed formalism for first-principles modeling of TE transport properties. I will demonstrate how this cutting-edge technique, based on density functional theory and the Boltzmann transport equation, can accurately predict TE characteristics and provide new insights into the scattering and transport physics of these materials.

R2-1 Theoretical modeling of materials 2 (DCMMP) I Modélisation théorique de matériaux 2 (DPMCM) / 2008

Intermediate band materials for high efficiency solar cells: overview and future directions (I)

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Intermediate band (IB) materials are a novel class of materials that, like semiconductors, have a band gap but also have an extra set of allowed electronic levels entirely contained within the semiconductor band gap, allowing sub-gap photon absorption. Solar cells made from such materials have the potential to radically improve photovoltaic efficiencies, similar to triple-junction cells. IB materials are also explored for use as infrared photodetectors. Current IB devices are made from three classes of materials: quantum dots, highly-mismatched alloys, and hyperdoped semiconductors. None has simultaneously achieved high sub-gap absorption and sufficient carrier lifetime. I will describe theoretical and experimental work to understand carrier lifetimes and their impact on device efficiencies. I will introduce a figure of merit, which predicts the potential effectiveness of candidate IB materials for both photodetectors and solar cells in advance of device fabrication. This figure of merit captures the tradeoff between enhanced absorption and enhanced recombination within an IB material, and it suggests a path toward efficient IB materials. I will give examples of measurements of the figure of merit and demonstrate a method for theoretical predictions for new systems.

R1-1 Theoretical Modeling of Materials 1 (DCMMP) | La modélisation théorique de matériaux 1 (DPMCM) / 2009

Electronic States of the Moiré superlattice (I)

Author: Hong Guo[1]

Co-authors: Hu Chen [1]; Vincent Micnaud-Rioux [1]

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Two-dimensional (2D) van der Waals (vdW) heterostructures have attracted great attention in the past five years. By stacking different 2D materials to bond via the vdW force, these artificial heterostructures provide new material phase space for exploration. In this work we focus on one aspect of the 2D vdW material: the Moiré pattern. In visual arts, Moiré pattern is an optical perception of a new pattern formed on top of two similar stacking patterns. In 2D vdW materials, Moiré pattern can be a physical superlattice which brings about novel electronic properties. Using our recently developed solver of the Kohn-Sham density functional theory that can handle very large systems –as large as more than ten thousand atoms, we have calculated electronic properties of the Moiré superlattices. We show multiple and topologically protected helical valley currents to be easily achievable by certain Moiré patterns formed on the 2D vdW heterostructure of graphene on boron-nitride.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2010

POS-39 An Organic Anode Enabling High Concentration and Cell Potential of An All-Organic Redox Flow Battery

Authors: Fahad Alkhayri[1]; C. Adam Dyker[1]

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Redox flow batteries (RFBs), as large scale stationary energy storage systems, have attracted a lot of attention recently as a leading technology to enable integration of renewable energy with the power grid and thereby reduce CO2 emissions caused by the excessive use of fossil fuels. Most work on these systems are primarily based on metal complexes in aqueous electrolytes (limited potential window), or non-aqueous electrolytes (wider potential window). Most recently, a few metal-free systems have been investigated which employ organic materials as both catholyte and anolyte. Such systems offer the potential for reduced environmental load and low cost. Organic compounds with high redox potentials, which can be used for catholyte solutions, are readily available, but new anolyte materials based on organic compounds with low redox potentials are needed. In this work, an organic anode with a low redox potential and good solubility in non-aqueous electrolytes was designed and coupled with a high redox cathode to give an all-organic battery system with high energy density. Electrochemical testing of an all-organic non-aqueous redox flow-type battery employing 2,2,6,6-tetramethyl-1-piperidinyloxy and bispyridinylidene as cathodic and anodic active materials, respectively, will be discussed.

R1-1 Theoretical Modeling of Materials 1 (DCMMP) | La modélisation théorique de matériaux 1 (DPMCM) / 2011

Application of the exchange-hole dipole moment dispersion model to surfaces and 2D materials (I)

Author: Erin Johnson[1]

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The exchange-hole dipole moment (XDM) method is a density-functional model of London dispersion based upon second-order perturbation theory. The XDM dispersion coefficients are non-empirical and depend directly on the electron density and related properties. XDM offers simultaneous high accuracy for a diverse range of systems due to the variation of the calculated atomic dispersion coefficients with the electronic environment. In this talk, we focus on applications of XDM to adsorption of small molecules and of graphene on noble metal surfaces. We also consider the interlayer interactions in 2D electrides, an unusual class of materials possessing interstitial electron layers sandwiched between cationic atomic layers of the solid.

T3-3 Particle Physics IV (PPD) | Physique des particules IV (PPD) / 2012

High mass Diboson Resonances with the ATLAS Detector (G)*

Author: Robert Les[1]

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Many extensions to the Standard Model predict new particles at the TeV scale which decay to pairs of electro-weak gauge bosons. The ATLAS detector is one the most sensitive probes for these scenarios because it studies the LHC collisions which have unprecedented center of mass energies and

luminosity. In conjunction with new experimental techniques for identifying the hadronic decays of weak bosons, searches have been able to greatly increase the sensitivity for these TeV scale resonances. In this talk I will summarize recent results from diboson resonance searches with the 36.1fb-1 of 13TeV pp collision data with ATLAS.

R2-2 Electrochemical Energy Storage (DAPI) | Stockage d'énergie électrochimique (DPAI) / 2013

From the Research Lab to the Market: Advanced Battery Testing and Diagnostics

Author: Chris Burns[1]

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Rechargeable lithium-ion batteries play an important role in the transition away from non-renewable sources of energy. Due to the long lifetime demanded of sustainable technologies, high accuracy, high precision testing is needed to enable reliable predictions of the lifetime of batteries within a short period of time. Novonix is a company spun out of Dr. Jeff Dahn's lab at Dalhousie University that specializes in developing equipment with a strong focus on the use of High Precision Coulometry (HPC) for lifetime evaluation of lithium-ion cells. This presentation will discuss the HPC technique used to study the performance and failure of lithium-ion batteries in addition to the realities of starting a company out of a research lab.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2015

POS-2 Electron Impact Excitation of Adenine in the VUV.

Authors: Josh Trocchi[1]; Jeffrey Dech[1]; Wladek Kedzierski[1]; J William McConkey[1]

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Dissociative excitation of adenine (C5H5N5) into excited atomic fragments has been studied in the electron impact energy range from threshold to 400 eV. A crossed beam system coupled to a vacuum ultraviolet (VUV) monochromator is used to study emissions in the wavelength range from 90 to 200 nm. The beam of adenine vapor from a stainless steel oven is crossed at right angles by the electron beam and the resultant VUV radiation is detected in a mutually orthogonal direction. Excitation of the H Lyman series, the strongest features in the spectrum, is considered in detail.

Financial support from NSERC, Canada, is gratefully acknowledged.

T1-5 Quirks and Quarks (PPD/DTP) I « Quirks » et quarks (PPD/DPT) / 2016

QCD-constrained dynamical spin effects in the pion.

Authors: Ruben Sandapen[1]; Mohammad Ahmady[2]

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In a recent paper, we have shown that dynamical spin effects are important to describe pion observables within holographic light-front QCD. The relative importance of such effects was freely chosen to fit the data. We now show that these dynamical spin effects can actually be theoretically constrained if we dare to extrapolate the use of an exact QCD relation away from the chiral limit. Despite this new theoretical constraint, we find that the dynamical spin effects still bring a significant improvement to describe the pion observables.

T1-5 Quirks and Quarks (PPD/DTP) I « Quirks » et quarks (PPD/DPT) / 2018

Masses of Light Quarkonium 0^{+-} Hybrids from Gaussian Sum-Rules

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We compute masses of light quarkonium and strangeonium 0^{+-} hybrids using Gaussian sum-rules. Correlation functions account for condensates up to dimension-six and are calculated at leading-order in α_s. Our analysis indicates that the resonance signal strength in this channel is distributed over a wide range, inconsistent with a single narrow resonance. A single wide resonance is also disfavoured as the resonance width would have to be extremely large. Using a double narrow resonance model, we find excellent agreement between QCD and hadron phenomenology, and extract mass predictions of 2.6 GeV and 3.6 GeV.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2019

POS-23 Li-ion Differential Thermal Analysis; an in-situ method for studying changes to electrolyte

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Li-ion cells contain liquid electrolyte that degrades over the course of their lifetime. High temperatures, high charging currents, and high voltage exposure can all accelerate electrolyte degradation. This degradation will eventually contribute to the death of the cell. As the electrolyte degradation pathways are not currently well understood, tools for careful probing of the electrolyte are required

to further develop cell chemistries for longer lasting cells, which is especially important for long term grid level storage.

Li-ion differential thermal analysis (Li-ion DTA) is a non-destructive in-situ method for probing the state of an electrolyte in a liquid electrolyte cell. Various methods of studying electrolyte ex-situ, by opening a Li-ion cell, have been developed, but these destroy the cell of interest. Using Li-ion DTA methods, which do not damage the cell, the degradation to the electrolyte of a single cell can be tracked throughout its lifetime. The DTA method functions by cooling a sample cell to below the electrolyte freezing point using a temperature controlled cryostat, and heating the cell linearly in time back to room temperature where the electrolyte is liquid again. By comparing the resultant temperature-time signal of the sample cell to that of a reference cell that did not undergo a phase change in the same temperature range, the phase changes of the electrolyte in the sample cell can be determined. By comparing these phase change temperatures to known electrolyte compositional phase diagrams, the state of the electrolyte can be determined qualitatively, and, in future, quantitatively. The method will be explained and results from several long term experiments on aged Li-ion cells will be described.

T1-4 Mathematical Physics (DTP) | Physique mathématique (DPT) / 2020

Investigating a stellar system interior with an erfc metric.

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We have proposed, in a previous CAP conference, an erfc potential that can be integrated in a symmetric metric to define the space-time surrounding a static symmetric massive object. The geometry described by this metric provides a unique representation of a static symmetric stellar system that is continuous over all the coordinate ranges. No discontinuities and no singularities, coordinate or intrinsic, come into play. A first attempt to extend this analysis would be to interpret the resulting space-time equations in terms of an isotropic stellar interior, considering the corresponding Tμμ as describing a perfect fluid under an isotropic pressure P. Such an approach leads to inconsistencies, because the pressure cannot be assumed to be equal in all directions in the present model. A more realistic solution is obtained using the Pμμ and associating these to the field equations. Solving this system for the Pμμ provides relationships between the different components as well as analytical expressions for each one of these. As it can be seen with computer simulations, the erfc potential generates supplementary principal radial constraints and the Rμμ are directly linked to the pressure components. The energy momentum components generate internal pressure in the system and these pressure components generate space-time curvature. The energy density ρc2 produces an inward attractive pressure P11 and the two pressures P22 and P33 are equal and negative to maintain the equilibrium of this static model

W4-3 Advances in Nuclear and Particle Physics Theory (DTP/PPD/DNP) | Progrès en physique nucléaire et en physique des particules théorique (DPT/PPD/DPN) / 2021

Status of Higgs Portal Dark Matter (I)

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Higgs portal dark matter models assume a coupling between dark matter and baryonic matter through Higgs exchange. These models are constrained in the low mass sector through limits on the branch-

ing ratio into invisible Higgs decays. Higgs portal models are also increasingly tested in the high-mass sector through direct search experiments. I review the current status of the Higgs portal models and introduce a new class of fermionic Higgs portal models.

M2-2 Theory, Modelling and Forecasting II (DASP) | Théorie, modélisation et prévisions II (DPAE) / 2022

Improved Modelling of Shortwave Fadeout with 30 MHz riometer data

Author: Robyn Fiori[1]

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Bursts of enhanced electron density in the ionospheric D-region due to photoionization by X-ray radiation from solar X-ray flares leads to a fadeout of short wave signals, potentially causing a loss of high frequency radio communication in affected regions. D-region absorption is typically monitored using riometer instruments which typically operate at 30 MHz. There are well established relationships for modelling the absorption anticipated during a SWF event based on the energetic electron flux. These relationships are examined using the Natural Resources Canada riometer network which provides a unique opportunity to study SWF over a wide spread in latitude (45.4° to 82.5°) for a 90° band of longitude. Based on observations from an event on 11 March 2015, current methods for modelling SWF are shown to severely underestimate absorption. We devise an improved SWF model which corrects this underestimation. Improved modelling provides a better estimate of the peak absorption and its duration above threshold levels anticipated to impact HF radio communication.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2023

POS-10 Superposed epoch analysis of cosmic noise absorption due to co-rotation interaction regions (CIR)

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In order to adequately understand the effects that energetic particle precipitation bears on radio wave absorption, we have analysed cosmic noise absorption (CNA) measured by the imaging riometer at Kilpisjarvi, Finland (IRIS) during 1996-2011. We analysed periods of co-rotating interaction regions(CIR) occurring as a result of the interaction of high speed solar wind streams emanating from coronal holes. We utilised the superposed epoch analysis method to investigate the absorption signature during these events. We identified periods of maximum CNA enhancement for each of these events and the duration of elevated CNA. Each of these events show differing CNA enhancement periods and elevation thresholds.

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 2024

A symmetry of Brans-Dicke gravity as a novel solution-generating technique

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Brans-Dicke gravity, enriched by the possibility of an arbitrary potential V (ϕ) for the Brans-Dicke scalar field, and in the presence of conformally invariant matter admits a 1-parameter symmetry group. We explore the use of these symmetries as a solution-generating technique using known solutions as seeds. We apply this technique to generate, as examples, new spatially homogeneous and isotropic cosmologies, a 3-parameter family of spherical and time-dependent spacetimes conformal to a Campanelli-Lousto geometry, and a new family of cylindrically symmetric geometries

W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2025

Experimental and Computational Studies of 1D and 2D Chimera States in Populations of Coupled Chemical Oscillators (I)

Author: Ken Showalter[1]

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We have studied chimera and chimera-like states in populations of photochemically coupled Belousov-Zhabotinsky (BZ) oscillators. Simple chimeras and chimera states with multiple and traveling phase clusters, phase-slip behavior, and chimera-like states with phase waves are described. Simulations with a realistic model of the discrete BZ system of populations of homogeneous and heterogeneous oscillators are compared with each other and with experimental behavior. Spiral wave chimeras as well as chimera core instabilities are studied in large arrays of photochemically coupled oscillators.

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DAPI Poster Session & Finals: Poster Competition and Mingle Session with Industrial Partners/Employees (3)| Session d'affiches DPIA et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (3) / 2026

POS-41 Characterizing dynamic wetting behaviour on randomly roughened surfaces

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Surface wettability describes the behavior of liquids on substrates and their ability to remain in contact with it. Quantification of wettability is often reduced to a measurement of the contact angle that a liquid droplet makes on the surface. Although this practice has become ubiquitous in the literature, a growing number of researchers have voiced concerns that static contact angles alone cannot fully describe surface wetting properties. Our research findings fall in line with this sentiment and highlight the importance of reporting data from dynamic droplets. Wetting dynamics of more than 300 droplets were studied on randomly roughened surfaces to demonstrate the range over which advancing and receding contact angles can vary. Factors such as droplet size, rate of volume change, and shape fitting algorithms affected measured contact angles, and approximately 60% of all measurements were not representative of the droplet's dynamics. These results demonstrate that static contact angles alone are not enough to characterize a surface, and that more information related to dynamic wetting behavior, such as sliding angles and hysteresis, is essential.

W2-1 Pattern Formation 2 (DCMMP) | Formation de motif 2 (DPMCM) / 2027

Pilot-wave hydrodynamics (I)

Author: John Bush[1]

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A decade ago, Yves Couder in Paris discovered that droplets walking on a vibrating fluid bath exhibit several features previously thought to be exclusive to the microscopic, quantum realm. These walking droplets propel themselves by virtue of a resonant interaction with their own wavefield, and so represent the first macroscopic realization of a pilot-wave system of the form proposed for microscopic quantum dynamics by Louis de Broglie in the 1920s.
New experimental and theoretical results allow us to rationalize the emergence of quantum-like behavior in this hydrodynamic pilot-wave system in a number of settings, and explore its potential and limitations as a quantum analog.

T4-1 Energy Storage 2 (DCMMP) | Accumulation 2 (DPMCM) / 2028

Synthesis of Single Crystal LiNi0.6Mn0.2Co0.2O2 with Enhanced Electrochemical Performance for Lithium Ion Batteries (G)

Author: Hongyang Li[1]

Co-authors: Jing Li ; Xiaowei Ma ; Jeff Dahn [2]

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Lithium ion batteries are used in consumer electronics, electric vehicles and grid energy storage.1 New positive electrode materials like LiNi1-x-yMnxCoyO2 (NMC) are required to increase energy density, lower cost and increase lifetime. Conventional NMC has large secondary particles (10 - 15 μm) made of agglomerates of small grains (˜ 200 - 500 nm) and is thus called polycrystalline

NMC.2 Commercially available single crystal NMC532 materials show particles that are about ˜3 µm in size, and were shown to have superior stability at high voltages and elevated temperatures compared to conventional polycrystalline NMC532 by the authors.2 Conventional LiNi0.6Mn0.2Co0.2O2 (NMC622) usually offers more capacity than NMC532 when charged to the same upper cut-off voltage so NMC622 is attractive.3 It is expected that single crystal NMC622 could also provide better performance than typical polycrystalline NMC622 materials. This work explores the synthesis of single crystal LiNi0.6Mn0.2Co0.2O2 and preferred synthesis conditions were found. A washing and reheating method was used to remove residual lithium carbonate after sintering. The synthesized single crystal NMC622 material worked poorly without the use of electrolyte additives in the electrolyte. However, with selected additives, single crystal cells outperformed the polycrystalline reference cells in cycling tests. It is our opinion that single crystal NMC622 has a bright future in the Li-ion battery field.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2029

POS-22 What is the use of a lithium-ion battery that has zero volts?

Author: Yulong Liu[1]

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Normal Li-ion cells with a positive electrode and a negative electrode normally have a voltage near 4.0 V. There are many surprising things about lithium-ion cells. One of these is that unwanted chemical reactions between one charged electrode (say the positive) and the electrolyte can create reaction products that migrate to the other electrode (say the negative) and affect it dramatically [1,2]. In order to eliminate this "cross-talk", "symmetric"cells, which have two positive (or two negative electrodes) electrodes and hence an average voltage of zero, are used [3,4]. The charge discharge cycle performance of a symmetric cell is exclusively determined by the compatibility of the electrode of interest with the electrolyte of choice.

In this study, the compatibility of various electrolyte additives with Li[Ni0.6Mn0.2Co0.2]O2 positive electrodes were studied using positive-positive symmetric cells built in-house. Symmetric cell testing is a method to effectively evaluate materials made in an academic laboratory when machine-made electrodes and full Li-ion cells are not readily available.

1. A. J. Smith et al, J. Electrochem. Soc., 158, A1136 (2011)
2. E. Björklund et al J. Electrochem. Soc., 164, A3054–A3059 (2017)
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4. C. Shen et al., J. Electrochem. Soc., 164, A3349–A3356 (2017)

M3-6 Particle Physics III (PPD) | Physique des particules III (PPD) / 2030

Analysis of CDMSlite Run 3 (G)*

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The Super Cryogenic Dark Matter Search experiment (SuperCDMS) seeks direct evidence of Weakly Interacting Massive Particle (WIMP) dark matter through interactions with cryogenic germanium crystals. Particle interactions in the germanium produce phonons and electron-hole pairs. The CDMS low ionization threshold experiment (CDMSlite) is an operating mode of SuperCDMS that applies a high voltage bias of ˜70 V across the detector. This creates a phonon amplification of the charges through the Neganov-Luke effect, and thus opens a window to search for lower mass WIMPs, though at the expense of discrimination between electron and nuclear recoils. CDMSlite Run 3 is the final iteration of the experiment, using data collected at the SuperCDMS location at the Soudan Underground laboratory in 2015. In the analysis of Run 3 we are introducing advanced techniques that we did not use in earlier analyses, with the goals to improve the sensitivity in spite of a shorter exposure compared to Run 2, and to prepare our analysis toolbox for the upcoming SuperCDMS SNOLAB experiment, where half the detectors will be operated in this high voltage mode. Examples for these improvements are modelling the background to be used in a profile likelihood analysis, and salting the dataset as a method of blinding to reduce potential bias in the analysis. My presentation will discuss how we implement these techniques, as well as the status of the analysis and the expected improvements in sensitivity.

M1-2 Particle Physics I (PPD) | Physique des particules I (PPD) / 2031

Massive Neutrino Search in $\pi \to e\nu$ Decay

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The PIENU experiment at TRIUMF aims to make a high-precision measurement of the $\pi \to e\nu$ branching ratio: $R_\pi = \frac{\Gamma(\pi \to e\nu \ + \ \pi \to e\nu\gamma)}{\Gamma(\pi \to \mu\nu \ + \ \pi \to \mu\nu\gamma)}$. Measurement of R_π provides a sensitive test of lepton universality and tight constraints on many new physics scenarios. In addition, a heavy neutrino lighter than the pion could be detected through its effect on the $\pi \to e\nu$ energy spectrum.

New results will be presented, using the full PIENU dataset, placing limits on the mixing of a neutrino of mass 60-135 MeV/c^2 with the electron neutrino. These limits are improved by up to an order of magnitude over previous results. The status of the branching ratio analysis will be presented as well.

W3-3 Fields and Strings II (DTP) | Champs et cordes II (DPT) / 2032

Open EFTs and Gravity as a Medium (I)

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Precision calculations in de Sitter space (such as of inflationary predictions for primordial fluctuations) are often plagued by infrared problems and issues of secular time dependence. Similar issues about the breakdown of perturbation theory seem also to arise for information loss in black holes. This talk briefly summarizes how related problems can arise in other areas of physics, and how they are dealt with when they do. It is argued that Master-Equation/Lindblad techniques used in areas like optics also apply to cosmology (and possibly black holes) and can tell us how to extract reliably late-time predictions. Applied to inflation they lead to Starobinsky's stochastic methods, plus small

but important corrections. This is argued to explain why stochastic inflation seems to resum IR effects in simple examples, and allows these tools to be generalized to apply more broadly. Mentioned in passing the relevance of Open EFTs to the problem of Schrodinger's Cosmologist: how primordial quantum fluctuations decohere sometime between their production during inflation and their observation early in the later Big Bang Epoch.

W1-4 Translational Research in Medical Physics Symposium (DPMB/DAPI) | Symposium de recherche translationnelle en physique médicale (DPMB/DPAI) / 2033

Automated Optimization of Dynamic MRI Data Acquisition and Reconstruction Parameters using Image Quality Metrics (I)

Authors: Nathan Murtha[1]; James Rioux[2]; Allister Mason[1]; Oliver Marriott[1]; Chris Bowen[2]; Sharon Clarke[3]; Steven Beyea[4]

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Dynamic Magnetic Resonance Imaging (MRI) acquisitions –e.g. the acquisition of Dynamic Contrast Enhanced MRI for the determination of pharmacokinetic model parameters –are challenging due to their requirement for simultaneous spatial and temporal resolution. This is in particular true for applications of DCE-MRI in areas such as prostate cancer, where the dynamics can be rapid (on the order of seconds) and the spatial extent of structures small (on the order of millimeters).

The use of sparse data methods, notably Compressed Sensing (CS), can dramatically improve temporal resolution through under-sampling of k-space. However this comes at the expense of spatiotemporal contrast fidelity, which affect quantitative accuracy and clinical detectability, due to the effects of data compression and regularization. CS DCE-MRI often requires that the under-sampling factor be determined a priori, and furthermore there exists no framework for selecting the optimal regularization for the under-sampled data set.

More recently, "golden angle" under-sampling approaches have been proposed, in which data is acquired continuously, and during post-processing the data can be re-sampled to trade off temporal resolution with under-sampling factor. However, there exists no framework to objectively determine the under-sampling factor and regularization that are best suited to answer the relevant question (e.g., determining the Arterial Input Function, calculating Ktrans, etc). Typically, these decisions are either made on the basis of arbitrarily setting a target temporal resolution, or by measuring the root mean square error (RMSE).

We have recently studied the use of image quality metrics such as the Structural Similarity Image Metric, Feature Similarity Index Metric, and others. These metrics were first proposed in the computer imaging literature for characterizing the effect of data compression (e.g. JPEG) on natural images. Specifically, they were developed because they have been shown to better correlate with perceptual changes in image quality than RMSE. Our work has examined the use of these metrics, applied in the individual image domain, to objectively determining the under-sampling factor and regularization that correlates with data fidelity of the overall dynamic time series.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2034

POS-51 Bacterial Mounting and Concentration Techniques to Translate Laser-Induced Breakdown Spectroscopy into a Clinical Set-

ting

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Laser-induced breakdown spectroscopy (LIBS) is a rapid elemental analysis technique that has been used for the detection and identification of bacterial pathogens. There is a high demand for real-time identification of bacteria and the capabilities of LIBS for this are promising. Optimizing the bacterial mounting techniques prior to LIBS analysis in a clinical setting is currently underway. This includes the sample preparation steps of separating bacterial cells from the other unwanted cells that would most likely be present in a biological specimen. It also includes lowering the minimum number of bacterial cells required for detection and accurate identification by LIBS.

This poster will present our efforts to accomplish these goals. We have investigated the effectiveness of the detergent Tween 20 as a possible anti-clumping agent for bacterial cells deposited on a nitrocellulose filter paper by observing the LIBS signal from *E. coli* specimens deposited both with and without Tween. The ability to quickly separate a contaminant from a bacterial suspension through the use of centrifugation and filter media with different pore sizes will also be presented. In addition, the capability of a metal cone designed to concentrate bacterial depositions during centrifugation onto a smaller area of the filter paper will be demonstrated.

M3-2 General Contributions I (DASP) l Contributions générales 1 (DPAE) / 2035

Insight into Global Trends in Aerosol Composition over 2005–2015 Inferred from the OMI Ultraviolet Aerosol Index (G)*

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Observations of aerosol scattering and absorption offer valuable information about aerosol composition. We apply a simulation of the Ultraviolet Aerosol Index (UVAI), a method of detecting aerosol absorption from satellite observations, to interpret UVAI values observed by the Ozone Monitoring Instrument (OMI) over 2005–2015 to understand global trends in aerosol composition. We conduct our simulation using the vector radiative transfer model VLIDORT with aerosol fields from the global chemical transport model GEOS-Chem. We examine the 2005–2015 trends in individual aerosol species from GEOS-Chem, and apply these trends to the UVAI simulation to calculate the change in simulated UVAI due to the trends in individual aerosol species. We find that global trends in the UVAI are largely explained by trends in absorption by mineral dust, absorption by brown carbon, and scattering by secondary inorganic aerosol. Trends in absorption by mineral dust dominate the simulated UVAI trends over North Africa, the Middle-East, East Asia, and Australia. The UVAI simulation well resolves observed negative UVAI trends over Australia, but underestimates positive UVAI trends over North Africa and Central Asia near the Aral Sea, and underestimates negative UVAI trends over East Asia. We find evidence of an increasing dust source from the desiccating Aral Sea, that may not be well represented by the current generation of models. Trends in absorption by brown carbon dominate the simulated UVAI trends over biomass burning regions. The UVAI simulation reproduces observed negative trends over central South America and West Africa, but underestimates observed UVAI trends over boreal forests. Trends in scattering by secondary inorganic aerosol dominate the simulated UVAI trends over the eastern United States and eastern India. The UVAI simulation slightly overestimates the observed positive UVAI trends over the eastern United

States, and underestimates the observed negative UVAI trends over India. Quantitative simulation of the OMI UVAI offers new insight into global trends in aerosol composition.

M2-5 Nuclear Structure I (DNP) | Structure nucléaire (DPN) / 2036

Decay Spectroscopy of Neutron-Rich Cd Around the N = 82 Shell Closure (G)*

Authors: Nikita Bernier[1]; Iris Dillmann[None]; Reiner Kruecken[1]

Co-authors: Corina Andreoiu [2]; Gordon Ball [1]; Harris Bidaman [3]; V. Bildstein [3]; Michelle Dunlop [3]; Ryan Dunlop [3]; Lee Evitts [1]; Fatima Garcia [2]; Adam Garnsworthy [1]; Greg Hackman [1]; Andrea Jungclaus [4]; Dylan Perry Kisliuk [5]; Jens Lassen [1]; Andrew MacLean [3]; Mohamad Moukaddam [1]; Bruno Olaizola Mampaso [6]; Jason Park [7]; Costel Petrache [8]; Jennifer Pore ; Allison Radich [9]; james smallcombe ; Jenna Smith [1]; Carl Svensson [3]; Andrea Teigelhoefer [1]; Joseph Turko [3]; Tammy Zidar [3]

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The neutron-rich Cadmium isotopes around the well-known magic numbers at $Z = 50$ and $N = 82$ are prime candidates to study the evolving shell structure observed in exotic nuclei. Additionally, the extra binding energy observed around the nearby doubly-magic ^{132}Sn has direct correlations in astrophysical models, leading to the second r-process abundance peak at $A \approx 130$ and the corresponding waiting-point nuclei around $N = 82$. The β-decay of the $N = 82$ isotope ^{130}Cd into ^{130}In was first studied a decade ago [1], but the information for states of the lighter indium isotope (^{128}In) is still limited. Detailed $\beta\gamma$-spectroscopy of ^{128}Cd was accomplished using the GRIFFIN [2] facility at TRIUMF, which is capable of performing spectroscopy down to rates of 0.1 pps.

The ongoing analysis of the ^{128,131,132}Cd will be presented. Already in
^{128}Cd, 28 new transitions and 11 new states have been observed in addition to the 4 previously observed excited states [3]. These new results are compared with recent Shell Model calculations. For ^{131}Cd, results will be compared with the recent EURICA data. These data highlight the unique capabilities of GRIFFIN for decay spectroscopy on the most exotic, short-lived isotopes, and the necessity to re-investigate even "well-known" decay schemes for missing transitions.

[1] I. Dillmann *et al.*, Phys. Rev. Let. 91, 162503 (2003)

[2] C.E. Svensson and A.B. Garnsworthy, Hyperfine Int. 225, 127 (2014)

[3] B. Fogelberg, Proc. Intern. Conf. Nuclear Data for Science and Technology, Mito, Japan, p.837 (1988)

T4-7 Physics of Biosensing (DPMB) | Physique de la biodétection (DPMB) / 2037

Laser-Induced Breakdown Spectroscopy as a Rapid Diagnostic Tool for Bacterial Detection and Discrimination (G)*

Author: Alexandra Paulick[1]

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Bacterial pathogens can be differentiated via an elemental analysis technique known as laser-induced breakdown spectroscopy (LIBS). This technique can be of use in the rapid identification of bacterial pathogens, for which there is a high demand, particularly in a clinical setting. The identification of bacteria with LIBS must therefore be possible with the types and numbers of bacterial cells that would be obtained from a clinical diagnostic test. This talk will introduce the underlying principles behind the technique, summarize our current progress to date, and present our efforts to advance the use of LIBS for bacterial identification in a clinical setting.

Specifically, we will describe how the laser-induced plasma is created on our bacterial targets utilizing a nanosecond pulsed laser; how the time-resolved emission spectra are collected and analyzed using a high-resolution Echelle spectrometer; and how computerized chemometric algorithms are used to differentiate the highly-similar LIBS emission spectra from different bacterial species and genera. A sample preparation method for separating the bacteria from the other unwanted biological matter that could be present in a clinical specimen will be presented. A method for mounting the bacteria that improves our bacterial limit of detection compared to previous mounting procedures will also be presented. Lastly, we will report on our efforts to detect bacteria that have been collected using pathology swabs currently in use in the clinical setting.

T2-6 Experimental Techniques (DCMMP) | Techniques expérimentales (DPMCM) / 2038

Design Study for CLS 2.0

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The Canadian Light Source (CLS) located in Saskatoon on the campus of the University of Saskatchewan has been in operation since 2005. Upon completion of the Phase III beamlines in 2019, the total number of end-station will be over 25, leaving space for only one last beamline. In light of the growing demand for synchrotron light and the advances in accelerator physics in the past 20 years since the CLS was designed, a new Conceptual Design Report is being prepared to explore how the needs of Canadian scientists can be met. This talk will cover the trends in synchrotron light sources, the state-of-the-art technology and the present status of the CLD 2.0 design study.

PPD Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (5) | Session d'affiches PPD et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (5) / 2039

POS-47 Anarchy and rephasing invariants for neutrinos

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The implications of the anarchy principle on CP violation in the lepton sector are investigated. A systematic method is introduced to compute the probability density functions for the CP-violating rephasing invariants of the PMNS matrix from the Haar measure relevant to the anarchy principle. Contrary to the CKM matrix which is hierarchical, it is shown that the Haar measure, and hence the anarchy principle, are very likely to lead to the observed PMNS matrix. Predictions on the CP-violating Dirac and Majorana rephasing invariant are also obtained. They are in agreement with the experimental hint from T2K for the normal (or inverted) hierarchy.

W3-6 Particle Physics VIII (PPD) I Physique des particules VIII (PPD) / 2040

Measurement of the Drell–Yan triple-differential cross section in pp collisions at $sqrts$ = 8 TeV

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A measurement is presented of the triple-differential cross section for the Drell–Yan process $Z/\gamma^* \to \ell^+\ell^-$, where l^+l^- is an electron or a muon. The analysis usespp collision data at a centre-of-mass energy of $\sqrt{s} = 8$TeV collected by the ATLAS detector at the LHC in 2012. The measurement is performed for invariant masses of the lepton pairs, $m_{\ell\ell}$, between 46 and 200 GeV using a sample of 20.2 fb^{-1}. The data are presented in bins of invariant mass, absolute di-lepton rapidity, $|y_{\ell\ell}|$, and the angular variable $\cos\theta^*$ between the outgoing lepton and the incoming quark in the Collins-Soper frame. The measurements are performed in the range $|y_{\ell\ell}| < 2.4$ in the muon channel, and extended to $|y_{\ell\ell}| < 3.6$ in the electron channel. The cross sections are used to determine the Z boson forward-backward asymmetry as a function of $|y_{\ell\ell}|$ and $m_{\ell\ell}$. The measurements achieve high precision, below the percent level in the Z pole region, excluding the uncertainty in the integrated luminosity, and are in agreement with predictions. These precision data are sensitive to the parton distribution functions and the effective weak mixing angle.

W4-1 Energy Storage 4 (DCMMP) | Accumulation d'énergie 4 (DPMCM) / 2041

Bispyridinylidene Anolyles for Organic Redox Flow Batteries

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Redox flow batteries, which utilize solutions of active materials (anolyte and catholyte) rather than the solid state electrodes found in conventional batteries, are highly promising for stationary energy storage applications. Whereas most redox flow cells are based on metallic active species in aqueous media, we have been working on developing flow batteries based on solutions of redox active organic compounds in organic solvents that have the potential for higher energy density. Organic compounds with high redox potentials, which can be used for catholyte solutions, are available, but

in order to take advantage of the high cell potentials that are possible in organic solvents, new organic anolyte materials with lower redox potentials are needed. This presentation will outline our assessment of bispyridinylidene-based anolytes in a totally organic batteries featuring a catholyte based on 2,2,6,6-tetramethyl-1-piperidinyloxy. The bispyridinylidene is a relatively low voltage two-electron donor that can be modified to improve its solubility and to limit its ability to diffuse through the ion exchange membrane. Though cycle life needs to be improved, the cells display good coulombic and voltage efficiencies, and operate at ˜ 2 V.

W3-6 Particle Physics VIII (PPD) I Physique des particules VIII (PPD) / 2042

Search for dark matter candidates produced in Z(ll) + ETmiss events in 13 TeV proton-proton collisions with the ATLAS detector at the Large Hadron Collider (G)

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The ATLAS detector has been in an intense period of data-taking since the start of Run 2 in 2015. With 86 fb-1 collected so far, the prospects for discovering dark matter at the LHC have never been higher. WIMP dark matter may be produced in proton-proton collisions, yielding an excess of collision events with a large amount of invisible missing transverse momentum (ETmiss); such a process could cause a significant recoil in the other Standard Model particles produced in the event. A leptonically decaying Z boson is used as the recoiling tag particle in these mono-Z(ll) signatures. In this talk an overview of the analysis will be presented, including the signal models studied, major backgrounds and their estimation techniques, and the procedure used to set limits on the dark matter particles. Results will be presented, and prospects for this search using the full 2015-2018 Run 2 dataset will be discussed.

T3-5 Hadronic Physics (DNP) | Physique hadronique (DPN) / 2043

SoLID Heavy Gas Cherenkov Prototype (G)*

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The Solenoidal Large Intensity Device (SoLID) is a new detector planned for installation at Jefferson Lab's (JLab) Hall A, as part of the 12 GeV era of JLab physics. This detector will have a large acceptance, and be capable of operating at high luminosity, enabling multiple new experiments probing the inner structure of nucleons. We have received funding from CFI and Fedoruk Institute to build a prototype segment of SoLID's Heavy Gas Cherenkov detector (HGC) at University of Regina, in conjunction with Duke University. This detector will contain C_4F_{10} gas at a pressure of 1.5 atm, and will be used in identification of both positive and negative pions. In this talk we discuss the design challenges of the SoLID HGC, which must be strong enough to hold the pressure without bursting or leaking the expensive gas, and must have an entry window as thin as possible, to minimize impact on the data.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2044

POS-13 Failure-mode history-dependence in single crystal NMC532 / graphite Li ion cells

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In a real-world situation, a battery is not cycled continuously until death nor stored endlessly at top of charge. Test conditions should mimic real-world situations to better understand different failure mechanisms occurring within cells of the same build and electrolyte. Three complimentary tests are proposed to probe cycle-dependent and time-dependent aging under a spectrum of voltage and temperature stresses.
First, single crystal LiNi0.5Mn0.3Co0.2O2 (NMC)/graphite cells were evaluated under continuous cycling conditions. Cells were charged and discharged continuously (3 hour charge and 3 hour discharge) between 3.0 and 4.2 or 4.3V at 20, 40, or 55oC. Every 50 cycles there was a slow (20 hour charge and 20 hour discharge) cycle to monitor capacity loss. The slow cycle is assumed to be unaffected by decrease in cell rate capability. The capacity loss of the slow cycles was well described by an expression following the square root of time, and that this expression followed Arhennius'law to describe the acceleration of failure due to increased temperature.
Next, cells were evaluated under storage conditions. Cells were stored at "shipping voltage", 4.0, 4.1, 4.2, and 4.3V at 20, 40, and 55oC with regular (two week diminishing to five month frequency) reference performance tests (RPTs). A RPT includes 3 hour and 20 hour cycles (as above) from 3.0-4.1V at 20oC. Standardized conditions allowed absolute capacity loss and impedance growth to be compared directly across temperatures and voltages. Similar to cycling, C/20 capacity loss is proportional to the square root of time. Increased temperature has a stronger detrimental effect on cells stored at high potential than on cycled cells.
Finally, cells were evaluated using a hybrid cycle-store protocol. Cells cycling with 3 hour charge and discharges were allowed to rest open circuit at top of charge for 0, 12, 84, or 180h. Cells were tested to 4.1, 4.2, and 4.3V at 40oC. Capacity retention and impedance growth is worst for cells with the 12h storage condition. This observation can be explained based on the results of the previous two experiments as will be demonstrated.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2045

POS-21 Revealing the unwanted reactions in lithium-ion cells with isothermal microcalorimetry

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Improving the cost, lifetime, and energy density of lithium-ion cells is critical in the transition away from fossil fuels for energy production and transportation. Increasing the operational voltage of a lithium ion cell is one way to increase energy density and decrease cost. However, traditional solvents used in lithium-ion electrolytes are not stable at these potentials, causing what are termed

'parasitic reactions'–or the decomposition of electrolyte species into unwanted products. These reactions consume lithium content and electrolyte species, decreasing the available capacity of the cell, and can create films of reaction products on the electrodes which mitigate ion transfer, ultimately leading to cell death [1]. Due to the complexity of the electrochemical system, the exact mechanisms of parasitic reactions are often unknown and vary depending on electrode materials and coatings, electrolyte solvents, lithium salts, electrolyte additives, etc.

Isothermal microcalorimetry offers a unique way to probe parasitic reactions *in-situ* and non-destructively. The heat flow of a lithium-ion cell during operation has contributions from entropy changes in the electrode materials, the internal resistances in the cell (joule heating), and parasitic reactions. The heat flow from parasitic reactions can be found using a careful analysis during charge and discharge cycling of a cell. Using this analysis method, the parasitic heat flow has been found to directly correlate to cell lifetime [2, 3]. This presentation will highlight the advantages of this technique and how isothermal microcalorimetry has be used to aid in the design and understanding of electrolyte systems for high energy density, long lifetime lithium-ion cells.

[1] Xu, K. *Chem. Rev.* **2014**, 114, 11503–11618.
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M2-3 Particle Physics II (PPD) | Physique des particules II (PPD) / 2046

Update on the KDK (40K decay) experiment

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The nature of the dark matter thought to make up most of the matter in the universe is unknown. It may consist of new particles from beyond the standard model. For close to two decades, the DAMA experiment has claimed to have detected such particles. This claim is controversial, in particular because there is no accepted model for the background radioactivity in DAMA. One major unknown is the contribution of the decay of potassium 40 (40K) by electron capture (EC) to ground state. The KDK (40K decay) experiment at Oak Ridge National Laboratories (ORNL) brings together groups from Queen's, ORNL, the University of Tennessee, the Max Planck Institute and TRIUMF. KDK will measure the EC branching ratio using a 40K source, a small detector to trigger on the 3 keV X-rays from EC, and a large outer detector to veto the 1.4 MeV gamma rays coming from the competing electron capture decays to an excited state. We will present the status of the experiment, including data taking.

R1-2 Medical Imaging 2 (DPMB) | Imagerie médicale 2 (DPMB) / 2047

Machine Learning Applications in Functional Neuroimaging Data (I)

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The overarching goal of my research is to improve methods for non-invasively mapping the spatial and temporal patterns of electrophysiological activity that underlies human brain function and dysfunction. My team at the Biosignal Lab studies brain electrophysiology with magneto- and

electro-encephalography (M/EEG). These technologies provide spatially and temporally rich data about the changing magnetic fields and electric potentials resulting from synchronous neuronal activity, and how these signals change during perception and task performance. One approach that shows promise for studying M/EEG signal properties in this context is the use of pattern classification algorithms, or machine learning. We use machine learning to develop data-driven models that accurately classify between M/EEG data recorded at rest and data recorded during task performance. We look "under the hood" of effective models to understand what spatial and temporal patterns of the magnetic field and electric potential are driving accurate classification. This interpretation informs our understanding of the link between electrophysiology and information transfer in the human brain.

Much of the work that I will present focuses on small datasets (on the order of tens of human participants) acquired locally. I will show how machine learning allows us to determine which signals in which brain areas most strongly predict when a person is performing a task versus resting, and how these signals vary across a group. I will also present data to show how we are now using machine learning with large open-access datasets (on the order of hundreds of participants). In these larger datasets, we start to examine demographic shifts in task-related neuromagnetic activity and inter-subject variability. We also apply more complex (so-called "deep learning") pattern classification algorithms to explore brain electrophysiology in a way that has not been possible until recently.

Applying machine learning uncovers new ways to make predictions based on neuroimaging data. These predictions may be about what the person is doing, or the predictions could relate to how well the person is doing a task, if a person is unwell, or if their current course of treatment is likely to make them better. My research has the potential to inform the development of these predictive models.

R3-5 Multimodal and Nonlinear Imaging in Biological Systems (DPMB) | Imagerie multimodale et non-linéaire dans les systèmes biologiques (DPMB) / 2048

First observation of dinosaur skin layers using synchrotron radiation

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In this contribution, I will discuss the measurements using synchrotron radiation that led to the discovery of a remarkably well preserved skin layer of a hadrosaur from the Grand Prairie region. This is first ever observation of preserved epidermal skin layers in a large dinosaur. I will also present a direct comparison between these structures and those from an extant avian specimen, giving the first substancial evidence of the similarities between the organic layout of the skins of extinct non-avian and extant avian dinosaurs.

W3-2 Energy Storage 3 (DCMMP) | Accumulation d'énergie 3 (DPMCM) / 2049

Analyzing the Effect of Surface Coatings on Lithium Cycling Efficiency via Combinatorial Analysis

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There is a continual push to improve the energy density of lithium-ion batteries, but this is becoming increasingly difficult as it is believed that many of the best electrode materials have been found and optimized. In order to achieve higher energy densities to meet future storage demands it may be necessary to move "beyond lithium-ion".
Recent research efforts have focused on reviving the lithium metal negative electrode as a potential path to higher energy density [1]. With its high theoretical capacity and lowest reduction potential among metals, using lithium as a negative electrode can certainly increase the energy density of a cell. However, lithium metal anodes often demonstrate dendrite formation during electrodeposition instead of plating as a smooth film. Since conventional organic electrolytes are thermodynamically unstable to reduction by lithium, dendrite growth leads to continual loss of active lithium, resulting in poor cycling efficiencies (< 90%) and short cell lifetime [2]. These problems are exaggerated as the thickness of the plated lithium increases, making cells with industrially relevant material loadings a significant challenge.
Recent studies have shown that the morphology and plating efficiency of lithium can be greatly improved with nanostructured surface coatings [3,4]. Herein we report on the use of combinatorial materials analysis to investigate the effect of different nanostructured surface coatings on the electrochemical deposition of lithium metal. High throughput sputtering was used to make libraries of thin films with different composition, structure, and thickness. These sputtered libraries were deposited directly on 64-channel electrochemical cell plates and used to analyze the morphology and plating efficiency of lithium as a function of the 64 individual surface coatings. The influence of different electrolyte compositions with these surface coatings was also investigated. These results provide perspective regarding the value of thin film anode surface coatings as part of a broad strategy for achieving high (>98 %) lithium cycling efficiencies.

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T4-1 Energy Storage 2 (DCMMP) | Accumulation 2 (DPMCM) / 2051

Impact of aluminum substitution on the electronic and thermodynamic properties of NCA materials for lithium-ion batteries using first-principles methods (G)

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Tuning positive electrode materials in lithium-ion cells provides a promising means for lowering cost of materials while maintaining safety and energy density standards. Due to the rising cost of cobalt, it is important to find less expensive alternatives. Here we present results from first-principles computations within the formalism of density functional theory examining changes in electronic properties and thermodynamic stability of $Li_xNi_{1-y-z}Al_yCo_z$, where $0x1$ and $0y, z0.2$, positive electrode materials as a function of cobalt, aluminum, and lithium content. Results using a new exchange-correlation functional (SCAN) [1,2] within the class of meta-GGAs are compared

with the traditionally employed empirical GGA+U. Fundamental understanding of these properties may help in designing less expensive positive electrode materials.

[1] Strongly Constrained and Appropriately Normed Semilocal Density Functional, J. Sun, A. Ruzsinszky, and J.P. Perdew, Phys. Rev. Lett. 115, 036402 (2015)
[2] Accurate first-principles structures and energies of diversely bonded systems from an efficient density functional, J. Sun et al., Nature Chemistry 8, 831–836 (2016)

: R1-5 History of Physics (DHP) | Histoire de la physique (DHP) / 2052

The Role of the Cyclotrons in Photosynthesis Research

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Since the nineteenth century, biochemists and physiologists from all around the world tried to elucitade the pathways of intermediary metabolism of living organisms as for instance, in higher plants:

« One cannot emphasize too strongly that in the plant the synthesis of all organic substances must revert to the initial mechanism involved in the synthesis of carbohydrates, so that the synthesis of proteins, fats, alkaloids, acids, etc., is in the last analysis dependent upon the photosynthetic mechanism » (R. A. Gortner, Outlines of Biochemistry, 1929).

« En raison des relations certaines des glucosides avec les hydrates de carbone, des relations possibles des albuminoïdes avec les alcaloïdes, fournir aux questions posées une réponse définitive, ce sera résoudre, en grand partie, le problème des cycles de l'azote et du carbone » (A. Goris, Localisation et rôle des alcaloïdes chez les végétaux, 1914).

Only with the indispensable help of radioactive tracer techniques, notably C-14 position-specific putative precursor, that fundamental advances in the field of molecular biology of plants were made. Here, we discuss how the invention of the cyclotron by Ernest O. Lawrence and his coworkers in the 1930s was a crucial step to trace the path of carbon in photosynthesis, thus allowing effective progress in life sciences.

R3-5 Multimodal and Nonlinear Imaging in Biological Systems (DPMB) | Imagerie multimodale et non-linéaire dans les systèmes biologiques (DPMB) / 2053

Determination of the origin of third harmonic generation in bone for intravital nonlinear optical microscopy of bone tissue

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Osteocytes, the most abundant cells present in bone, regulate bone mass by chemical signaling through the lacunar-canalicular network (LCN). Bone diseases such as Hypophosphatemic Rickets cause painful bone twisting in children, and progress on understanding this disease is slow. The structural and mechanical properties of the LCN are difficult to understand since the LCN is embedded in bone, complicating in vivo studies. Currently, serial sectioning is most commonly used to study the LCN however, it usually produces morphological distortion because soft tissue embedded in bone does not cleave well.

Alternatively, nonlinear optical microscopy can be used to interrogate the LCN noninvasively with high spatial resolution in vivo without requiring physical sectioning. Nonlinear optical microscopy with ultrafast femtosecond fibre lasers in the telecom wavelength range have several advantages including improved penetration through bone and emission of third harmonic generation (THG) signal in the visible wavelength range. The LCN produces THG while the collagen in bone produces second harmonic generation (SHG).
To determine the origin of the THG signal from the LCN, an investigation was performed. Laser ablation was performed in bone in order to study the THG signal directionality. Forward- and epi-detected THG imaging was performed in live, dissected and ablated bone. It was found that THG signal is directed mostly in the forward direction, and originates from the bone-interstitial fluid boundaries. Interestingly, the THG intensity of canaliculi varied depending on their angle to the optical plane, having significantly higher amplitudes at higher angles.
Subsequently, a study of mice with transgenic hypophosphatemic rickets was performed to demonstrate the technique. THG imaging revealed statistically significant differences in the lacunar volume and density of canaliculi, offering the opportunity to study dynamical structural changes to the LCN during disease progression.

T3-6 Developing Scientific Practices in the Laboratory (DPE) | Exercice de la science en laboratoire (DEP) / 2054

Custom built laser instrumentation laboratories for physics and chemistry courses

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Undergraduate students are typically introduced to advanced optical instrumentation during their senior physics and chemistry courses. Experiments available from educational companies typically use low end optics in customized formats, beneficial for younger students eager to explore the physical and chemical phenomena under study. However, these setups prevent senior students from learning more advanced optical techniques increasingly desired by employers, such as experience with laser beam alignment, laser beam quality and divergence, the function of real (imperfect) optics, and limitations of photodetectors. Therefore, senior students would benefit from experience with the same professional equipment used in advanced research and development laboratories.

Consequently, we have developed three laboratory modules that provide students with the opportunity to build their own advanced instrumentation, allowing them to learn laser-based instrumental procedures while simultaneously determining the function of advanced optical components. In one experiment, students build a laser interferometer with which they study the temperature dependency of the refractive index of solutions. In a second module, students develop their own laser-beam profiler. In a third experiment, students develop their own laser-based polarimeter to measure polarization scattering and optical rotation by incorporating Stokes-based measurements.

The experiments consist of standard laboratory optics and optomechanics, more expensive than the low-cost versions of these instruments, but less expensive than the instruments sold by educational companies. Further, these parts are of high quality, and by choosing standard optics, compatibility issues are nonexistent. Optical components can be easily re-combined to produce alternative arrangements, allowing senior students to perform novel proof of principle optical techniques in literature. As a result, students gain understanding, confidence, and excitement for science, as well as practical experience by assembling, operating, and troubleshooting their devices. Furthermore, because students use the same equipment found in professional optics labs, they are more prepared for the workplaces of tomorrow.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2055

Decay of the false Skyrmions

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We consider the decay due to tunnelling of metastable Skyrmions that exist in the false vacuum. The possible mass term for the pions explicitly breaks the chiral symmetry. The only phenomenological constraint on the mass term is that the resultant pion mass be small. This allows for the possibility of local minima of the potential, which could give rise to metastable, so-called false vacuum configurations. The false vacuum can decay due to instantons, however, it can also entrap false Skyrmion configurations, which are unstable due to quantum tunnelling. We establish the existence of the false Skyrmions, and we compute the decay rate of the false Skyrmions in the thin wall limit.

R1-2 Medical Imaging 2 (DPMB) | Imagerie médicale 2 (DPMB) / 2056

Axon Diameter Measurements in the Human Corpus Callosum using Oscillating Gradient Spin Echo Sequences

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Recently methods to measure axon diameter distributions using magnetic resonance imaging (MRI) diffusion spectroscopy have been developed. Most early methods used single diffusion encoding sequences such as pulsed gradient spin echo and are thus sensitive to axons of diameters larger than 5 μm. We previously simulated oscillating gradient (OG) spin echo sequences to study smaller axons which include the majority of axons constituting cortical connections. Here we test the use of OG to infer axon diameters on regions of interest within a human brain autopsy sample containing the corpus callosum, the ependymal layer, and the cortex. To our knowledge, this is the first study using OG temporal diffusion spectroscopy for inferences of human axon diameters.
A portion of the normal-appearing corpus callosum from an autopsy of human brain was kept in formalin before being prepared for imaging. 24 hours before MRI it was replaced with PBS. For imaging it was subsequently placed into a sample tube filled with agarose (2% w/v) in a 15 mL sample tube. The sample was imaged using a 7 T MRI. Each 20 ms sinusoidal gradient pulse ranged from n = 1 to 15, in steps of 1. Six gradient strengths were used for each frequency and gradient pulses were separated by 24.52 ms.
Signals were fitted using two models, a two compartment ActiveAx model and AxCaliber model, using least squares minimization and mean axon diameters were extracted.
Ten 2000x magnification electron microscopy slices were studied from the region above the corresponding MRI. Axon diameters were manually measured using ImageJ software by drawing lines across the smallest diameter of cells that could be identified as axons.
Using the ActiveAx model, the mean effective diameter for axons in the corpus callosum ranged from: 1.8 ± 0.1 μm to 2.34 ± 0.05 μm. The mean effective diameter for ependymal cells in the ependymal layer ranged from 2.58 ± 0.06 μm to 2.80 ± 0.06 μm. Using the AxCaliber model, the axon diameter distribution indicated size of axons in the range of 0.9 to 3 μm. Our measurements made using histological techniques found 0.1-6 μm axon diameters in the sample, with an average overall of 0.6 ± 0.5μm, which is consistent with other histology measurements.
Our preliminary results indicate our method is sensitive to axons in the 2 μm range which is smaller

than previous measurements. These axons constitute the majority of cortical connections making our measurements clinically relevant. Higher gradient frequencies will be needed for future studies to probe even smaller diameters and more work needs to be done to optimize the choices of gradient amplitudes, gradient frequencies, and SNR to make a method which can be used on live animals. This is the first step toward inferences of micron-sized axon diameters in the human corpus callosum.

T2-6 Experimental Techniques (DCMMP) | Techniques expérimentales (DPMCM) / 2057

MacSANS: Small Angle Neutron Scattering for Nanostructured Materials at McMaster University

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MacSANS is a new small angle neutron scattering (SANS) beamline currently under construction at the McMaster Nuclear Reactor, a 5 MW research reactor based at McMaster University in Hamilton, Ontario. This beamline is designed to study a broad range of materials, including biological membranes, polymers, superconductors, and novel magnets, by probing structure and magnetism on length scales ranging from ˜0.5 to 125 nm. MacSANS will be the only instrument of its kind in Canada, and is scheduled to begin commissioning experiments in the spring of 2019. In this poster we will provide an overview of the instrument design, a description of the major components, and a discussion of potential scientific applications.

T3-3 Particle Physics IV (PPD) | Physique des particules IV (PPD) / 2058

Search for new dark sector particles in Higgs boson decays with the ATLAS detector at the LHC (G)*

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The recent discovery of the Higgs boson (h) is an affirmation of the Standard Model (SM) of particle physics and concludes several decades of experimental searches. However, the experimental investigation of its properties has just begun. Current measurements of h properties permit the fraction of h decays to Beyond-Standard-Model (BSM) particles to be as high as approximately 30%. These exotic decays are also well-motivated theoretically. Of particular interest is the decay of h to two dark sector particles each called Zd. This decay occurs in models where h interacts with a dark sector which could have a rich and interesting phenomenology like the SM. A dark sector could naturally address many of the questions left unanswered by the SM. The higher rate of h production resulting from the increased proton beam intensity and energy of the Large Hadron Collider (LHC) in the 2015-2018 data-taking run –combined with strong theoretical motivation and tantalizing hints seen in past searches –makes this decay a promising avenue for the

discovery of new physics. I will present current results of this search, and prospects for the full 2015-2018 dataset.

T4-3 Particle Physics V (PPD) | Physique des particules V (PPD) / 2059

Status of the Belle II Experiment on the SuperKEKB Collider (I)

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The Belle II electron-positron collider experiment at the KEK laboratory in Japan is undergoing detector commissioning this year, with first data taking using the full detector planned for early 2019. I will present the physics goals and current status of the project with a summary of recent activities relating to detector construction and the commissioning of the SuperKEKB accelerator. I will also report on the activities of Canadian groups that contribute to Belle II, as we commence the operational phase of the project.

T4-4 Films, surfaces and composites (DCMMP) | Films, surfaces et composites (DPMCM) / 2060

Structure and Properties of Exfoliated MoS2-Polyaniline Nanocomposites

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Molybdenum disulfide was produced in an exfoliated state by combining molybdic acid with an excess of thiourea at 500℃ under nitrogen. Nanocomposites of the conducting polymer polyaniline (PANI) and exfoliated MoS2 were then synthesized. The nanocomposites with varying percentage by weight of exfoliated MoS2 were characterized using powder X-Ray diffraction, electrical conductivity measurements, Seebeck coefficient measurements, thermogravimetric analysis, scanning electron microscopy, and transmission electron microscopy. An intriguing result was seen in the conductivity data, where several of the nanocomposites containing relatively small percentages of exfoliated MoS2 yielded higher conductivity overall in comparison to a sample of pure PANI. The exfoliated MoS2 used in this work is highly disordered, and is expected to be predominantly the 2H polytype. This form of MoS2 has very low conductivity, thus the increased conductivity of the nanocomposite suggests that PANI is most likely stabilizing MoS2 in its 1T metallic form, which is higher in conductivity.

R2-4 Theoretical and computational biophysics (DPMB) | Biophysique théorique et calculatoire (DPMB) / 2062

Sequence-specific random-phase-approximation theory for polyampholytic intrinsically disordered proteins in liquid-liquid phase separation

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Intrinsically disordered proteins (IDPs) are proteins lacking hydrophobic but are enriched in polar, charged, and aromatic amino acids. IDPs do not fold into a unique structure in isolation and often remain disordered in performing biological function. Recently, some IDPs have been discovered to undergo reversible liquid-liquid phase separation (LLPS) in aqueous solution, forming membraneless organelles of condensed IDPs or mixtures of IDPs with other proteins and/or nucleic acids in the cell. Without a membrane, these organelles can rapidly respond to environmental stimuli, thus playing critical roles in many biological functions. Charge sequence pattern has been identified as one of the most important determining factor for the propensity of an IDP to undergo LLPS. To understand this sequence-specific phenomenon, we develop a random-phase-approximation (RPA) theory for phase separation of polyampholytic IDPs. We have applied our theory to the disordered N-terminus region of RNA helicase Ddx4 proteins, an IDP enriched in charged and aromatic amino acids. Our theory predicts that Ddx4 phase behavior is significantly influenced by its charged sequence and pi-electron interactions driven by aromatic rings, consistent with experiments on wild-type, a charge-scrambled mutant, and a mutant with reduced aromaticity of Ddx4. We then investigated 30 model sequences that are different permutations of an equal number of positively and negatively charged residues. We demonstrated a strong correlation between phase separation and single-chain compactness of IDPs. We have also researched salt-free ternary aqueous solutions including two different IDP species. Depending on the similarity/dissimilarity in charge pattern between the two IDP sequences, they can either coalesce or exclude each other when forming LLPS. Such sequence-sensitive phase behavior indicates a possible "fuzzy" mechanism for molecular recognition between IDPs. Our theory can be applied to arbitrary charged biopolymers as a general framework for studying sequence-dependent biological phase separation.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2063

POS-20 Structural, Electrochemical and Thermal Properties of Nickel-rich LiNixMnyCozO2 Materials

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Nickle-rich LiNixMnyCozO2 (x + y +z = 1) (NMC) (Ni content higher than 60% of the total transition metals) is one of the most promising positive electrode materials for lithium-ion cells due to its high specific capacity of up to 220 mAh/g. Conventional NMC materials such as LiNi0.4Mn0.4Co0.2O2,

LiNi0.5Mn0.3Co0.2O2, LiNi0.6Mn0.2Co0.2O2 etc. have more than 20% Co among the transition metal atoms. However, the high price of Co prevents the development of lithium ion batteries with low cost and high energy density for grid energy storage and electric vehicles. To lower the Co content while still maintaining good electrochemical performance, herein, the authors studied three series of materials with different transition metal ratios, which are LiNi0.6Mn(0.4-x)CoxO2 (x=0, 0.1, 0.2), LiNi(0.9-x)MnxCo0.1O2 (x=0.1, 0.2, 0.25) and LiNi0.8Mn(0.2-x)CoxO2 (x=0, 0.1, 0.2). The materials were synthesized via a co-precipitation-solid state sintering method [1, 2]. Powder X-ray diffraction and Rietveld refinement were carried out to investigate the structural properties of the materials. Coin-type cells were made to measure the electrochemical properties of the materials. In addition, accelerating rate calorimetry (ARC) was used to study the safety of charged NMC cathode materials in the presence of electrolyte. It was found that LiNi0.6Mn0.3Co0.1O2 and LiNi0.7Mn0.2Co0.1O2, which have 50% less Co content than current commercialized materials, exhibited excellent capacity and thermal stability, and therefore deserve careful consideration as next generation materials.

[1] van Bommel, Andrew, and J. R. Dahn. "Analysis of the growth mechanism of coprecipitated spherical and dense nickel, manganese, and cobalt-containing hydroxides in the presence of aqueous ammonia." Chemistry of Materials 21.8 (2009): 1500-1503.

[2] Li, Jing, et al. "Synthesis of Single Crystal LiNi0.5Mn0.3Co0.2O2 for Lithium Ion Batteries." Journal of The Electrochemical Society 16a4.14 (2017): A3529-A3537.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2064

POS-19 Carbon allotropes grafted with poly (pyrrole) derivatives via living radical polymerizations: electrochemical analysis of nano-composites for energy storage

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Carbon-based nanomaterials are key components in energy storage devices. Their functions can be tailored by adjusting or developing new synthesis pathways. In this study, two living radical polymerization techniques, an electrochemically-aided atom transfer radical polymerization (e-ATRP) and reversible addition chain transfer polymerization (RAFT), were applied for grafting of carbon allotropes such as multi-walled carbon nanotubes (MWCNT), graphene and single-walled carbon nanohorns (SWCNH) with a 2-(1H-pyrrol-1-yl)ethyl methacrylate. The functionalized carbons were examined as polymerization initiators in the RAFT and e-ATRP synthesis. The Fourier-transform infrared and Raman spectroscopies were used to identify the reaction products at each phase and for the final composites. TEM imaging showed that the morphology of composites made from the same carbon allotrope are not significantly different for RAFT and e-ATRP products; and the structure of the ultimate product strongly depends on the type of carbon. Also, the poly(pyrrole) film or the particle size was very small (in all cases less than 30 nm), demonstrating the control over the polymer morphology in living polymerization techniques. The high specific gravimetric capacitances over 456 F g-1 and electrochemical stability up to 7500 cycles were obtained for MWCNT-grafted-poly(pyrrole), and slightly less for Graphene-based composites synthetized by e-ATRP, showing the advantages of this method over RAFT. The electrode voltages for all composites were higher as compared to the pure polymer electrodes, with some benefit of RAFT over e-ATRP product, and with significant improvement observed for the MWCNT- and Graphene-based systems. Regardless of the synthesis method, all composites demonstrated enhanced specific capacitance as compared to their individual components, revealing the synergy of double-layer capacitance from the carbon and the pseudo-capacitance generated by the polymer fraction.

T3-2 Thin Films, Magnetism and Solar Cells (DCMMP) | Films minces, magnétisme et piles solaires (DPMCM) / 2065

The 2D percolation transition in Fe/W(110) ultrathin films: Measurements of the phase transition line and critical exponent at finite temperature

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Percolation is a geometric condition that occurs naturally in the growth of two-dimensional (2D) films (and in many other contexts). Atoms that are deposited on a substrate aggregate to form isolated islands whose size bounds the range of correlated behavior, or correlation length, of the system. At greater deposition the islands coalesce, and at a critical fractional coverage of the substrate, p=p_c, at least one island forms a connected path throughout the entire sample. Then the correlation length has diverged and the system has "percolated". The percolation transition is a second order phase transition. When the deposited atoms normally support magnetic phases, the percolation transition is often accompanied by a second order magnetic transition, and can be studied using the magnetization M or susceptibility χ. Most experimental studies of percolation measure the properties of a series of samples, each with a fixed coverage, as a function of temperature or an applied field to determine whether or not it has percolated. This method cannot record and investigate percolation as it occurs. Our recent experiments on Fe/W(110) take the unusual approach of measuring χ(p) as the film grows at constant temperature and percolation occurs.

We have detected a sharp, narrow peak in χ(p) near a Fe coverage of one atomic layer on W(110) that is consistent with a second order phase transition. Using measurements at a series of constant temperatures, we have constructed the phase transition line in the (p,T) plane, and compared it quantitatively to the predictions of scaling theory as applied to the bicritical point (p_c , T=0). We have also made quantitative comparisons of measurements of χ(p≈p_c , T) and χ(p, T=255 K) to scaling theory and found that the phase transition is in agreement with the predictions for the 2D percolation of a 2D Ising system. In particular, we measure the percolation critical exponent of the susceptibility (or mean island size) to be γ_p=2.39±0.04, in excellent agreement with the theoretical value of 43/18.

T1-5 Quirks and Quarks (PPD/DTP) I « Quirks » et quarks (PPD/DPT) / 2066

*** Withdrawn ***AdS/QCD predictions for B decay to Kˆ* and two neutrinos

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$B \to K^* \nu \bar{\nu}$ is an excellent venue to test various model predictions for $B \to K^*$ transition form factors. Here we compare predictions for the differential branching ratio, as well as the longitudinal polarization fraction obtained from AdS/QCD holographic light-front wavefunction and QCD sum rules.

R3-3 Particle Physics X (PPD) | Physique des particules X (PPD) / 2067

Status of PICO-40L

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The PICO collaboration aims at direct detection of dark matter using superheated liquid detectors, or bubble chambers. Several generations of PICO detector have operated at SNOLAB, setting world-leading limits on the WIMP-proton spin-dependent coupling. PICO-40L is the next iteration of the PICO detector, and has been substantially redesigned since its predecessor, PICO-60. The main improvements are expected to be operational stability and background control. The construction of PICO-40L at SNOLAB is well underway, with data-taking expected to begin in the summer of 2018.

In addition to the further exploration of WIMP-coupling parameter space, the purpose of PICO-40L is to demonstrate the new design's feasibility for the next-generation ton-scale detector, PICO-500. The status of the PICO-40L detector commissioning, schedule for data-taking, and projected sensitivity to WIMP interactions will be presented.

W3-4 Soft matter and molecular dynamic (DPMB/DCMMP) | Matière molle et dynamique moléculaire (DPMB/DPMCM)) / 2068

Physical properties of model membranes: From membrane asymmetry to vitamin E (I)

Author: Drew Marquardt[1]

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Despite almost 90 years of study the physiological role of vitamin E is still muddied by controversy. Research, both fundamental and clinical, has generated conflicting and contradictory results throughout literature.

Deficiency in α-tocopherol (aToc), the physiological relevant form of vitamin E, has been show to lead to a multitude of conditions including infertility and neuromuscular dysfunctions. Many theories have been brought forward regarding the biological function of vitamin E, these include its being a ligand for some unknown receptor, and an antioxidant. Recent investigations present evidence of an antioxidant mechanism for vitamin E that correlates strongly with its physical location in a model lipid bilayer.

The proposed mechanism addresses the position of aToc in the membrane, how aToc partitions between lipids is lacking. Although assertions have been made, to the best of our knowledge, no direct experimental evidence exists on this topic. We have begun testing the partitioning of aToc into different lipid species and antioxidant hypothesis is reinforced. The data suggest that aToc preferentially resides in disordered membrane systems; those typically susceptible to oxidation. Initial experiments have observed aToc partitioning into fluid (disordered) membranes from ordered gel phase membranes.

We bring our models closer to biological membranes by investigating aToc in membrane "rafts". Lipid-only domains are well-established mimetic systems for membrane "rafts", enabling the study of their physical properties under strictly controlled conditions. We will apply a variety of experimental techniques to study the influence and partitioning of aToc into membrane "raft"compositions (coexisting liquid-ordered (Lo) and liquid disordered (Ld) phases). Preliminary investigations on lipid "raft"forming systems have shown that the introduction of aToc to the membrane increases the amount of the liquid ordered phase. This behaviour is characteristic of aToc driving cholesterol from the disordered phase, furthering demonstrating aToc preferentially partitioning into the oxygen sensitive disordered environments. These insights will help answer the question "does vitamin E partition into lipid domains which are appropriate for an antioxidant function?"

W4-2 Nonlinear Optics (DAMOPC) | Optique non linéaire (DPAMPC) / 2069

Light polarization control by reflection off an ultrathin, phase change layer

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We theoretically investigate and experimentally demonstrate polarization modulation of a beam of light interacting with a nanometer-thin layer of vanadium dioxide (VO2), a phase change material. As the material undergoes a phase transition from insulator to metal, large variations in refractive indices impart unequal phase shifts on s- and p-components of the electric field of light, thereby altering the polarization state in reflection. This control over polarization is achieved over a wide spectrum, ranging from 400 nm to above 2000 nm, on time scales of seconds to picoseconds by thermal or optical activation of VO2, and over propagation lengths of 25 nm, much shorter than in devices based on electro-optics and liquid crystals.

W3-7 Applied Physics Instrumentation (DAPI) | Instrumentation de physique appliquée (DPAI) / 2070

Hydraulic and mechanical investigations of permeable materials based on tire crumb

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Thanks to recycling and diversion initiatives over the last decade, the number of tires finding their way to landfills has been greatly reduced. The majority of rubber produced from recycled tires is in the form of crumb, which is most often created by mechanical grinding resulting in particle diameters between 1 and 5 millimeters. Because of the energy required to break and reform the chemical crosslinks that give tire rubbers their strength, much of the tire crumb produced finds application as a filler that is bound together by a continuous matrix. Typical binders include cement, asphalt and polyurethane.

We present results of experiments which explore the potential for tire crumb to be used as permeable construction materials that permit infiltration of water. As precipitation events increase in intensity, stormwater management guidelines increasingly call for infiltration of stormwater so that demands on infrastructure may be reduced. By providing a path by which stormwater can pass underground, impact of precipitation on river levels, erosion, and pollution are all reduced.

The extent to which permeability affects mechanical strength is of importance when manufacturing products such as walkways, road surfaces and other load-bearing materials. We have explored the effect of changing binder fraction and tire crumb particle size on both the compressive strength and hydraulic conductivity of composite samples. Two widely-accessible binder materials with very different mechanical properties were used: polysiloxane-based sealant and polyurethane adhesive. A wide range of sample properties were achieved with adjustment of a minimal number of process parameters and without the need for specialized components or equipment, making the results of these experiments pertinent to applications in remote locations or those where access to equipment is otherwise limited.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2071

POS-52 Calibration of a Nonlinear Optical Polarimeter

Author: Katherine Budden[1]

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Nonlinear optical microscopy is a novel technique used for imaging biological structures in tissues. The technique uses nonlinear optical processes such as second and third harmonic generation (SHG and THG, respectively), for producing image contrast. Imaging of biological tissues with SHG and THG signals has several advantages over traditional microscopy methods that rely on single-photon excitation fluorescence, including intrinsic three-dimensional imaging at submicron spatial resolution without the use of dyes. Furthermore, nonlinear microscopy techniques reduce photodamage to tissue samples since SHG and THG are parametric processes. Finally, a novel property of nonlinear microscopy is its innate ability to obtain structural information of endogenous biological structures, which is accomplished by the use of polarization resolved measurements.

Performing polarization resolved measurements in nonlinear microscopy allows the extraction of nonlinear susceptibility elements which can be analysed for structural sample analysis. These measurements are typically performed by modulating the polarisation of the incident laser, and measuring the polarization of the outgoing SHG and THG signals. Currently, polarisation nonlinear microscopy is a slow process due to the use of rotating actuators limiting dynamic information. While several groups have begun using faster polarization schemes, they do so while sacrificing polarization states.
Fast polarization modulation at different wavelengths are being investigated for nonlinear optical microscopy. Modeling of polarization modulation by liquid crystal phase retarders was implemented with Python using Jones and Mueller polarization calculus to quantify measurement states with the least error and the most information. Monte-Carlo modeling results will be presented quantifying the different polarimetry states. Additionally, experimental data of calibrating liquid crystal polarization modulators will be presented. Future implementation of this multi-spectral polarimeter with a nonlinear microscope is expected to allow structural determination in for example, live tissue, where diseased tissue can be monitored during treatment, potentially replacing current invasive and time-consuming traditional histology methods.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2072

POS-3 Studying Medium-Sized Molecules in the Far-Infrared Spectral Region with the Canadian Light Source

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Pyrrole and furan, two aromatic five-membered ring molecules, have been the subject of extensive ab initio and experimental studies. We have taken Fourier transform far-infrared spectra of these molecules at the Canadian Light Source. Two fully-entangled vibrational bands of furan, n8 and n21 at ˜ 870 and 873 cm-1, that are present in the spectra show some perturbations and interact with each other via Coriolis coupling. In pyrrole, a weak c-type band, n13 at ˜ 830 cm-1, is observed, in addition

to two other vibrational modes of pyrrole, n9 and n10 at ˜ 880 and 864 cm-1, that experience the same perturbation as do the bands of furan. We will discuss our analysis and attempts at deperturbation of these bands.

A larger related molecular system, Catechol, consists of a six-membered ring and two OH groups. The high-resolution rotation-vibration spectra of this molecule have never been taken. However, low-resolution data [1]show some vibrational transitions between ˜ 450-4000 cm-1. Motivated by the potential applications of ring molecules in the field of molecular electronics, we decided to take high resolution spectra of Catechol at the Canadian Light source in Saskatchewan. Our progress in obtaining rotationally resolved vibrational spectra of Catechol will also be discussed.

References:
[1] http://webbook.nist.gov/cgi/cbook.cgi?ID=C120809&Mask=80

T2-6 Experimental Techniques (DCMMP) | Techniques expérimentales (DPMCM) / 2073

quasiparticle research on 3d material using ARPES

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In this presentation, I will present the many-body interactions in solids studies by high resolution ARPES. High-resolution angle-resolved photoemission spectroscopy studies of Fe (1 1 0) ; Ni(110) and other 3d single crystals have been conducted to clarify the role of many-body interactions acting on the quasi-particles at the Fermi level at low temperatures.

W3-6 Particle Physics VIII (PPD) I Physique des particules VIII (PPD) / 2074

Status of T2K and future (I)

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Neutrino oscillation measurement entered a precision era. In summer 2017, T2K disfavoured CP conserving phase of δcp=0,π at 2σ level. CP asymmetry in neutrino and anti-neutrino νμ->νe appearances can be as large as 20% depending on the CP phase δcp, which is within the reach of new projects, HyperK and DUNE. HyperK aims at statistical error of ˜3% for the asymmetry. It is essential to control the systematic uncertainties well below the statistical errors for the discovery. The mixing angle $_{23}$, which was discovered in the atmospheric neutrino mixing, is consistent with maximal mixing ($\sin^2 2_{23}$˜1), possibly indicating μ-τ symmetry in the lepton mixing. This result is already started to be limited by the systematic uncertainty. I will describe essential challenges and opportunities in handling systematic uncertainties in precision neutrino oscillation measurements, and describe emerging efforts to handle them which are lead by the Canadian long baseline neutrino group.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2075

POS-11 Determination of the effective parallel geomagnetic field along a path using Faraday rotation and total electron content from Automatic Dependent Surveillance Broadcast signals

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A plane polarized electromagnetic (EM) wave that propagates through a plasma, (anti-)parallel to a magnetic field, experiences a gradual rotation of its plane of polarization called Faraday rotation (FR). Automatic Dependent Surveillance Broadcast (ADS-B) signals are linearly plane polarized and therefore are susceptible to FR as they traverse the ionospheric plasma, where they encounter a field-aligned component of the geomagnetic field and anisotropies in the ionospheric medium. An EM-wave ray tracing model was used to generate simulated ADS-B data to determine the wave path and the polarization state at incremental distances along the ray path resulting in estimates for the total electron content (TEC) and FR received at the satellite receiver position. Results will be discussed that use the TEC and FR values from multiple aircraft at different latitudes transmitting ADS-B signals to a satellite receiver to infer the effective parallel component of the geomagnetic field along the path.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2076

POS-18 Study of Al2O3 Coated Positive Electrode Materials

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Lithium Ion Batteries are widely used in a large variety of consumer products. With the rise in use in electric vehicles, increasing the energy density of LIBs is a priority. One way of accomplishing this is to increase the charge cutoff potential. However, this results in significant deterioration of the LIBs caused by side reactions between the electrolyte and the electrode. A possible solution to this is to use a coating to protect the positive electrode material. Al2O3 is currently being studied as a possible protective coating.
The Al2O3 is deposited through atomic layer deposition, which creates a thinner more even coating than the alternative wet-chemistry method. Two thicknesses of Al2O3 coatings are being investigated on two different types of positive electrode material, Lithium Nickel Manganese Cobalt Oxide (NMC) and Lithium Cobalt Aluminum Oxide (NCA). Samples from each material and coating type are heat treated to different temperatures ranging from 400˚C to 900˚C. To study the effects of the heat treatment temperature on the Al2O3 coating the samples underwent a range of different types of characterization testing. Scanning electron microscopy (SEM), x-ray photoelectron spectroscopy (XPS), x-ray absorption spectroscopy (XAS) and aluminum solid state nuclear magnetic resonance (Al NMR) have been used to study the heat-treated samples.

Results of the Al NMR on the thick coated NMC series suggests diffusion of the Al2O3 coating into the NMC begins with 400˚C heat treatment. XPS results differ from this, suggesting that diffusion begins at 600˚C for the thin coated material and 700˚C for the thick coated material. This suggests that the Al2O3 coating is thicker than the XPS measurement depth and the initial diffusion from the coating isn't visible to XPS while it is to NMR. As the heat treatment temperature increases, so does the diffusion of the Al2O3 layer into the NMC until the layer is reduced enough that the underlying NMC becomes visible to XPS measurement.
All electrode material powder samples were used to form electrodes and coin cell batteries were made from these for thorough electrochemical testing to evaluate the high voltage performance of the various coatings and heat treatment temperatures.

M3-6 Particle Physics III (PPD) | Physique des particules III (PPD) / 2077

Cosmogenic Production Rates in Germanium with CDMSlite Run 2 (G)*

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The Super Cryogenic Dark Matter Search (SuperCDMS) uses cryogenic semiconductor detectors to search for Weakly Interacting Massive Particles (WIMPs), a well-motivated class of candidate particles for the dark matter that constitutes 27% of the energy density of the universe. The CDMS Low Ionization Threshold Experiment (CDMSlite) probes the low mass WIMP region (<10 GeV/c²) by applying a high voltage (HV) across the SuperCDMS detectors, utilizing the Neganov-Trofimov-Luke effect to amplify small energy deposits. While this results in a very low energy threshold (<60 eV has been achieved), it is no longer possible to discriminate the electron recoil background from a potential nuclear recoil WIMP signal. In the SuperCDMS Soudan experiment (completed in 2015), two germanium detectors were operated in the CDMSlite mode.

In the next phase of SuperCDMS at SNOLAB, half of the detectors will be operated in HV mode. The limiting background is expected to result from cosmogenic activation of the detector material itself; ³H dominates in germanium (and is also significant in silicon). However, with a wide spread in the results of theoretical calculations and only one experimental data point with large uncertainty, the cosmogenic production rate of ³H in germanium is not well known. Using data from the second run of CDMSlite at Soudan and the location history of the detector, cosmogenic production rates are extracted for ³H and several other cosmogenically produced isotopes.

T1-1 Energy Storage 1 (DCMMP) | Accumulation d'énergie 1 (DPMCM) / 2078

Extracting State Information from Batteries with Electrochemical Acoustic Signal Interpretation (I)

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We have recently determined a correlation between the acoustic response, state of charge and state of health of closed system electrochemical energy storage systems. Because a closed cell is a mass redistribution reactor, and in a standard cell the volume is effectively fixed, the distribution of density

within a battery must change as a function of state of charge and, along with density, the elastic moduli of the anode and cathode changes as well. Since

cs = sqrt(E/rho)

This basic relation establishes a link between acoustic behavior and battery state. In this presentation we will review the physical basis of our hypothesis and present progress in

1. Correlating structural evolution and failure analysis with acoustic signal evolution
2. Preliminary inverse models which describe the changes we see in the acoustic/state of charge response
3. "Physics free"machine learning results to examine the uniqueness of an acoustic signal for a given battery in a given state of charge and health.

M3-2 General Contributions I (DASP) l Contributions générales 1 (DPAE) / 2079

Atmospheric Research in the High Arctic: The PEARL Experience (I)

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It is well-known that the atmosphere in the polar regions of this planet is considerably different from the more temperate regions due to a variety of factors including the planetary rotation, the magnetic field and the fact that the extreme polar regions undergo an annual cycle of light and darkness which overwhelms the 24-hour cycle that characterises the lower latitudes.

For the last decade a group of university and government researchers operating as an informal group called the Canadian Network for the Detection of Atmospheric Change (CANDAC) have operated a year-round observatory at Eureka, Nunavut on the 80N latitude line. This observatory has been dubbed the Polar Environment Atmospheric Research Laboratory (PEARL).

Research at PEARL spans the atmosphere from the surface at about 100km and teams from many Canadian universities as well as international groups are engaged in research at the site.

One talk cannot suffice to show the entire range of the research currently underway at PEARL and so highlights, perhaps of more interest to a physics community, will be presented along with some account of the history and speculation about the future of research at PEARL.

PEARL is currently supported by Natural Sciences and Engineering Research Council (NSERC), Environment and Climate Change Canada (ECCC) and the Canadian Space Agency.

R3-3 Particle Physics X (PPD) | Physique des particules X (PPD) / 2080

Photo-neutron Calibrations of SuperCDMS Dark Matter Detectors

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The Super Cryogenic Dark Matter Search (SuperCDMS) experiment has used data taken at the Soudan Underground Mine between 2011-2015 to search for nuclear recoils near 1 keV. Nuclear recoils at this energy constrain the possibility of low-mass Weakly Interacting Massive Particles (WIMPs). The Soudan SuperCDMS detectors produced a world-leading limit on the cross section of spin-independent WIMP-nucleon interactions at low masses (~1.6-5.5 GeV/c^2). The main uncertainty in the latest published limit is in the understanding of the nuclear recoil energy scale.

To improve this understanding, calibrations took place on the SuperCDMS detectors using ^{124}Sb/^{9}Be and ^{88}Y/^{9}Be photo-neutron sources. The sources used produce quasi-monoenergetic neutrons that are being used to calibrate the nuclear recoil energy scale in the range of 1 keV to 8 keV. Extracted results of the ionization yield will then be compared to predictions from the Lindhard ionization yield model. This is the default model that is well tested at high energy but not at low energy. This talk will discuss the motivation for this calibration along with a description of the current status of the analysis.

T3-2 Thin Films, Magnetism and Solar Cells (DCMMP) | Films minces, magnétisme et piles solaires (DPMCM) / 2081

Solar cells comparison in high altitude. (U)*

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The intent of this project was to compare the electrical outputs of two types of solar cells under different treatments in a high altitude and low atmosphere environment. Four cells were compared: a standard photovoltaic (PV) cell, a Gallium Antimonide (GaSb) thermophotovoltaic (TPV) cell sensitive to infrared radiation, and another pair of PV and TPV cells under Fresnel lenses treatment (PV-F, TPV-F). The cells were mounted on a custom-designed scientific payload, which was integrated on a high altitude balloon launched at NASA's Columbia Scientific Balloon Facility location in Fort Sumner, New Mexico. The payload data were collected throughout the balloon's ascent, and at the balloon's float altitude of approximately 33km. Analysis of the results, when normalized for difference in surface area between cells, suggest that the PV cells consistently produced more current than the TPV cells, both with and without Fresnel lenses. The PV cell produced an average of 1.498 times more current than the TPV cell, while the PV-F cell produced an average of 1.611 times more current than the TPV-F cell. Additionally, the PV cell produced an average of 1.574 times more current than the PV-F cell, while the TPV cell produced an average of 1.693 times more current than the TPV-F cell. Therefore, the data suggest that PV cells perform better than TPV cells, and that Fresnel lenses decrease the output of both cell types. Further exploration of the results in a current/time analysis showed a strong correlation between the PV and TPV cells, and a strong correlation between the PV-F and TPV-F cells, with different trends appearing in each pair of data comparisons. Analysis of the variation in trends in data between the PV and TPV cells and the PV-F and TPV-F cells allowed for conclusions regarding the reasons for the overall hindrance caused by the Fresnel lenses during flight. Comparing the performance of PV cells and TPV cells, it is clear that the current technology used in TPV cells do not make them viable for high altitude applications.

W2-3 Particle Physics VII (PPD) | Physique des particules VII (PPD) / 2082

Separation of Cherenkov and Scintillation Light in SNO+ (G)*

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Solar neutrinos are an irreducible background for the SNO+ double beta decay experiment. Neutrino interactions in the SNO+ detector produce directional Cherenkov light which, if separated from the dominant scintillation light, would allow for neutrino direction reconstruction and elimination of solar neutrino signals. Other liquid scintillator detectors can also benefit from direction information and so understanding the factors that enable Cherenkov discrimination would be valuable. I have built a Monte Carlo simulation to determine whether this scintillation/Cherenkov discrimination is in fact possible and to study the factors affecting it. Should it prove possible to distinguish between the signals this will allow for a major improvement in SNO+ and possible applications in other liquid-scintillator based detectors.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2083

POS-54 Morphological changes of collagen fibrils adsorbed to a strained elastic substrate

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We have previously demonstrated that the mechanical properties of collagen fibrils extracted from tendons are non- uniform along their length at the micrometre scale. We want to investigate how this non- uniformity affects fibril deformation as they are stretched or compressed. We build a platform compatible with an atomic force microscope (AFM) to strain a thin elastic sheet onto which collagen fibrils have been adsorbed, for the purposes of investigating the development of localized deformation along the length of a fibril as the elastic substrate is strained. By stretching the elastic substrate with adsorbed collagen fibrils in combination with in situ AFM imaging, the ratio of transverse elongations can be measured as it varies locally along the length of the fibril. By stretching the elastic substrate prior to depositing fibril onto the surface and releasing substrate strain, we measure fibril buckling wavelength as a response to compressive strain and its dependence on fibril cross section. In this case deviations from the ideal sinusoidal response of a buckled beam attached to an elastic substrate is used to identify mechanical non-uniformities along the fibril length.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2084

POS-8 Project VeSElkA: results of abundance analysis for the stars HD53929 and HD63975

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High resolution and high signal to noise spectra of two HgMn stars, HD53929 and HD63975, were analysed in the frame of Project VeSElkA (Vertical Stratification of Element Abundances) to search for vertical stratification of element abundances in their stellar atmospheres. These stars show signatures of a slow axial rotation and most probably possess hydrodynamically stable stellar atmospheres, where the atomic diffusion mechanism can cause abundance accumulation or depreciation

of particular chemical elements at the certain atmospheric depths. With the help of the ZEEMAN2 code, we were able to determine average abundance of analysed chemical species and to detect in both studied stars an increase of phosphorus abundance towards the upper atmospheric layers. The strong overabundances of Mn derived in the stellar atmospheres of HD53929 and HD63975 confirms that they are HgMn type stars.

T4-6 DASP General Contributions II (DASP) | DPAE: contributions générales II (DPAE) / 2085

Search for Vertical Abundance Stratification of Chemical Elements in HD176232 (U)*

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Two high resolution and high signal to noise ratio spectra of HD176232 have been analyzed to study the chemical abundances in atmosphere of this star using the ZEEMAN2 code. These spectra were recently obtained with the spectropolarimeter ESPaDOnS at the Canada-France-Hawaii telescope (CFHT) in the frame of the project VeSElkA. The project's objective is the search for signatures of vertical stratification of chemical element abundance within chemically particular (CP) stars. The surface gravity and effective temperature of HD176232 were derived from the fitting of nine Balmer line profiles through the FITSB2 code. Over one hundred line profiles were analyzed in each spectrum and the average abundance of 32 chemical elements were measured. Some of them, for example, cobalt, neodymium, samarium and gadolinium show a significantly enriched abundance in the stellar atmosphere of HD176232, while carbon and molybdenum seem to be in deficit. Also, our analysis reveals an abundance stratification with optical depth for calcium, cobalt, iron, manganese and nickel.

T4-1 Energy Storage 2 (DCMMP) | Accumulation 2 (DPMCM) / 2086

Density Functional Theory Studies on the Role of Electrolyte Additives in Lithium-ion Batteries

Authors: David Hall[1]; Stephen Glazier[1]; Leah Ellis[2]; Jenn Allen[1]; Ulrike Werner-Zwanziger[2]; Jeff Dahn[1]

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To further progress the adoption of electric vehicles and other high power energy storage applications, it is desirable to develop lithium-ion cell chemistries that offer longer lifetimes at high temperatures and cell voltages, without significantly increasing the cost. The introduction of sacrificial electrolyte additives on the order of a few weight percent is a practical method to form protective solid-electrolyte interphase (SEI) layers that limit electrolyte decomposition during cell storage and operation. In recent years, significant efforts have provided new understanding of the underlying chemistry of several such additives, including sulfur-containing heterocyclic compounds and species that contain a Lewis acid-base adduct.

This work will present how density functional theory (DFT) calculations have been used to explore the underlying chemical reactions leading to SEI formation. Two sulfur-containing additives, prop-1-ene-1,3-sultone (PES) and ethylene sulfate (DTD), and two Lewis adducts, pyridine boron trifluoride (PBF) and pyridine phosphorus pentafluorophosphate (PPF), will be discussed. The DFT results offer new insight into the onset potential and reaction products of electrochemical reduction. By pairing DFT with a diverse set of experimental techniques, including X-ray photoelectron spectroscopy,

isothermal microcalorimetry, solid-state nuclear magnetic resonance spectroscopy, gas volume measurements, and electrochemical techniques, new SEI components are proposed for each additive. In general, the results in this work confirm previous recommendations that a wide variety of experimental techniques, coupled with computational methods such as density functional theory, can offer new insights into the underlying chemistry of SEI formation in lithium-ion cells. It is hoped that future work can apply the results of this work to understand what makes a 'good'electrolyte additive and, ultimately, to design new and improved electrolyte cell chemistries.

T3-7 Surface Sciences (DSS) I Science des surfaces (DSS) / 2087

Preferred orientation of electroplated copper films on roll-annealed copper substrates

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Roll-annealed (RA) copper foils are commonly used in the printed circuit industry as flexible conductive base materials. The RA process produces foils with the crystallites aligned in particular directions. RA foils used in applications have either {100}<001> "cube"texture, or a mixture of {112}<111> "copper", {123}<634> "s"and "cube"textures. Manufacturing circuits requires the deposition of electroless and galvanic Cu layers on the RA foils. The substrate texture can lead to growth of large epitaxial crystals with a rough surface, which causes problems in subsequent processing steps. We show that with an appropriately designed electroless Cu interlayer, the deposit texture is sufficiently suppressed and a smooth galvanic layer is obtained. We present XRD pole figure based analysis of substrates and electroless/galvanic deposits.

T1-6 Topics in medical physics and biophysics (DPMB) / Sujets en physique médicale et biophysique (DPMB) / 2088

Organic semiconductor radiation dosimeters

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Accurate, quantitative measurements of radiation fields are essential prerequisites for the safe and effective use of ionizing radiation in diagnostic and therapeutic medical applications. Common examples of radiation detectors include: ionization chambers, thermoluminescent dosimeters (TLDs), films and various electronic devices. Semiconductor dosimeters such as p/n type silicon diodes and MOSFETs have found widespread adoption due to their high sensitivity and easy processing. A significant limitation of these devices, however, is their lack of tissue equivalence. The high atomic number (relative to soft tissue) of silicon causes these devices to over-respond to photon beams that include a significant low energy (e.g. kilovoltage) component due to an enhanced photoelectric interaction coefficient.

This work presents preliminary measurements with organic semiconductor diodes and organic floating gate (FG) transistors as dosimeters capable of providing a tissue equivalent response to ionizing radiation. The direct detection of X-rays from a medical linear accelerator using Phthalocyanine/C60 based organic planar heterojunction diodes is presented. The diodes produce a linear increase in current with increasing dose rate and show a stable response after exposure to doses up to 5000 cGy. The Pentacene-based organic floating gate transistors have also been investigated for dosimetry applications. The possibility of resetting the transistors for repeated use and sensitivity optimization by electrical charging of floating gate through Fowler-Nordheim tunneling is currently being investigated. The sensitivity of these devices has been determined from the transistor threshold voltage shift as a function of accumulated dose. After negative or positive pre-charge of floating gate the average sensitivity was 0.09V/Gy, 0.045V/Gy, 0.02 V/Gy, 0.01 V/Gy at 10 Gy, 20Gy, 30 Gy, 40 Gy, 50 Gy, 60 Gy, respectively. The sensitivity of FG pentacene transistors was stable after two pre –charge cycles of the FG.

T4-8 Novel Approaches to Promoting Engagement in Physics Classes (DPE) | Nouvelles approches pour promouvoir l'engagement dans les classes de physique (DEP) / 2090

Supplementary Video Tutorials for Introductory Physics Courses

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Problem solving is a major stumbling block in the introductory physics courses in both STEM and life science programs. Our students have been provided with an optional tool to supplement and reinforce lecture and in-class tutorial instruction. A series of video tutorials were created to address curriculum topics covered in first year physics courses. The tutorials target the topics that are known to be particularly challenging for first year students. The video tutorials consist of a theoretical introduction - review of the main concepts in the topic the video addresses - followed by problem solving tips and examples of applications. The tutorials were screen-captured using Camtasia, with voice track added to the presentations. The tutorials were made available to Ryerson University students through D2L Brightspace course management system and/or Google Drive. The video tutorials support student engagement inside and outside the classroom, by enabling students to access on demand, at their own pace and time, specific instructions, which relate directly to the material they learn in the course. Initial students'response to the resource has been very positive, and we plan to expand the project to include other topics from the first year curriculum as well as create videos for selected upper year courses. Session participants will learn about the process of creating the tutorials. Examples of video tutorials will be provided.

T4-3 Particle Physics V (PPD) | Physique des particules V (PPD) / 2091

Measurement of Z bosons produced in association with jets via vector boson fusion at 13 TeV with the ATLAS detector (G)*

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At the large hadron collider, most Z bosons are produced in a qqZ vertex, sometimes in association with jets produced via the strong interaction. A more rare production mode for Z bosons is through

a triple gauge coupling via a process called vector boson fusion (VBF). This VBF Z process is similar in nature to VBF Higgs production, which is of great interest and is being studied by large groups of physicists on the ATLAS and CMS experiments. VBF Z production is interesting in its own right as a probe for new physics via the triple gauge coupling. Measurements of the cross section and kinematic distributions of VBF Z production can also be used to constrain new physics scenarios, such as fits to an effective field theory extension of the Standard Model Lagrangian. An analysis of the standard model VBF Z process is ongoing, the general structure of the analysis will be discussed along with details of the systematic variations and pileup contamination of the Monte Carlo (MC) simulation. The VBF signal is measured by extrapolating between carefully chosen regions of phase space to best model signal and background distributions. Understanding the MC simulation is crucial to making an accurate final measure of the VBF Z cross section.

T2-4 Medical Imaging 1 (DPMB) | Imagerie médicales 1 (DPMB) / 2092

WITHDRAWN – Multi-Modality Comparison of Wrist and Ankle joints: A Feasibility Study

Authors: David Tessier[1]; Beatriz Barata[2]; Aaron Fenster[1]

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A prototype clinical study is being developed to assess pre-adult patients with hemophilic arthropathy. Patients with this condition experience pain in ankle, knee, wrist, or elbow joints due to joint bleeds. Typical ultrasound exams involve probe to skin contact to generate an image, which places a moderate to high level of pain on the effected joint. To overcome the physical touch of an ultrasound probe to the skin, a prototype has been built that consists of a three-dimensional (3D) ultrasound (US) system, and a water filled plastic cylindrical tub. The latter is able to freely rotate about a base plate, while an off-the-shelf electromagnetic encoder, attached to the rotational shaft of the tub, provides the rotational position of the device. Moreover, software running on a Microsoft Windows computer, written by developers at The Robarts Research Institute, takes the encoder position from a USB interface along with conventional two-dimensional (2D) ultrasound images to create a 3D volume. The 2D US images are recorded with a given angular sampling and reconstructed into the 3D volume in an inverse fan geometry. The 3D image is able to provide a viewpoint that is unreachable in conventional 2D ultrasonography, since a manipulation through all planes is possible. Preliminary testing of the device has shown favorable image quality and level of details in two health human wrist and ankle pairs. The prototype design, study protocol workflow, and preliminary results will be presented; specifically showing corresponding anatomical landmarks between 3D ultrasound and MR images. The future work for the study is a clinical trial at Sick Kids hospital in Toronto; whereby, ultrasound / MRI data from each subject will be viewed by two radiologists who are separated from the other aspects of the study. Interpretations from both modalities will gauge the feasibility of this approach for use in imaging hemophilic arthropathy in limb joints.

T4-7 Physics of Biosensing (DPMB) | Physique de la biodétection (DPMB) / 2093

Materials Innovations for Enhancing the Limit of Detection of Biosensors (I)

Author: Leyla Soleymani[None]

Miniaturized biosensors are essential components of continuous health monitoring systems, which are expected to significantly impact human health management. Biosensors integrate biorecognition elements with transducers to detect the presence, absence, and quantity of biologically-relevant elements. Nanoscale materials play a critical role in enhancing the sensitivity and specificity of these

devices.
In this work, we have developed a fabrication toolbox for creating interfaces that combine biorecognition and signal transduction. More specifically, we use multiple tunable materials building blocks to create electrochemical or photoelectrochemical biosensors. A wrinkled scaffold with tunable feature sizes is used to create a high density network of nanoparticles. A biofunctionalized network of semiconductive or metallic nanoparticles is used to create integrated biorecognition/signal transduction interfaces. Furthermore, a network of nanoparticles featuring molecular linkers is used to reduce biofouling and non-specific adsorption in biosensors. By combining the materials strategies developed in this work, we demonstrate multiple biosensor examples for detecting specific nucleic acid sequences and protein targets. Finally, a clinically-relevant biosensor for the detection of Brain Derived Neurotrophic Factor is demonstrated.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2094

POS-28 3D-to-2D transition of phonon transport in nanomaterials: a first-principles analysis

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Quasi-2D materials are composed of stacks of atomically thin layers. While individual monolayers have unique thermal and electronic properties on their own, quasi-2D materials introduce an array of new characteristics, such as anisotropic transport properties and thickness-dependent properties, which have important applications in optoelectronics and thermoelectrics. Our group is particularly interested in observing how the phonon/thermal transport properties of these materials behave as they transition from 3D bulk materials (strong interlayer coupling) to 2D nanomaterials (weak interlayer coupling). In particular, we use first-principles calculations to predict phonon dispersions, scattering rates, and thermal conductivities as we vary the distance between subsequent layers. Our current focus is on Rhenium Disulfide (ReS2), which maintains much of its monolayer characteristics in bulk form due to exceptionally weak bonding between layers. Our calculations will provide a detailed understanding of the unique thermal transport properties of these novel quasi-2D materials and may serve to motivate future technological innovation.

W2-3 Particle Physics VII (PPD) | Physique des particules VII (PPD) / 2095

Infrared Photon Interactions in SuperCDMS Detectors (G)*

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The Super Cryogenic Dark Matter Search (SuperCDMS) experiment is in the process of incorporating improvements in several aspects, such as experiment location, detectors, and readout electronics. With these improvements, the focus of the new phase of the experiment at SNOLAB will be Weakly Interacting Massive Particles (WIMPs) in the mass range below ˜10 GeV/c². In order to better understand and monitor the detector behavior in the low-energy range (below a keV) where recoils from such low mass WIMPs would be observed, we are developing a new calibration method based on infrared photons. In my talk, I will be summarizing our most recent tests probing the

response of SuperCDMS germanium detectors to interactions with infrared photons and the progress in using this method to monitor detector stability.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2096

POS-29 Computational and Experimental Investigations of Inverse Perovskites as Thermoelectric Materials

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More than half of the energy produced worldwide is currently lost as waste heat and recovering a fraction of the lost energy would have an enormous impact on global climate change. In this sense, thermoelectric materials can convert waste heat to useful electricity. However, because of their low efficiency, high cost, and use of scarce resources, thermoelectric materials are not widely applied. Oxygen-containing inverse perovskites can provide a potential way to reduce the cost and enhance the sustainability of thermoelectric materials. In general, the presence of oxygen may be expected to reduce electron mobility and hence electrical conductivity; however, our computational studies revealed that oxygen-containing inverse perovskites have a high electrical conductivity. Furthermore, high Seebeck coefficients were calculated, originating from multiple degenerate bands leading to an enhanced power factor. Preliminary experimental results confirm the high electrical conductivity of these materials.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2097

POS-9 Results of abundancy analysis for Sirius

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The results of analysing of the chemical abundance in stellar atmosphere of Sirius are presented as a part of the project VeSElkA that aims to search for evidence of vertical stratification of elements' abundance in chemically peculiar (CP) stars. Using the high resolution and high signal to noise spectra obtained with the spectropolarimeter NARVAL, we have analysed hundreds of line profiles with the help of the code ZEEMAN2. The estimates of average abundance for 39 chemical elements were obtained for two phases of orbital rotation of Sirius in binary system. We were able to find a significant overabundance of argon, scandium, manganese, cobalt and some rare-earth elements, and an under-abundance of molybdenum for two phases of Sirius orbital motion in binary system.

R1-3 Particle Physics IX (PPD) | Physique des particules IX (PPD) / 2099

CUTE –A low background facility for testing cryogenic detectors

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The Cryogenic Underground Test (CUTE) facility is under construction at SNOLAB, aiming to test the performance of the cryogenic detectors of the Super Cryogenic Dark Matter Search (SuperCDMS) experiment.

The 'Ultra Quiet Technique'(UQT®) is applied to reduce the vibration transmission from an advanced dry dilution refrigerator (CryoConcept, France) that allows operating the cryogenic detectors at low temperature. In addition, a dedicated suspension system has been developed to decouple the cryostat from the environment with a low stiffness support.

The CUTE facility is designed for an expected background rate less than ˜3 events/(keV kg d) at the energies below 2 keV. This is achieved by placing the dilution refrigerator in a drywell in the center of a 3.6 m diameter water tank. A 10 cm of low-activity lead will be placed inside the drywell to further reduce the gamma background from environment. The Bremsstrahlung from 210Pb contamination in the lead will be reduced by a 2 cm inner layer of copper or archeological lead.

Thus, the expected background will allow not only to perform any required calibrations and functionality tests, but also to measure the cosmogenic activation of the detector target material. The cosmogenic 3H in Ge and 32Si in Si are expected to be the limiting background components for SuperCDMS at low energy. Furthermore, the sensitivity to very low mass WIMPs can be improved taking advantage of the low energy threshold in the new SuperCDMS detectors.

We report here the current status and scientific program of the CUTE facility to host various cryogenic detectors for performance testing and unique physics runs.

PPD Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (5) | Session d'affiches PPD et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (5) / 2100

POS-45 Calibration systems for the Cryogenic Underground Test facility (CUTE) at SNOLAB

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The installation of a Cryogenic Underground Test facility (CUTE) is currently ongoing at SNOLAB. The facility includes a cryogen-free dilution refrigerator which is installed within a drywell at the center of a water tank, and shielded with several layers of low radioactivity lead and ultra-pure copper. CUTE will be used for performance tests, characterization measurements, background tests, and calibrations for the SuperCDMS detector towers within a low background environment. In order to achieve the scientific goals foreseen for the CUTE facility, a dedicated calibration system is required. We are designing a remotely accessible system with a convenient graphical user interface (GUI) for precise and reproducible source positioning. This work describes the design and status of this calibration system for CUTE.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2101

POS-30 Photoacoustic FTIR as an isotopic analysis technique

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Fourier Transform Infrared (FTIR) spectroscopic techniques are well established for their ability to identify mixtures of compounds and polymorphs in solid materials. These spectra can be recorded using either optical or acoustic detectors. Transmission FTIR spectroscopy (FTIR-TR) has been used in the past to access crystallinity differences in archaeological and lab-produced calcium carbonate samples by examining the spectral peak positions and relative peak heights. Examining the same samples using a photoacoustic detector (FTIR-PAS) showed a roughly 3-fold enhancement to isotopic peak intensities of calcite that were poorly resolved above noise level using FTIR-TR. Surprisingly, the origin of this enhancement of weak peaks is not clearly described in the literature. Here we show that, because of the weak peak enhancement, FTIR-PAS is a useful isotopic analysis tool. Common data collection and processing parameters (mirror speed, spectral windowing and phase correction) were eliminated as potential causes for the observed peak enhancements. Particle size effect studies using monodisperse silica showed an over-all signal increase. From these results, we concluded that the origin of the isotopic peak enhancement is inherent to the acoustic detection. This isotopic peak enhancement makes PAS detection the method of choice for those in fields such as archaeology, geology or the petroleum industry. Offering a combination not observed in more traditional methods such as X-Ray diffraction, X-ray absorption fine structure or transmission electron microscopy, FTIR-PAS offers rapid, non-destructive identification of both solid sample isotope content and structural information which can be used to infer the formation conditions and processes of undergone by the material.

T4-3 Particle Physics V (PPD) | Physique des particules V (PPD) / 2102

Emerging Triggers: Creating a Safe Space for Dark Matter (G)*

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Our current knowledge of particle physics is best described by the standard model (SM). Despite this, astronomical observations of dark matter made over the past few decades mean that the SM must be incomplete. New models are now motivating the possibility of dark matter being governed by the an extended $SU(3)$ gauge theory resembling Quantum Chromodynamics (QCD) for the strong force. This model includes a stable dark baryon, similar to the proton, as a possible dark matter candidate. If these dark hadrons are accessible at the LHC the dark analogue to the quark will produce a parton shower throughout the detector volume, eventually fragmenting into jets of invisible (dark) colour singlet hadrons. When the unstable particles eventually decay into visible quarks/leptons, a novel jet structure will be seen displaced from the proton-proton collision vertex, termed an 'emerging jet'. With the experiments at CERN producing enormous amounts of data per collision, triggers are implemented for reducing the data by means of vetoing events that deviate from a set of pre-defined criteria. These triggers could potentially throw away an interesting signal if not properly optimized. We use existing triggers, alone and in combination, in obtaining the maximum detected efficiency of an emerging jets signal. The same tools that are familiar for QCD are used to simulate these processes under identical conditions at the ATLAS & CMS experiments. Alongside simulating highly energetic, simple 'toy' processes, interactions with added particle radiation give a better gauge to the complicated dynamics of the theory. The extracted efficiencies corresponding to various triggers will be presented. Finally, new methods of signal discrimination will be discussed for a variety of models.

R3-4 Condensed Matter / Quantum Theory (DTP/DCMMP) | Matière condensée / théorie quantique (DPT/DPMCM) / 2103

Mott transition as an organizing principle for high-temperature superconductivity (I)

Authors: André-Marie Tremblay[1]; Marion Thénault[1]

Co-authors: Simon Bergeron [1]; Maxime Charlebois [1]; Lorenzo Fratino [2]; Alexandre Prémont-Foley [1]; Charles-David Hébert [1]; Alexis Reymbaut [1]; David Sénéchal [1]; Olivier Simard [1]; Giovanni Sordi [2]; Patrick Sémon [3]

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In the presence of strong electronic repulsion, a half-filled-band material can be insulating, instead of metallic as one would have expected from standard solid-state physics. Such a material is a Mott insulator. The first-order transition from metal to Mott insulator as a function of interaction strength in two-dimensions is well described by cluster generalizations of dynamical mean-field theory. In this talk we show, using that method, that an extension of the first-order Mott transition persists when the insulator is doped, and that this transition controls much of the phase diagram of the high-Tc cuprates. It leads to a temperature T, *near half-filling, below which density of states is lost. This is the so-called pseudogap regime. The T* line as a function of doping has a slope and an intercept that depend on pressure, band structure and magnetic field in ways that are consistent with experiments. In addition, the remnant of the first-order Mott transition away from half-filling also controls high-temperature superconductivity. The superfluid stiffness is highly non-BCS and is likely to control the value of the superconducting transition temperature in the pseudogap regime. Coexistence with other phases is more detrimental to superfluid stiffness than it is to the superconducting order parameter.

M2-4 DPMB 101 (DPMB) | (DPMB) / 2104

The past, present and future of X-ray Computed Tomography (I)

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Computed Tomography (CT) is considered a mature technology as it did not change significantly since the advent of multislice devices (2000s) and helical acquisitions (1990s). However, innovations in CT are still happening. After a brief history of CT, the evolution of this imaging modality during the last few years will be reviewed from technological, social and medical perspectives. On the technological front, CT can nowadays rely on unprecedented computing power, allowing the execution of advanced reconstruction algorithms in a reasonable time. Massively parallel Graphics Processing Units (GPUs), for instance, allow the used of complex physical models in iterative reconstruction schemes. These approaches can yield better images acquired at lower patient doses. From a health physics perspective, the steadily increasing number of CT studies performed each year has drawn the attention of the media and radiation safety authorities. CT manufacturers, well aware of this situation, nowadays propose technologies aiming at reducing the radiation dose to the patient. These technologies will be reviewed and discussed. From a medical perspective, CT nowadays allow new applications thanks to technological developments. The case of dual-energy imaging will be reviewed and discussed. Finally, current research avenues in CT will be reviewed, from technological and medical perspectives.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2105

POS-17 Analysis of "Rollover Failure"of Lithium-ion Cells

Author: Xiaowei Ma[1]

Co-authors: Jessie Hallow [1]; Lauren Thompson [1]; Michael Bauer [1]; Alison Keefe ; Jing Li [2]; Stephen Glazier [1]; Lin Ma [3]; David Hall [1]; Connor Aiken ; Matthew Genovese [1]; Marc Cormier [1]; Jeff Dahn [1]

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Sometimes lithium-ion cells show a very insidious type of failure where they display close to 100% of their capacity for about 1000 charge-discharge cycles and then lose most of their capacity in only 100 cycles or so with very little warning to the user. This is called "rollover failure". Experimental observations show that the likelihood of rollover failure increases with upper cutoff potential of lithium-ion cells. Since increasing the upper cutoff potential is essential to increase the energy density of lithium-ion cells, a full understanding of the causes of rollover failure is essential, but this is proving very difficult to attain.

In this presentation, the phenomenon of rollover failure during long-term cycling will be discussed based on a comparison among Li(Ni0.5Mn0.3Co0.2)O2/graphite pouch cells with different electrolyte and electrode designs undergoing different testing protocols. A few facts can be gleaned from the data:
1. For cells charged to the same upper cutoff potential, those showing the highest rates of electrolyte oxidation at the positive electrode (due to electrolyte or cell chemistry changes) are most prone to rollover failure.
2. Any cell is more prone to rollover failure if charged to higher potential. This increases the rate of electrolyte oxidation at the positive electrode.
3. When cells are disassembled after rollover failure, they invariably show unexpected and unwanted lithium metal plating on the surface of the graphite negative electrode.
Based on these and other observations some simple handwaving models of rollover failure can be postulated but serious experimental studies using a variety of methods are required for full understanding. It is hoped that this lecture can spur other researchers to help tackle this critical problem!

W2-1 Pattern Formation 2 (DCMMP) | Formation de motif 2 (DPMCM) / 2106

Power-law Viscoelastic Rheology Controls the Occurrence of Aftershocks

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Aftershocks are ubiquitous in nature. They are the manifestation of relaxation phenomena observed in various physical systems. In one prominent example, they typically occur after large earthquakes. They also occur in other natural or experimental systems, for example, in solar flares, in fracture experiments on porous materials and acoustic emissions, after stock market crashes, in internet traffic

variability, to mention a few. The observed aftershock sequences usually obey several well defined non-trivial empirical laws in magnitude, temporal, and spatial domains. In many cases their characteristics follow scale-invariant distributions. The occurrence of aftershocks displays a prominent temporal behavior due to time-dependent mechanisms of stress and/or energy transfer. In this work, we consider a slider-block model to mimic the behavior of a seismogenic fault. In the model, we introduce a nonlinear viscoelastic coupling mechanism to capture the essential characteristics of crustal rheology and stress interaction between the blocks and the medium. We show that the nonlinear viscoelasticity plays a critical role in triggering of aftershocks. It explains the functional form of the empirical Omori-Utsu law, which describes the temporal decay of the aftershock rate, and gives physical interpretation of its parameters. The proposed model also suggests that the power-law rheology of the medium controls the decay rate of aftershocks. To verify this, we analyzed several prominent earthquake aftershock sequences to estimate their decay rates and correlate with the rheological properties of the underlying lower crust and mantle, which were estimated from the postseismic surface deformation. Our modelling suggests that the power-law rheology exponent n controls the decay rate of aftershocks and is related to the parameter p of the Omori-Utsu law. The obtained results indicate that for the first time we provide a clear mechanism for the aftershock generation that follow a power-law decay rate and give a physical interpretation of its functional form. The obtained results highlight the importance of nonlinear viscoelastic effects operating in various systems exhibiting relaxation phenomena and can stimulate relevant empirical observations and experiments in order to detect and quantify such effects.

T1-4 Mathematical Physics (DTP) | Physique mathématique (DPT) / 2107

A path to correspondence rules for SU3 Wigner function (G)*

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I highlight how the problem of obtaining correspondence rules for SU3 Wigner function differs from that of the SU2 problem. I show how these rules are easily obtained for the Q-functions but how the transition from Q to Wigner functions for SU3 brings about novel features not present in SU2. A path to solution will be proposed.

M1-6 Biophysics, microscopy and diseases (DPMB) / Biophysique, microscopie et maladies (DPMB) / 2108

Scaling Laws and Global Dimensions of Disordered Proteins: Single-molecule Data and Polymer Physics Theory (I)

Author: Claudiu Gradinaru[1]

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Sic1 is a disordered kinase inhibitor, which must be phosphorylated on at least six sites to allow its recognition by the WD40 binding domain of the Cdc4 protein in the yeast cell cycle. The highly-cooperative, switch-like dependence on the number of phosphorylated sites on Sic1 cannot be accounted for by traditional thermodynamic models of cooperativity. We used single-molecule fluorescence techniques to study the dimensions and dynamics of Sic1's N-terminal targeting region

(residues 1-90, henceforth Sic1) and phosphorylated Sic1 (pSic1). A quantitative relationship between sequence properties and ensemble properties is a prerequisite for understanding IDP phosphorylation and its role in highly cooperative binding.
Single-molecule Förster Resonance Energy Transfer (smFRET) data obtained for dye-labelled Sic1, pSic1, and the pSic1-WD40 complex were used to infer the dimensions of disordered ensembles for different states of Sic1. In a refinement to the conventional approaches for inferring IDP dimensions from smFRET experiments, we use distance distributions from Monte Carlo simulations, which extensively sample coarse-grained protein conformations. The application of polymer physics theory/simulations towards smFRET data interpretation, and towards IDP binding, contributes to the growing toolkit for understanding how IDPs function in the absence of a stable 3D structure.

M2-1 Ultrafast EM Waves II: THz Science (DAMOPC/DCMMP) | Ondes EM ultrarapides II: Science des THz / 2109

Measurement and control of electron dynamics using THz light fields (I)

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Phase-locked, few cycle pulses of THz light are powerful tools for both probing and controlling charge carriers in condensed matter. Used as time-resolved spectroscopic probes, meV scale excitations can be monitored with sub-picosecond temporal resolution. In this talk, I discuss recent multi-THz measurements on organometallic metal halide perovskites revealing exciton energetics, screening dynamics and the effects of strong spin-orbit interactions. In addition to probing dynamics, strong field THz pulses can be used to control the motion of charged particles on sub-cycle time scales. I will discuss our recent work on sub-cycle THz field emission of femtosecond electron wavepackets from metal nanotips. Electrons are accelerated in the local THz fields to keV energies with femtoCoulomb bunch charges, a step towards a light field-driven ultrafast electron microscope. Finally, a new method for arbitrarily shaping THz fields in time will be presented, based on an optically addressable dynamic waveguide. The ability to create multiple pulse sequences from a single THz pulse opens the door to advanced forms of multi-dimensional THz spectroscopy.

R3-4 Condensed Matter / Quantum Theory (DTP/DCMMP) | Matière condensée / théorie quantique (DPT/DPMCM) / 2110

Quantum communication with coherent states (I)

Authors: Juan Miguel Arrazola[1]; Ben Lovitz[2]; Ashutosh Marwah[2]; David Touchette[2]; Norbert Lutkenhaus[2]

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The use of quantum mechanical signals in communication opens up the opportunity to build new communication systems that accomplishes tasks that communication with classical signals structures cannot achieve. Prominent examples are Quantum Key Distribution Protocols, which allows the generation of secret keys without computational assumptions of adversaries. Over the past decade, protocols have been developed that achieve tasks that can also be accomplished with classical signals, but the quantum version of the protocol either uses less resources, or leaks less information between the involved parties. The gap between quantum and classical can be exponential in the input size of the problems. Examples are the comparison of data, the scheduling of appointments

and others. Until recently, it was thought that these protocols are of mere conceptual value, but that the quantum advantage could not be realized. We changed that by developing quantum optical versions of these abstract protocols that can run with simple laser pulses, beam-splitters and detectors. [1-3] By now the first protocols have been successfully implemented [4], showing that a quantum advantage can be realized. The next step is to find and realize protocols that have a high practical value.
We are at the early stages of the development of optical quantum communication protocols with quantitative advantages. In this presentation I will give an overview of our progress
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M3-6 Particle Physics III (PPD) | Physique des particules III (PPD) / 2111

The Status of the PICO Dark Matter Search Experiment (I)

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This talk will present the current status of the PICO dark matter experimental program. The PICO detectors are based on the bubble chamber technology and record potential interactions of WIMPs in the target fluid through phase transitions induced by the energy depositions of recoiling nuclei. The technique is complementary to other dark matter search methods and has lead to several world-leading results for spin-dependent WIMP interactions. The current state of the results from PICO operations will be presented, as well as an update on the status and prognosis for the new detector configuration PICO-40, currently being installed at SNOLAB. The future prospects for a tonne scale "PICO-500"will also be described.

R1-3 Particle Physics IX (PPD) | Physique des particules IX (PPD) / 2112

Results from the DAMIC at SNOLAB Experiment

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Millimeter-thick charge-coupled devices (CCDs) are outstanding particle detectors. Although initially developed for near-infrared astronomy, the low pixel noise also makes them the most sensitive detectors to signals from ionizing radiation. By virtue of their very low energy threshold, and their unique capabilities for background characterization based on their high spatial resolution, CCDs are poised to become the leading technology in the search for a wide variety of dark matter candidates with masses in the range 1 eV–10 GeV. I will present the current status of the completed seven-CCD array of DAMIC at SNOLAB. Sensitivity to WIMP-nucleus elastic scattering has been significantly improved thanks to the increased exposure, lower noise and lower radioactive backgrounds of the final detector configuration. I will also discuss the recent progress towards DAMIC-1K, a lower-background 1-kg CCD dark matter detector.

M1-5 Nuclear Astrophysics (DNP) | Astrophysique nucléaire (DPN) / 2113

Investigation of High-Lying (alpha,g) Resonances in 22Ne via High-Resolution Gamma Ray Spectroscopy in Inverse Kinematics (G)*

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In asymptotic giant branch (AGB) stars, 22Ne plays an important role in several nucleosynthesis processes, with its production competing with the synthesis of 19F through the so called 'poisoning reaction', and the following transfer into 25Mg acting as one of the main neutron sources for the s-process, affecting the reaction rates of numerous isotopes.

In this contribution, we present a preliminary look into a recent neutron transfer experiment done at TRIUMF in July 2017, studying the high-lying resonances of the 22Ne nucleus. Using TIGRESS, we can accurately determine these resonance energies, utilizing the precision of the HPGe detectors. Alongside this, we can use data taken simultaneously with the SHARC silicon detector to determine the spins for these resonances, and finally, apply Doppler shift attenuation method to constrain the lifetimes of resonances down to femtoseconds.

R1-6 Quantum Computing and Communication (DAMOPC/DTP/DCMMP) | Calcul et communication quantiques (DPAMPC/DPT/DPMCM) / 2114

Adaptive Optics for Quantum Key Distribution between an Earth station and a Satellite

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Global-scale distances for Quantum Key Distribution (QKD) can be achieved by utilizing an orbiting satellite acting as an intermediate node between two or more ground stations as has been recently demonstrated with the Chinese satellite Micius and there are further missions to follow from various countries including Canada (QEYSSat). Each of these missions have different methods to implement QKD, but the desired effect of global distances is the same. With QKD states encoded in photon polarization, the total number of photons collected (or equivalently, the total received optical power) is the limiting factor to the secure key generation rate. In this study we analyze an optical uplink, and how atmospheric turbulence affects the signal strength. Atmospheric turbulence mixes air of different temperatures and, hence, possessing different refractive indices along the beam path, inducing phase errors in the propagating beam. These phase errors have negligible impact on the beam in the near field, but their evolution creates temporal intensity fluctuations (scintillation), beam wander, and beam broadening along the path to the satellite which all negatively affect the secure key generation rate. Here we investigate the use of adaptive optics to mitigate the effects of the atmosphere on the collected power of an uplink to a satellite-based receiver for QKD. We model four representative scenarios of atmospheric conditions using the Hufnagel-Valley generalized turbulence model which relate to prospective ground station location turbulence strengths, and determine the impact of using an adaptive optics on the successful key generation rate. We also model low-Earth-orbit vs.

geostationary orbits as well as laser guide stars to determine if they can further improve the total secure key generation rate.

M3-6 Particle Physics III (PPD) | Physique des particules III (PPD) / 2115

Compensation of Magnetic Fields at the TRIUMF nEDM Experiment (G)*

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The existence of a non-zero neutron electric dipole moment (nEDM) would violate parity and time-reversal symmetry. Extensions to the Standard Model predict the nEDM to be 10^{-26} – 10^{-28} e-cm. The current best upper limit set by Sussex/RAL/ILL nEDM experiment is 3.0×10^{-26} e-cm. The nEDM experiment at TRIUMF is aiming at the 10^{-27} e-cm sensitivity level. We are developing the world's highest density source of UCN. The experiment requires a very stable (<˜pT) and homogeneous (<˜nT/m) magnetic field (B0) within the measurement cell. My involvement in the nEDM experiment is the development of active magnetic shielding to stabilize the external magnetic field by compensation coils. A prototype active magnetic shield has been tested at The University of Winnipeg. I will report on experimental results from this prototype and its performance compared to simulation studies. I will also discuss the greater challenges expected at TRIUMF, due to the large cyclotron field (almost an order of magnitude larger than in our lab in Winnipeg) and the changing magnetic environment from large iron structures. Simulation studies of the implementation at TRIUMF will also be reported.

W1-3 Particle Physics VI (PPD) I Physique des particules VI (PPD) / 2116

The ATLAS Upgrade for the High-Luminosity LHC (I)

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The Large Hadron Collider (LHC) at CERN will be upgraded to a new machine, the High Luminosity LHC, staring up in 2026 with seven times the current luminosity. The ATLAS experiment will then collect 3000 fb-1 of proton collisions at 14 TeV centre-of-mass energy. This large data set will increase the discovery reach and allow higher precision in many measurements. The ATLAS detector needs several improvements to cope with the unprecedented luminosity and radiation damage.

This talk will summarise the new physics reach and describe the planned detector and trigger improvements, concentrating on the Canadian contributions in the liquid argon calorimeter and the new silicon inner tracker.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2117

POS-53 Effects of native state topology vs. sequence in protein folding

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Most small single-domain proteins spontaneously organize into essentially unique three-dimensional structures determined by their amino acid sequence. While much has been learned about this folding process from experiment and theory, open questions remain. Here we use an intermediate-level coarse-grained model with 7 atoms per amino acid to explore the interplay of two factors in the folding process, namely (1) the amino acid sequence and (2)the topological complexity of the native fold. To this end, we first design three different 35-54 amino acid model sequences that fold into 3alpha, 4beta+alpha and beta barrel structures, respectively, and hence exhibit varying fold complexities. The folding free energy landscapes of these three sequences are determined using Monte Carlo simulations. We thereafter employ a novel multisequence algorithm to determine the folding thermodynamics of large numbers of mutants of the three proteins. Effects of the mutations on the folding free energy landscapes within and between the folds are compared.

W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2118

Effect of cross-linking on the size-distribution of collagen fibrils (G)*

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We have shown that collagen fibrils have a preferred equilibrium fibril radius. However, the radial distribution of fibrils in tissues is typically polydisperse. Tendon fibrils in particular can exhibit a bimodal distribution of radii within the same tissue. This suggests non-equilibrium effects are important in fibril formation. To investigate these effects, we applied 2d coarsening dynamics to a system of fibril cross sections. We adapted the dynamics to account for both the equilibrium fibril radius and age-dependent cross-linking of individual fibrils. We find for tendon fibrils that a broad range of fibril radii are stable with respect to a bulk non-fibril (cholesteric) phase, and that cross-linking freezes the fibril distribution away from the equilibrium.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2119

POS-5 Modeling and Characterizing Polarization Distortion for Real-world Quantum Key Distribution Implementations

Author: Sebastian Slaman[1]

Co-authors: Ramy Tannous [1]; Jean-Philippe Bourgoin [1]; Thomas Jennewein [1]

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Integrity of digital security is crucial for maintaining the secrecy of banking data, personal information, company trade secrets, governmental records, and more. A perfectly implemented quantum cryptographic scheme, such as quantum key distribution (QKD), would be impossible to break. Freespace QKD systems commonly rely on polarization encoded single-photons. However, the optics required to manipulate photons can perturb the polarization, reducing the encoded state's integrity thus, decreasing the quality of the quantum channel. Here I present a method for characterizing the effects of optical elements on photon polarization with respect to QKD performance. This computational model describes polarization effects by tracing light propagation paths through many individual optical elements. This research will forward for the development of freespace QKD reliability.

T3-4 Gravity and Cosmology (DTP/DHP) | Gravité et cosmologie (DPT/DHP) / 2120

Bianchi IX dynamics in dust time (G)

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It is well established that the near singularity dynamics of a Bianchi IX spacetime can be characterized as a series of transitions between Kasner solutions (BKL map). The majority of results obtained in this limit rely on an (intrinsic) geometric time variable (f(g)). This time variable is not suitable to determine the intermediate regime dynamics of Bianchi IX with matter. We study Bianchi IX with dust and show that using dust as time can give us a handle on the intermediate dynamics; a transition map involving a degree of freedom from the matter sector, which reduces to the BKL map near the singularity. Moreover, the analysis gives us a new physical picture in which the dynamics is characterized by a series of transitions between Bianchi I solutions with dust.

T3-1 Photonics (DAMOPC / DCMMP) | Photoniques (DPAMPC / DPMCM) / 2121

Coupled spatial and spectral properties of a spectrally broadband photon pair source in bulk PPLN (G)*

Author: Aimee Gunther[1]

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While quantum properties of light promise much-needed enhancements to metrology, further development of quantum light sources are needed to readily harness energy-time correlations for applications in imaging and spectroscopy. Spectrally broadband photon pairs, generated from the process of spontaneous parametric down-conversion (SPDC), require tight energy-time anti-correlations in order to achieve appreciable quantum frequency conversion rates needed in many of these applications. Such photon pair sources with Type-0 (eee) wave interactions have been characterized for

periodically poled potassium titanyl phosphate (PPKTP) but not for periodically poled lithium niobate (PPLN), a more nonlinear, or efficient, crystal. Here, we demonstrate an easier method of (indirectly) characterizing the "x-spectrum", or coupled spatial and spectral photon emission properties, in a simpler, single-shot method of SPDC spatial mode measurement. A high brightness photon pair source, operating at 532 nm ⟶ 1064 nm + 1064 nm, is characterized with this method using a ubiquitous silicon CCD beam profiling camera and spectral filters and compared with a theoretical model. Such a method and a model can allow for tailored control of spatial and spectral entangled photon pair properties and is adaptable to other photon pair source brightnesses and camera efficiencies. This can be especially useful in quantum optical experiment design.

T3-7 Surface Sciences (DSS) I Science des surfaces (DSS) / 2122

Hydrogen Generation and Co-deposition in Electroless Copper Plating

Authors: Tanu Sharma[1]; Alexandre E Landry[2]; Alexandre Leger[2]; Delilah A Brown[1]; Ralf Bruening[1]; Tobias Bernhard[3]; Sebastian Zarwell[3]; Frank Bruening[4]

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Electroless copper films are used in printed circuit board industry to establish a conductive layer on insulating substrates. These films may have failures (voids, blisters) related to stress and/or hydrogen co-deposition in Cu films. Typical methods to determine amount of hydrogen are destructive and indirect. We have developed a time-resolved method to measure amount of hydrogen released from Cu deposits after plating. At ambient conditions, films with high initial hydrogen loading release hydrogen for several days. Hydrogen content and hydrogen-related compressive film stress component in copper are proportional with a slope of (3.2±0.3) MPa/at.% H. Nickel, as an additive, promotes adhesion and changes stress in electroless copper film from compressive to tensile. The present work shows that nickel suppresses hydrogen incorporation into the Cu film from typically 25 to 0.01 at.% (thus explaining the stress effect), while hydrogen release during plating remains almost unchanged.

T2-5 Instrumentation and Imaging (DAPI) | Instrumentation et imagerie (DPAI) / 2123

Multi-Wavelength Light Trapping Using Width-Graded Plasmonic Nanogratings (G)*

Authors: Katelyn Dixon[1]; Ali Zeineddine[1]; Moein Shayegannia[1]; Nastaran Kazemi-Zanjani[1]; Arthur Montazeri[2]; Naomi Matsuura[1]; Nazir Kherani[1]

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Light incident on nanoscale metal-insulator-metal (MIM) plasmonic gratings generates surface plasmon polaritons (SPPs) which resonate and propagate within the grating structure. A variation in the SPP resonant wavelength is achieved by gradually increasing the width of the MIM grooves

symmetrically about a central groove to create a graded grating, which leads to a gradient in the effective refractive index wherein the index increases in the direction of the central groove. The index gradient guides non-localized SPP waves towards the grating center which, in combination with localized SPP modes within the narrowest central grooves, produce multi-wavelength electric field enhancement at the center of the grating.

Central grooves with sub-50 nm widths enable enhanced localization of multiple wavelengths of light. Therefore, these structures can be used as unique substrates for surface enhanced Raman spectroscopy (SERS), having the potential to achieve unprecedented detection sensitivity, specificity and rapidity. However, large scale fabrication of such narrow gratings using standard nanofabrication techniques is not cost effective and limits the minimum groove width to approximately 50 nm. Herein we report on the development of a novel nanoplasmonic graded grating with a sub-10 nm central groove flanked by increasingly wider grooves on either side, which are fabricated economically using state-of-the-art, thin film sputter deposition.

These structures are also studied using COMSOL Multiphysics modelling where we vary the minimum groove width, groove-to-groove separation and groove depth, and thus demonstrate localization of broadband incident light with intensity enhancements of over five orders of magnitude. Additionally, we explore the effect of the number of grooves and the material composition of the structure on the near-field optical response. Experimental results from confocal fluorescence microscopy demonstrate multi-wavelength localization within the grating structures. In addition, SERS characterization of low concentration biomolecules using the gratings reveal the potential of these nanoplasmonic graded gratings as a rapid and highly sensitive platform for the detection of a variety of molecular species amenable to a wide range of applications including health, environment and security.

R3-3 Particle Physics X (PPD) | Physique des particules X (PPD) / 2124

Understanding eV-threshold calorimeters for SuperCDMS and other dark matter searches

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A wide variety of experiments to directly search for dark matter/atom scattering are being pursued. To search for low-mass dark matter, detectors are exploiting recent advances in calorimeter technology and are pushing the physical limits of ionization calorimetry with single photon or electron detection. SuperCDMS SNOLAB and other upcoming experiments will be using these technologies to provide substantial increases in sub-GeV/c^2 dark matter sensitivity.

At the limit of single photon or electron sensitivity, calorimeter sensitivity should no longer a simple linear function of the number of quanta observed. A more complete understanding of how the energy and momentum from a dark matter-nucleus collision partitions between electron excitation, phonon generation, defect formation is required.

A calibration is being undertaken beginning this summer at the University of Montreal, using SuperCDMS style sensors on a silicon chip, to characterize low-energy nuclear recoils. Recoils from both the elastic scattering of low-energy neutrons and nuclear Thomson scattering of MeV-energy photons will be measured. Details of and new effects that may be seen by this experiment, such as directional dependent sensitivities, will be discussed.

: R1-5 History of Physics (DHP) | Histoire de la physique (DHP) / 2125

John Stuart Foster and Canada's First Cyclotron

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Seventy years ago, the McGill University 100-MeV synchro-cyclotron was under construction. During its almost 40 years of operations, many discoveries were made and a large number of doctoral students were educated. The long-term influence of the cyclotron lab on the landscape of Canadian subatomic physics was considerable and is arguably greater than that of Rutherford, an earlier engine of discovery at McGill.

The cyclotron owed its existence to the vision of John Stuart Foster who almost single-handedly led its funding and building stages, using his considerable scientific prestige and personal skills as well as his important connections in the international community. In this presentation I will describe the path he took, starting with his initial proposal, made in 1935, only three years after Lawrence and Livingston's first demonstration of the cyclotron concept.

PPD Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (5) | Session d'affiches PPD et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (5) / 2126

POS-46 A Sensitive Assay Technique for 210Pb in Water Developed for the SNO+ Experiment

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SNO+ is a multipurpose neutrino physics experiment adapting the Sudbury Neutrino Observatory (SNO) detector located 2 kilometers underground in the SNOLAB facility in Sudbury, Canada. A sensitive technique to assay 210Pb in water was developed by SNO+. For the lower energy measurements of interest to SNO+, radon daughter radioisotopes, especially 210Po and 210Bi supported by 210Pb, are important. Since water will be used in the purification of both the liquid scintillator and the tellurium that will be chemically loaded in SNO+ to search for neutrinoless double beta decay, the 210Pb assay technique will be used to carefully monitor and control 210Pb levels in the water. The technique is capable of measuring 0.4 +/- 0.13 mBq/mˆ3 of 210Pb for a 10 tonne assay. This 210Pb procedure represents an extension of the water assay technique, based on the capture of Ra and Th radioisotopes using Hydrous Titanium Oxide (HTiO), that was developed by the SNO experiment. Ra sensitivities equivalent to 232Th: 4 x 10ˆ-16 gTh/D2O and 238U: 3 x 10ˆ-16 gU/g D2O were achieved with this technique (NIM A 604: 531-535 (2009)). The HTiO technique will be used in SNO+ to monitor 238U and 232Th contamination levels in the shielding water and the performance of the water purification system at SNOLAB.

W1-3 Particle Physics VI (PPD) I Physique des particules VI (PPD) / 2127

Rn-222 Concentrations within the Water Phase of the SNO+ Experiment (G)*

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Radon-222 and its daughters are a primary background within SNO+, a large liquid scintillator detector located deep underground at SNOLAB, designed to detect rare neutrino interactions. Therefore

it is crucial to determine the remaining trace amounts contributing to the experiment's background signal carefully.
A cryogenic radon trapping system is used to monitor the backgrounds observed in both water and scintillator phases of the experiment. This system has been improved and must be tested and then operated frequently. Concentrations up to 3.5×10ˆ-14 g 238U/g H2O can be measured in water. Radon-222 measurement techniques and results within SNO+ will be discussed in this presentation.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2128

POS-31 Exploration of 2D materials for high-efficiency thermoelectric conversion

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Thermoelectric materials can be used to construct solid-state devices that convert excess heat into electrical power. Because roughly half of all energy generated is lost as waste heat, efficient thermoelectric devices represent an opportunity to significantly reduce global energy production. However, predicting whether a material will exhibit efficient thermoelectric conversion is a highly nontrivial task due to the complicated interdependence of the relevant material properties, namely electrical conductivity, thermal conductivity and Seebeck coefficient. This makes ab initio methods for calculating thermoelectric properties extremely valuable, as they allow for the identification of novel materials/structures with excellent thermoelectric characteristics, without the need for expensive and time-consuming experimental trial-and-error.

By combining density functional theory calculations of electronic structure with rigorous transport theory, our group is able to calculate the thermoelectric properties of materials entirely from first-principles. This poster will present our investigations of a class of 2D materials (for example bismuth telluride) that have been suggested to possess desirable properties for efficient thermoelectric conversion not shared by their bulk counterparts, making them a promising candidate for use in next-generation thermoelectric devices.

R3-3 Particle Physics X (PPD) | Physique des particules X (PPD) / 2129

The SNO+ Calibration Program

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With a 6 km water equivalent overburden in the Canadian Shield, SNO+ plans to make a competitive measurement of neutrinoless double beta decay in Tellurium doped liquid organic scintillator. Additionally, the detector has the capacity to make measurements of reactor, supernova, solar and geoneutrinos. Since December 2016, the detector is taking data as a water Cherenkov detector to set limits on nucleon decay and determine the external backgrounds. SNO+ requires a detailed

calibration program to determine the optical and energy response of the detector. This presentation will describe the calibration hardware as well as the calibration program in the water phase of SNO+ and how these calibrations affect the systematics of upcoming measurements.

W4-1 Energy Storage 4 (DCMMP) | Accumulation d'énergie 4 (DPMCM) / 2130

Organic electrolytes for use in low-cost aqueous redox flow batteries (G)

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Co-author: Ian Hill [2]

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Redox flow batteries are a promising solution for large-scale energy storage. Many flow batteries have been successfully commercialized; however, these systems typically involve the use of expensive metallic redox couples such as vanadium, iron-vanadium and iron-chromium, which exceed the US Department of Energy's cost target of $100 kWh-1.

One approach to reducing systems costs involves the application of organic redox couples, which can be synthesized from abundant low-cost materials. An additional benefit of organic materials is that their reaction kinetics and material properties (such as solubility, number of redox states, and reduction potential) can be adjusted through changes in synthetic design. Quinones are a family of organic materials with well-studied electrochemical properties [1,2]. Owing to their electrochemical reversibility tunable reduction potential and solubility, quinones have recently been demonstrated as an effective class of redox couples in aqueous organic flow batteries [3,4].

This project investigates the use of a commercially available quinone dye –3,4-dihydroxy-9,10-anthraquinone-2-sulfonate sodium (alizarin red S.) –as a negative electrolyte in an alkaline redox flow battery. Paired with potassium ferrocyanide, the system demonstrates a nominal operating voltage of 1.1 V, when cycled at 50 mA (10mA/cm2). Using these cycling conditions under a blanket of flowing argon, the system is shown to exhibit a stable coulombic efficiency of ˜90% and voltage efficiency of ˜60% for over 50 cycles before irreversible capacity fade begins to occur. The development, design and results for this aqueous flow battery system will be presented.

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T3-1 Photonics (DAMOPC / DCMMP) | Photoniques (DPAMPC / DPMCM) / 2131

Improving the quality of heralded single-photon sources with cascaded downconversion

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Single photons play an important role in several quantum technologies, acting as flying qubits to transfer quantum information for both computing and communication applications. In many cases, it is acceptable for these single photons to be produced randomly, as long as they are accompanied by heralding signals announcing their creation. Such heralded single photons sources are straightforward to implement with pairs of photons produced by spontaneous parametric downconversion, by detecting one photon from a pair to announce the presence of its partner. However, the quality of single photons produced in this way is limited. Detector dark counts and multi-pairs events inevitably lead to cases where, instead of preparing a state with one photon, several photons or no photons at all are produced. To address this issue, we propose the use of a second downconversion stage to precertify the presence of a heralded single photon. We show the additional heralding signal provided by this scheme leads to sources with improved single-photon properties, as quantified by the heralded second-order correlation function, g(2). Significantly, we find that this improvement is present even at equal single-photon production rates, and can be achieved with current detectors and downconversion crystal. Our results are most relevant to applications in which single photon with high number purity are essential.

W2-2 Light-Matter Interactions I (DAMOPC) | Interactions lumière-matière (DPAMPC) / 2132

Quantum fluctuations in dipolar Bose-Einstein condensates and Bose-Bose mixtures (G)

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Recent experiments with the highly magnetic atoms dysprosium and erbium have revealed the formation of a novel form of ultra-dilute stable droplets in dipolar Bose-Einstein condensates (BEC). This surprising result has been explained by the stabilization given by quantum fluctuations.
We will discuss the effects of these beyond-mean-field corrections of a dipolar BEC in three dimensions as well as in a quasi-one-dimensional geometry.
Moreover, we will show that the same arguments can be applied to a system of a mixture of two different bosons in absence of atomic dipoles but with different inter- and intra-coupling constants.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2133

POS-55 Response of an Organic Photodiode to a Kilovoltage Photon Beam under Different Bias Conditions

Author: Michael Hupman[1]

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The response of an organic photodiode to fields of 300 kVp photon beams was measured while varying the bias applied to the diode. A heterojunction photodiode was fabricated by spin coating a blend of P3HT and PCBM on a glass substrate. The bottom contact was ITO and the top contact aluminum. The photodiode was irradiated with an Xstrahl 300 orthovoltage x-ray unit (Xstrahl Ltd., Surrey, UK). All irradiations were performed with a 5 cm diameter, 30 cm length cone with the photodiode placed on top of 10 cm of solid water to allow for backscatter. The photodiode was irradiated in 100 MU increments. For each bias the measurement was repeated 3 times. The diode current was measured using a source measurement unit (Keithley 2614B). All machine outputs were measured with a calibrated ionization chamber. The total charge collected for an increment of dose was determined by integrating the area under the curve of the current as a function of time when the beam was on. The sensitivity of the diode was then calculated by dividing the total charge collected by the dose. The noise was measured by irradiating the setup without the photodiode, but all electrical connections in place and the current measured. With the beam off the measured current was 1 ± 1 pA. With the beam on, but no photodiode in the holder the current increased to 5 ± 1 pA. With a dose rate of 4.1 cGy/s the measured current was 110 ± 10, 330 ± 30, 460 ± 30, and 550 ± 50 pA for applied biases of 0, 1, 1.5, and 2 V, respectively. The calculated sensitivity was 26 ± 2, 86 ± 8, 110 ± 7, and 130 ± 10 pC/cGy for applied biases of 0, 1, 1.5, and 2 V, respectively.

W3-5 Quantum Sensors and Quantum Technology (DAMOPC) | Détecteurs quantiques et technologie quantique (DPAMPC) / 2134

Optical fiber nanoprobe for the detection of chemicals (G)

Authors: Gautam Das[1]; Joshua Trevisanutto[1]

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Surface Enhanced Raman Spectroscopy (SERS) is a powerful tool for detecting chemicals, including rhodamine 6G (R6G), at the molecular level. The authors have developed a plasmonic structure by depositing gold nanorods (GNRs, aspect ratio: 6.4) on a tapered optical fiber via optical tweezing. A 1064 nm laser was coupled to the un-tapered end of the tapered fiber for tweezing. The tweezing process was repeated with several other laser wavelengths such as He-Ne 632 nm. In order to show the efficiency of the plasmonic structure the authors will present the SERS spectra of R6G. Authors will also describe techniques (Transmission, and reflection modes) which can be used in conjunction with the nano-probe in order to collect scattered light from the sample.
The research was financially supported by Natural Sciences and Engineering Research Council of Canada (NSERC) and Canada Foundations for Innovations. Authors also acknowledge the members of the Photonics Research Group, Dr. Reznik's research group, and Dr. Aicheng Chen's research group.

T3-6 Developing Scientific Practices in the Laboratory (DPE) | Exercice de la science en laboratoire (DEP) / 2135

QExpy: A python package for undergraduate laboratories

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A common complaint from students in undergraduate physics laboratories is that they spend too much time propagating uncertainties and not enough time understanding the physics. We have worked with students at Queen's University to develop QExpy, a python package designed to facilitate undergraduate physics laboratories, while easing students into learning to program in python.

The open source package can be downloaded by anyone and allows students to easily propagate uncertainties using a variety of methods including Monte Carlo, as well as to make interactive plots and fit arbitrary models to the their data. The package was specifically designed to be easy to use, pedagogic, and well-integrated with the Jupyter Notebooks framework. QExpy has been used by several hundred students at Queen's University, including first year students, and this presentation will highlight some of its features.

T3-1 Photonics (DAMOPC / DCMMP) | Photoniques (DPAMPC / DPMCM) / 2136

Photonic device for the detection of trace gases (G)

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A trace gas detection device has applications in environmental monitoring and healthcare. Authors will present the working principle of a trace gas sensor operating at room temperature, which was developed using the intracavity absorption spectroscopy method. In the system, a gas cell based on hollow core photonic crystal fiber (PCF) was used as an intracavity cell. The experiments were repeated using a multi-pass gas cell and compared with the results from the PCF based gas cell. The laser wavelength was selected by a fiber Bragg grating (FBG) with a peak wavelength close to one of the absorption lines of the gas sample to be detected. The presentation will include results based on the greenhouse gas, nitrous oxide (N2O), and acetylene (C2H2). The effect of off-resonance laser wavelength, response time and the detection limit of the device will be discussed. Finally, authors will present the application of the device for the measurement of N2O flux. The system can be made to operate in the detection of other gases by using a tunable FBG.

The research was financially supported by Natural Sciences and Engineering Research Council of Canada (NSERC) and Canada Foundations for Innovations.

M1-5 Nuclear Astrophysics (DNP) | Astrophysique nucléaire (DPN) / 2137

Half-Lives of the Neutron-Rich $N \approx 82$ Isotopes $^{128-130}$Cd and ^{131}In (G)*

Authors: Ryan Dunlop[1]; Iris Dillmann[None]; Carl Svensson[1]; Corina Andreoiu[2]; Gordon Ball[3]; Nikita Bernier[3]; Harris Bidaman[1]; Paula Boubel[1]; Christina Burbadge[None]; Roger Caballero-Folch[4]; Michelle Dunlop[1]; Lee Evitts[3]; Fatima Garcia[2]; Garnsworthy Adam B.[3]; Paul Garrett[1]; Greg Hackman[3]; Hallam Sam[3]; Jack Henderson[3]; Ilyushkin Sergei[5]; Dylan Perry Kisliuk[6]; Reiner Kruecken[3]; Jens Lassen[3]; Ruohong Li[3]; E MacConnachie[3]; Andrew MacLean[1]; McGee Erin[1]; Mohamad Moukaddam[3]; Bruno Olaizola Mampaso[7]; E Padilla-Rodal[8]; Jason Park[9]; Paetkau Owen[3]; Costel Petrache[10]; Jennifer Pore[None]; Allison Radich[11]; Ruotsalainen Panu[3]; james smallcombe[None]; Jenna Smith[3]; Andrea Teigelhoefer[3]; Joseph Turko[1]; Tammy Zidar[1]; V. Bildstein[1]

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Half-lives of $N = 82$ nuclei below doubly-magic ^{132}Sn are key input parameters for calculations of any astrophysical r-process scenario and play an important role in the formation and shape of the second r-process abundance peak. In the past, shell-model calculations of neutron-rich nuclei near the $N = 82$ neutron shell closure that are not yet experimentally accessible have been performed by adjusting the quenching of the Gamow-Teller (GT) operator to reproduce the ^{130}Cd half-life reported in Ref. 1. The calculated half-lives of other nuclei in the region are known to be systematically too long. Recently, a shorter half-life for ^{130}Cd was reported [2,3]. A re-scaling of the GT quenching to the new ^{130}Cd half-life by a constant factor for all nuclei in the region resolved the discrepancy. However, the reduced quenching of the GT operator creates a new discrepancy in the calculated half-life of ^{131}In. The measurement of ^{131}In is complicated due to the presence of three known β-decaying states with roughly the same half-life, making photopeak gating an ideal method to measure each of these half-lives. In this talk, the half-lives of $^{128-130}$Cd and ^{131}In, as well as the spectroscopy of ^{131}Sn, measured using the GRIFFIN γ-ray spectrometer at TRIUMF will be presented.

1 M. Hannawald *et al.*, Nucl. Phys. A **688**, 578 (2001).
2 R. Dunlop *et al.*, Phys. Rev. C **93**, 062801(R)
3 G. Lorusso *et al.*, Phys. Rev. Lett. **114**, 192501 (2015).

M2-2 Theory, Modelling and Forecasting II (DASP) | Théorie, modélisation et prévisions II (DPAE) / 2138

Hydro-Quebec and Geomagnetic Disturbance : historical observations, data/forecast integration, recent real event and space weather gaps (I)

Author: Sebastien Guillon[1]

Co-author: Martin Connors [2]

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This presentation will discuss Hydro-Quebec's historical records and observations of geomagnetic disturbance. We will show how data/forecasts are used and integrated in control room operation. A real event will be presented in detail. Looking at the future, we will illustrate some gaps and research needs. The main idea of the presentation is that electricity provides relevant feedbacks to space weather physics.
La présentation discutera des perturbations géomagnétiques historiques enregistrées et observées à Hydro-Québec. Nous montrerons comment les données/prévisions sont intégrées dans les opérations du centre de contrôle. Un événement réel sera présenté en détails. Au niveau du futur, nous illustrerons des pistes de recherche à combler. L'idée majeure de la présentation est que l'électricité fournit des informations pertinentes sur la physique de la météorologie spatiale.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2139

Free energy of a folded semiflexible polymer confined to a nanochannel of various geometries

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Monte Carlo simulations are used to study the conformational properties of a folded semiflexible polymer confined to a long channel. We measure the variation in the conformational free energy with respect to the end-to-end distance of the polymer, and from these functions we extract the free energy of the hairpin fold as well as the entropic force arising from interactions between the portions of the polymer that overlap along the channel. We consider the scaling of the free energies with respect to varying the persistence length of the polymer and the channel dimensions for confinement in cylindrical, rectangular and triangular channels. We focus on polymer behaviour in both the classic Odijk and backfolded Odijk regimes. We find the scaling of the entropic force to be close to that predicted from a scaling argument that treats interactions between deflection segments at the second virial level. In addition, the measured hairpin fold free energy is consistent with that obtained directly from a recent theoretical calculation for cylindrical channels. It is also consistent with values determined from measurements of the global persistence length of a polymer in the backfolded Odijk regime in recent simulation studies.

M2-5 Nuclear Structure I (DNP) | Structure nucléaire (DPN) / 2140

Structure of ^{188}Hg From Gamma-ray Spectroscopy With GRIFFIN (G)*

Author: A. D. MacLean[1]

Co-authors: F. A. Ali [2]; C. Andreiou [3]; G. C. Ball [4]; N. Bernier [4]; H. Bidaman [2]; V. Bildstein [2]; M. Bowry [4]; R. Caballero-Folch [4]; I. Dillmann [4]; A. B. Garnsworthy [4]; P. E. Garrett [1]; B. Jigmeddorj [2]; A. I. Kilic [2]; B. Olaizola [4]; Y. Saito [4]; J. Smallcombe [4]; C. E. Svensson [1]; J. Turko [1]; K. Whitmore [3]; T. Zidar [2]

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Shape coexistence is associated with nuclear deformations at low excitation energies and has been a topic of extensive research in nuclear physics over the past 60 years. Shape coexistence is driven by two opposing forces. One is the stabilizing effect of closed shells causing the nucleus to have a spherical shape, while the other is the residual interaction between proton and neutrons, the correlation energy gain, in which the proton-neutron interaction energy is a major contribution 1. A region of particular interest is the neutron deficient Hg isotopes, which is a well-known region of shape coexistence. A large isotope shift in the neutron deficient Hg isotopes was reported in the 1970's and is interpreted as differently shaped potentials along the isotopic chain causing differences in deformation 2. Using the high efficiency GRIFFIN spectrometer, a detailed study of the excited states populated in ^{188}Hg following the β^+/EC decay of ^{188}Tl was preformed as part of an experimental campaign to help further a comprehensive understanding of nuclear structure evolution in this region.

1 Kris Heyde and John L. Wood. Shape coexistence in atomic nuclei. Rev. Mod. Phys., 83, 1467-1521, Nov 2011.
2 J. Bohn et. al.. Sudden change in the nuclear charge distribution of very light mercury isotopes. Physics Letters B, 38, 308 –311, 1972.

T1-3 Ground-based and In Situ Observations I (DASP) l Observations terrestres et In situ I (DPAE) / 2141

Science Effects of Observing Affects of Langmuir Probe Coatings on Swarm (G)*

Author: Candice Quinn[1]

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The European Space Agency's trio of Swarm were launched in November 2013 to measure the environment around Earth using a suite of instruments. Each satellite is equipped with two Langmuir probes that run in parallel and have different coatings. One is gold plated and the other has a titanium nitrate coating. This configuration on each satellite provides an opportunity to study if and how coatings on Langmuir probes may affect plasma density and temperature measurements.

In this study, data are selected from each probe pair to control for solar illumination, magnetic field orientation, and operative mode to assess the extent to which differences in measurements are present. Any differences from the two probes can be attributed to the surface coatings. Preliminary results will be presented and discussed.

W1-2 Strategies and Good Practices for Teaching Atomic, Molecular and Optical Physics (DAMOPC/DPE) | Stratégies et bonnes pratiques d'enseignement de la physique atomique, moléculaire et optique (DPAMPC/DEP) / 2142

Towards passive polarization compensation of quantum key distribution signals for free-space quantum communication (G)*

Author: Ramy Tannous[1]

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As the world becomes ever more connected, activities such as online banking, shopping and personal data storage will become increasingly popular. The security of these services is essential since private information is involved. Cryptography that rely on computational complexity have not been proven to be secure. Quantum key Distribution (QKD) uses the physical phenomena prevalent in the quantum nature of light to perform cryptanalytically secure key transfer. Implementations of QKD is continuing to move from the research laboratory to real world applications. Fiber based QKD systems are already commercialized and free-space systems are rapidly developing. For free-space applications, one of the many challenges of perfect implementation is aligning and maintaining the reference frame of the polarization states that are sent over the communication channel. Current solutions require active polarization compensation, while passive compensation techniques can drastically reduce implementation costs and hardware. One experimental method being examined utilizes polarization-maintaining fibers (PMF) to properly define one polarization basis by taking advantage of the fiber core properties. I will present this implementation employing entangled photons to show its feasibility for free-space quantum communication applications.

T2-4 Medical Imaging 1 (DPMB) | Imagerie médicales 1 (DPMB) / 2143

Laplacian-Inspired Design of a Highly-Homogeneous, RF Shielded Magnet for Low-Field TRASE MRI (G)*

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TRansmit Array Spatial Encoding (TRASE) is a Magnetic Resonance Imaging (MRI) method which uses phase gradients of the B_1 field –rather than magnitude gradients of the B_0 field –to achieve spatial encoding. The potential benefits and limitations of this technique are still being explored in both conventional and low-field magnets. This work designs a highly homogeneous, low-field magnet (<10 mT) to further studies of TRASE in this regime. The design method is novel and allows for ostensibly perfect field homogeneity. Furthermore, given that TRASE does not require the application of switched B_0 gradients, we propose to build the magnet on an aluminum housing which acts both as a heat sink and an effective low-frequency RF shield.

This talk will present the design method, convergence tests of this method, and the final design. The method is founded upon consideration of two coaxial cylindrical surfaces of finite lengths with surface currents on their bodies and end caps. Boundary conditions are set such that the outer surface perfectly shields the field created. Using finite element methods, the Laplacian of the magnetic scalar potential , and hence magnetic field B, is found in the region between the cylinders. One is free to specify any solution to the Laplace equation in the inner region, including $= -Bz/_o$, which gives a uniform field. By moving the outer surface farther and farther away, we are able to converge to a solution for a single, finite-length cylinder in free space with the perfectly uniform internal field of an infinitely long solenoid. The discontinuity of the scalar potential across the cylinder boundary is, in fact, equivalent to the stream function, and, as a result, evenly spaced contours of give the coil winding pattern. Because no current flows at the center of the end caps, access holes can be created in these regions.

W3-4 Soft matter and molecular dynamic (DPMB/DCMMP) | Matière molle et dynamique moléculaire (DPMB/DPMCM)) / 2144

Capillary levelling of a liquid stepped film supported on an immiscible liquid film (G)*

Authors: Carmen Lee[1]; Vincent Bertin[None]; JOHN NIVEN[1]; Thomas Salez[2]; Elie Raphael[2]; Kari Dalnoki-Veress[1]

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Thin polymeric films have numerous technological applications and their stability has garnered intense interest. The stability and flow of a thin, viscous film is sensitive to the boundary conditions as the film thickness approaches the nanoscale. Here we probe a liquid-liquid boundary condition: a stepped polymer film is placed above a different, immiscible polymer film. The ensemble is supported by a solid substrate. The temporal evolution of the air-polymer interface, as well as the polymer-polymer interface were studied using atomic force microscopy. The polymer-polymer interface was exposed by using a selective solvent to remove the top film. Experimental results show

that the step at the air-polymer interface levels off to minimize the excess surface area, and that there is substantial deformation at the interface between the two polymers during the levelling process. These findings are discussed in light of a developed lubrication model.

W3-8 Nuclear Structure II (DNP) | Structure nucléaire II (DPN) / 2145

Investigation of the nuclear structure of ^{33}Al through β-decay of ^{33}Mg to probe the island of inversion (G)

Author: Tammy Zidar[1]

Co-authors: A. B. Garnsworthy [2]; A. D. MacLean [3]; B. Olaizola [2]; C. E. Svensson [3]; Christina Burbadge ; David Cross ; E MacConnachie [4]; E Padilla-Rodal [5]; Gordon Ball [4]; I. Dillmann [2]; Jack Henderson [4]; Jenna Smith [4]; Jennifer Pore ; Joseph Turko [1]; Lee Evitts [4]; Michelle Dunlop [1]; Mohamad Moukaddam [4]; Mustafa Rajabali [6]; Nikita Bernier [4]; P. E. Garrett [3]; Ryan Dunlop [1]; Sergey Ilyushkin ; V. Bildstein [7]

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Some nuclei far from the valley of stability have been found to have ground state properties that are different than those naively expected from the nuclear shell model. The term 'island of inversion' is used to refer to regions of the nuclear landscape in which deformed intruder configurations dominate nuclear ground states over the normal spherical shell model ones. The nuclear structure of transitional nuclei, in which the normal and intruder configurations compete, can be used to test theoretical models used to explain the inversion mechanism. One such transition occurs along the N = 20 isotones, where neutron-rich ^{32}Mg is known to have a deformed ground-state configuration in the $f_{7/2}$ shell, while ^{34}Si displays a normal one. Previous studies [1, 2] of the intermediate N = 20 isotone ^{33}Al have yielded conflicting results regarding its structure. In the present work, ^{33}Al was studied through the β-decay of ^{33}Mg to clarify these discrepancies.

A low-energy radioactive beam of ^{33}Mg was delivered at a rate of 10^4 ions/s by the Isotope Separator and Accelerator (ISAC-I) facility at TRIUMF. Data were collected with the GRIFFIN 3 high-purity germanium γ-ray spectrometer coupled with the SCEPTAR plastic scintillator β particle detector. The majority of the data were collected in a cycled mode (with a period of $\sim$10 s beam on, 1.5 s beam off) to provide sensitivity to all of the ^{33}Mg, ^{33}Al, ^{32}Al (β-n daughter) and ^{33}Si half-lives. The high efficiency of the GRIFFIN detector provided new γ-γ coincidences to elucidate the excited state structure of ^{33}Al, and the capability of GRIFFIN to detect weak transitions has provided more complete β-decay branching ratios for the ^{33}Mg$\rightarrow$ ^{33}Al$\rightarrow$ ^{33}Si decay chain. Results from this analysis will be presented and their significance discussed.

1 V. Tripathi, et al., Phys. Rev. Lett. 101, 142504 (2008)
2 J. C. Angélique, et al., AIP Conf. Proc. 831, 134 (2006)
3 C. E. Svensson and A. B. Garnsworthy, Hyperfine Int. 225, 127 (2014)

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2146

POS-16 Using Atomic Force Microscopy to Characterize Energy Storage Materials

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In the quest for high performance materials for energy storage, a comprehensive toolbox of characterization techniques - both experimental and theoretical - is an absolute necessity. In recent years, many techniques have been increasingly focussed on combining observations of material structure, composition, and dynamics to develop a complete picture on how various material properties affect overall performance. This is generally achieved either by custom built hardware that incorporates several characterization techniques that can be performed consecutively, or by successive ex-situ measurements that each capture different information. There do exist, however, some emerging techniques that can capture both dynamic and structural information simultaneously, one of which is atomic force microscopy (AFM). The operating principle of AFM employs an extremely sensitive and highly localized force sensor (probe), which makes it a very good candidate for measuring local dynamic processes. Here we will present some of the leading work on various implementations of AFM and how they are applied to energy materials, including time-resolved electrostatic force microscopy (EFM), which enable the direct probing of charge transport processes with high spatial resolution.

In EFM-based techniques, the probe is used to detect changes in the local electric field, which can arise from a variety of processes including the movement of ions. By driving ionic transport with an applied potential and acquiring the response signal over time, it can be used to directly measure the bulk ionic conductivity of a substrate and - if done at varying temperatures - the local activation energy and hopping barriers. Using this time-resolved technique on a heterogeneous sample, we have observed spatial variations in the response signal on the order of 50nm, demonstrating the true power of this technique. The topographic images obtained also allow for further characterization on the exact same physical regions of the sample, which eliminates the effects of averaging over large macroscopic areas.
These measurements allow us to directly peer into the relationship between local structure and dynamics with the spatial and temporal resolution not previously available with many standard approaches. This has lead to the maturation of AFM into a staple in the characterization toolbox for energy materials.

W3-1 Creating Authentic Physics Learning Experiences (DPE) | Créer d'authentiques expériences d'apprentissage en physique (DEP) / 2147

Integrating Online Information Search in Tutorials –Effects on Student Learning and Perceptions

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Searching for information online has been an integral part of our lives for quite some time now. But many instructors - and students - will consider googling information to solve an assignment as cheating, perhaps thinking only of assignments that aim at lower levels of learning. How can we integrate online search in tutorials in a meaningful way, to make problem solving more authentic

and hopefully increase the students'engagement with the subject and even their understanding of physics?

We studied these questions in a one-year project involving three different first year Physics courses, using a combination of methods: Setting up an experimental group (with online search) and a control group (textbook and lecture notes only) allowed us to study effects on exam performance. We used a survey to study the students'perception of the different methods, and tutorial observations to document the students'activities and conversations.

We will show results from the exams, the surveys and the tutorial observations that illustrate our findings: In this project, we did not find a positive effect of online search on exam performance, but we gained valuable, sometimes surprising, insight into how useful, reliable or engaging the students perceived different resources. Observing the students in the tutorials revealed a large variability in research skills and approaches to team work. We conclude that integrating online search in a meaningful way requires specific problem design as well as teaching of research skills, including how to assess the reliability of sources, which should prove useful for other teaching formats as well.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2148

POS-32 Assessment of the Performance of Four Dispersion-Corrected DFT Methods Using Optoelectonic Properties and Binding Energies of Organic Monomer-Fullerene Pairs

Author: Sarah A. Ayoub[1]

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With the aid of different polymer materials, intermolecular interactions, energy levels, and optical absorption spectra of polymers and fullerenes can be adjusted so as to enhance the efficiencies of heterogeneous organic solar cells. It is known that computational simulations such as density functional theory (DFT) can play an important role in identifying polymers with favourable properties and hence in speeding up the process of designing organic solar cells with higher efficiencies. However, what is often not known is which one of the dispersion-corrected DFT (D-DFT) methods gives the most accurate results (relative to the experimental data) for the various properties of conjugated systems such as are found in heterogeneous organic solar cells. In this study, we employ four D-DFT methods (such as ωB97x-D, B97-D3, B3LYP-D3, and PBE1PBE-D3) to calculate the binding energies and, using the D-DFT optimized geometries, we perform single point DFT/B3LYP calculations to obtain HOMO and LUMO eigenvalues, and HOMO-LUMO band gaps of the various (promising) molecular pairings of organic monomers and fullerenes. In addition, we employ time dependent DFT (TD-DFT) to obtain the maximum absorption wavelengths of the monomers of interest. Our results show that B97-D3 and B3LYP-D3 computations give the largest binding energies relative to the other D-DFT methods and they yield (relative to experimental values) the most accurate electronic and absorption results. This study provides a detailed comparison of results as obtained using the four D-DFT methods for the various properties of the monomer/fullerene combinations.

W2-6 Inclusive Science Education (Part 1) (DPE/CEWIP) I Éducation scientifique inclusive (1ère partie) (DEP/CEFEP) / 2149

How to keep more students in physics: Ideas from the literature (G)*

Author: Laura Stiles-Clarke[1]

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Many physics professors and departments are concerned about the number of students who complete their degree programs, and the often much larger number of students who leave. This has been an ongoing concern in physics, other sciences, and engineering for several decades, especially for female students and students from underrepresented racial and ethnic groups. What can physics professors, staff, and departments do to keep students in physics programs for longer? I will present some ideas from the literature and help participants to begin to think about what they may already be doing, and what they could do, to increase student success.

T2-4 Medical Imaging 1 (DPMB) | Imagerie médicales 1 (DPMB) / 2150

Range and dose verification for proton therapy using using gamma spectroscopy of contrast agents. (G)*

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Proton therapy is gaining popularity as a tumor irradiation method due to the superior dose distribution offered by heavy charged particles. The subject of range and dose verification has been approached from several angles and fields.

Upon interaction with low-energy protons, certain nuclei undergo fusion-evaporation reactions. The resulting reaction products emit a cascade of characteristic gamma rays as they decay to their ground state. The product of these fusion-evaporation reactions is highly dependent on the energy of the incident proton. This means that the relative intensity of the competing fusion-evaporation channels can be correlated with the energy of the proton beam, and, by extension, its range. By administering an appropriate contrast agent to the tumor being irradiated, we are able to measure the intensity of characteristic prompt gamma rays resulting from fusion-evaporation reactions occurring inside the tumour.

We propose to take advantage of the timing and energy resolutions of a fast scintillator detector to measure beam range and dose administered in proton radiation therapy. Fast scintillator detectors are used frequently in nuclear research due to their good timing resolution and reasonable energy resolution, and have begun to make their way into the medical field.

Our Geant4 simulation results show that this technique would allow for accurate measurement of beam range relative to the position of the tumour within the body, as well as dose administered to the tumour. Additionally, the excited states resulting from the reactions of interest are very short-lived and as such this measurement is taken while the beam is online. This is advantageous because it allows for dose monitoring during the treatment as opposed to afterwards.

The presented approach combines the unique expertise at TRIUMF in the fields of both gamma ray spectroscopy in nuclear physics research and proton therapy in order to strive towards improved cancer radiation therapy.

R3-4 Condensed Matter / Quantum Theory (DTP/DCMMP) | Matière condensée / théorie quantique (DPT/DPMCM) / 2151

Entanglement signatures of emergent Dirac fermions: kagome spin liquid and quantum criticality (I)

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Quantum spin liquids (QSL) are exotic phases of matter that host fractionalized excitations. It is difficult for local probes to characterize QSL, whereas quantum entanglement can serve as a powerful diagnostic tool due to its non-locality. The kagome antiferromagnetic Heisenberg model is one of the most studied and experimentally relevant models for QSL, but its solution remains under debate. Here, we perform a numerical Aharonov-Bohm experiment on this model and uncover universal features of the entanglement entropy. By means of the density-matrix renormalization group, we reveal the entanglement signatures of emergent Dirac spinons, which are the fractionalized excitations of the QSL. This scheme provides qualitative insights into the nature of kagome QSL, and can be used to study other quantum states of matter. As a concrete example, we also benchmark our methods on an interacting quantum critical point between a Dirac semimetal and a charge ordered phase.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2152

POS-36 Vein glorious graphite for Li-ion Batteries

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Graphite is used as the negative electrode in most Lithium-ion battery chemistries. As demand for Li-ion batteries grows, so does demand for graphite. To help satisfy demand Elcora has acquired a vein graphite mine in Sri Lanka. This talk will discuss the journey graphite takes from the mine to a commercial cell.
Several topics will be discussed. For example:
• Graphite mining techniques
• Purification methods at the mine
• Spheronization
• Thermal purification
• Surface coating
• Cost
• Performance in Li-ion batteries

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T1-6 Topics in medical physics and biophysics (DPMB) / Sujets en physique médicale et biophysique (DPMB) / 2153

Copper stable isotope redistribution is regulated by gut bacteria in the gastrointestinal tract of mice (G)

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Co-authors: Fernando A. Vicentini [2]; Simon A. Hirota [3]; Keith A. Sharkey [3]; Michael Wieser [1]

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Stable isotope abundances vary in nature due to differences in zero-point energies of the binding site of a molecule upon isotopic substitution. This causes isotopes of an element to participate in reactions with different rates resulting in a redistribution of the isotopes in a system. Although the range in relative isotopic abundance of copper in natural materials is narrow, < 1.0%, current measurement techniques allow for quantification of changes as small as 0.01%. Recent attention is focussing on the redistribution of copper isotopes in biological systems.
The present study investigated the influence of gut bacteria on the redistribution of stable copper isotopes in the gastrointestinal tract of mice. Trillions of bacteria reside in our gastrointestinal tract and play an important role in energy homeostasis, protection against pathogens, nutrient metabolism, host immunity and intestinal barrier function. Here we compared the isotopic redistribution of copper isotopes in mice with gut bacteria significantly impacted by antibiotic consumption. A significant difference, ˜0.1%, in copper isotope abundances was measured in the proximal colons of the gastrointestinal tracts of antibiotic-treated mice, indicating a drastic change in copper processing in this region when bacteria were eliminated. In order to investigate the mechanism of these changes we examined copper transporters in the epithelium as they have been shown to modulate the extent of isotopic redistribution[1]. Both CTR1, responsible for copper import, and ATP7A, responsible for copper efflux, were significantly down-regulated in antibiotic-treated mice. Down-regulation of these proteins in intestinal epithelial cells is associated with increased extracellular copper[2,3] and suggest that gut bacteria are influencing the amount of bioavailable copper to cells. These results highlight the relationship between gut bacteria and copper, both identified as having an important role in health.
References:
1 Cadiou, J., et al. (2017) Scientific reports 7, p. 44533.
2 Petris, M. J., et al. (2003) Journal of Biological Chemistry 278, p. 9639
3 Chun, H., et al. (2017) Scientific reports 7, p. 12001.

M3-4 Cold and Trapped Atoms, and Tests of Fundamental Symmetries I (DNP/DTP/PPD/DAMOPC) | | Atomes froids et piégés, et tests de symétries fondamentales I (DPN/DPT/PPD/DPAMPC) / 2154

Precision antihydrogen gravitational mass measurement in ALPHA-g

Authors: Alex Khramov[1]; Andrea Capra[1]; Andrew Evans[2]; Art Olin[1]; Chukman So[2]; Darij Starko[3]; David Russell Gill[4]; Estifa'a Zaid[5]; Joseph McKenna[1]; Justine Munich[6]; Konstantin Olchanski [1]; Lars Martin[1]; Leonid Kurchaninov[1]; Makoto Fujiwara[1]; Mike Hayden[6]; Nathan Evetts[7]; Nicolas Massacret[1]; Pierre Amaudruz[1]; Rob Collister [1]; Robert Thompson[2]; Scott Menary [3]; Taka Momose[7]; Walter Hardy[7]

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The weight of antimatter is a crucial missing measurement in our picture of the natural world. It is important in two ways: 1. The predominance of matter created in the Big Bang demands some form of mismatch in properties between matter and antimatter. Many experiments have sensitively compared their charge, magnetic moment, nuclear bonding and decay behaviour, yet no significant mismatch has been found to date to explain the cosmic matter dominance. One of the last unexplored domains is gravitational behaviour. 2. Our understanding of the subatomic world is wholly incompatible with General Relativity, the dominant phenomenon on astronomical scales. New ideas on a unified theory on atomic and gravitational interactions may require antimatter to respond uniquely to gravity. Measuring such behaviour experimentally will provide vital evidence to accept or reject these ideas, and further the development of a unified view of nature.

Experimentally, weighing antimatter has been difficult because electrical influences on the charged, energetic antiparticles commonly created in accelerators massively overwhelm their gravitational response. Their short life in these machines also leaves no time for observation. The antihydrogen trapping technology developed by the world-leading ALPHA collaboration has, however, completely altered this picture, by generating antimatter that has low energy, long lifetime and immunity to electric forces. The new ALPHA-g experiment is designed to leverage this new technology, and weigh antimatter by letting antiatoms escape through the bottom and top of a tall magnetic confinement system. By precisely controlling the magnetic field of the openings, the escape bias induced by gravity can infer antihydrogen weight to within 1%. This constitutes the most sensitive antimatter gravity measurement ever made, and a significant breakthrough in subatomic and fundamental physics. Its results have potential to revolutionise our understanding of matter and antimatter, natural forces and the process of creation.

In this presentation, we outline the basic principles and experimental design of the ALPHA-g experiment, with emphasis on technical challenges involved in the experiment.

T4-4 Films, surfaces and composites (DCMMP) | Films, surfaces et composites (DPMCM) / 2155

Improving the corrosion resistance of SS 316 (G)

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This talk will look at cost effective and environmentally friendly surface treatments to improve the corrosion resistance of SS 316. Mechanically polished samples were treated by heating in deionized water, a hydrogen peroxide solution, electropolishing and heat treating in an oven. Cyclic voltammetry and optical microscopy were used to measure corrosion on the samples in a 0.9% NaCl solution. X-ray photoelectron spectroscopy was also used to analyze the composition of the different oxide layers. The greatest improvement in corrosion resistance was observed after treating the steel in a hydrogen peroxide solution. However, electropolishing also showed a large improvement while having other practical advantages.

T1-3 Ground-based and In Situ Observations I (DASP) l Observations terrestres et In situ I (DPAE) / 2156

Dayside reverse plasma flows for northward IMF as seen by the SuperDARN and RISR-C radars (G)*

Authors: Peter Bankole[1]; Alexander Koustov[1]; Robyn Fiori[2]

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Plasma flow patterns at northward-oriented IMF are not well defined. For example, near noon sunward flows (reverse flows) often deviate from the midnight-noon meridian and the amount of deviation can be as large as several hours of magnetic local time. Over the last several years, significant data on reverse flows have been accumulated in the Canadian sector of Arctic where three PolarDARN radars routinely produce global-scale plasma flow maps while the RISR incoherent scatter radars at Resolute Bay provide more localized information. In addition, polar cap SuperDARN radars in the southern hemisphere monitor plasma flows in about the same magnetic local time sector. In this study, we investigate the meridional sunward flows in both hemispheres, their response to IMF turnings as well as the shape and location of the reverse convection cells.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2157

POS-4 Relativistic corrections to nonrelativistic electric dipole transitions in heliumlike atoms

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Radiative transition probabilities in atoms are normally calculated from nonrelativistic wave functions and the electric dipole transition operator. The theory of relativistic corrections to nonrelativistic energies is well established in terms of the Breit interaction, but the same is not true for relativistic corrections to transition probabilities. Our objectives are first, to start from operators derived from quantum electrodynamics for the lowest-order relativistic corrections and verify that they yield the same results as from solutions to the Dirac equation for the case of hydrogen. And second, apply the same operators (including two-electron corrections) to the case of electric dipole transitions in heliumlike ions. In both cases, relativistic corrections become increasingly important with increasing nuclear charge.

T2-5 Instrumentation and Imaging (DAPI) | Instrumentation et imagerie (DPAI) / 2158

On an alternative neutron source

Author: Genevieve Harrisson[1]

Co-authors: Gang Li [1]; Ronald B. Rogge [1]; Zin Tun [2]; Bryan van der Ende [1]

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Traditional point sources of neutrons produce free neutrons in isotropic directions and with kinetic energy in the MeV energy domain. These neutrons are too fast for many applications as the probability of interaction between neutrons and surrounding matter is often higher at low neutron energies. Therefore, to optimize interaction between neutrons and its environment, these neutrons are slowed down in the eV or meV energy domain with a moderator.
This presentation describes a novel method for neutron moderation from an isotropic source by utilizing a rotating moderator to provide a versatile source of neutrons. The source of primary neutrons, the rotation speed of the moderator, the physical properties of the moderator and neutron scattering instruments surrounding the moderator are all adjustable parameters impacting the final neutron spectrum. A GEANT4 (toolkit for the simulation of the passage of particles through matter) simulation was built and shows that this rotating neutron moderator can partially focus neutrons in space; neutrons are emitted preferentially in the rotation plane, but throughout the longitudinal domain because of its circular configuration. To further increase neutron flux, it is desirable to consolidate the emitting neutrons to a narrower longitudinal domain. Fortunately, the direction of emission of the neutrons, relative to the moderator, is known as it depends on the rotation speed. This important detail allows use of neutron supermirrors to achieve longitudinal consolidation, since alignment of supermirrors requires accurate control. Therefore, McStas (Monte Carlo code) was used to evaluate the possibility of using supermirrors to collect neutrons from the rotating moderator into a beam. Unfortunately, constructing such a device is limited by material strength to withstand the rotational forces and temperatures required.

T2-5 Instrumentation and Imaging (DAPI) | Instrumentation et imagerie (DPAI) / 2159

Gas Flow Velocity Field and Turbulent Anisotropy Measurements using Magnetic Resonance Imaging (G)*

Authors: Amy-Rae Gauthier[1]; Benedict Newling[1]

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Fluid turbulence has been called the "last unsolved problem of classical physics"and the measurement of this phenomenon presents a formidable challenge. Turbulent systems are highly sensitive to perturbations, and so a non-invasive technique is needed to probe their properties. Turbulence is also difficult to fully characterize, particularly in the case of anisotropic turbulence. Magnetic Resonance Imaging (MRI) is a useful and versatile tool in this regard, because with the application of magnetic field gradients, MRI can be sensitized to various flow characteristics. The particular version of MRI used to measure turbulent gases is the motion-encoded Single Point Ramped Imaging with T1 Enhancement (SPRITE) technique developed at the University of New Brunswick. With the application of motion-sensitizing magnetic field gradients, SPRITE can be used to measure the three-dimensional time-averaged velocity field. This information is contained within the phase of the detected signal. Results of this type of measurement will be presented with a recorder as a turbulent flow system, which is often used as an example wind-instrument in musical acoustics. SPRITE can also be used to measure the anisotropy in mean-squared displacements caused by turbulent fluctuations. This information is contained within the signal amplitude of the detected signal. Results from measurements on gas flow through a cylindrical pipe with a hemi-cylindrical obstruction will be presented. These results show that at the time scale probed by this measurement, turbulence is anisotropic.

M2-5 Nuclear Structure I (DNP) | Structure nucléaire (DPN) / 2160

High-Precision Half-Life Measurement for the Superallowed β^+ Emitter ^{22}Mg (G)*

Author: Michelle Dunlop[1]

Co-authors: C. Andreoiu [2]; G. C. Ball [3]; N. Bernier [3]; H. Bidaman [4]; V. Bildstein [4]; M. Bowry [3]; C. Burbadge ; R. Caballero-Folch [5]; A. Diaz Varela [1]; R. Dunlop [1]; A. B. Garnsworthy [3]; P. E. Garrett [6]; G. Hackman [7]; B. Jigmeddorj [4]; K. G. Leach [8]; J. R. Leslie [9]; A. D. MacLean [6]; J. Measures [7]; C. Natzke [8]; B. Olaizola [3]; Y. Saito [3]; J. K. Smith [10]; C. E. Svensson [6]; J. Turko [6]; T. Zidar [4]

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High precision measurements of the $\mathcal{F}t$ values for superallowed Fermi beta transitions between $J^\pi = 0^+$ and isospin $T = 1$ isobaric analogue states allow for stringent tests of the electroweak interaction described by the Standard Model. These transitions provide an experimental probe of the Conserved-Vector-Current hypothesis, the most precise determination of the up-down element of the Cabibbo-Kobayashi-Maskawa quark-mixing matrix, V_{ud}, and set stringent limits on the existence of scalar currents in the weak interaction. In order to use the superallowed decays to perform such tests, however, several theoretical corrections must be applied to the experimental data. In particular, many studies of the isospin symmetry breaking correction, δ_C, have been performed with large model dependent variations. Precise experimental determinations of the ft values can be used to help constrain the different models used in the calculation of δ_C.

The uncertainty in the ^{22}Mg superallowed $\mathcal{F}t$ value is dominated by the uncertainty in the experimental ft value. Prior to this work, the adopted half-life of ^{22}Mg was dominated by a single high-precision measurement ($T_{1/2} = 3.8755 \pm 0.0012$ s 1) which disagrees with the only other, and less precise, measurement ($T_{1/2} = 3.857 \pm 0.009$ s 2) which yielded a $\chi^2/\nu = 4.0$ and resulted in the inflation of the weighted-average half-life by a factor of 2. The discrepancy between these two measurements was addressed through a high-precision half-life measurement for ^{22}Mg which was carried out at TRIUMF's Isotope Separator and Accelerator (ISAC) facility. This experiment was performed using a 4π continuous-flow gas proportional counter to detect the β particles with near 100\% efficiency. The result of $T_{1/2} = 3.87400 \pm 0.00079$ s is a factor of 3 more precise than the previously adopted world average and resolves a discrepancy between the two previously published ^{22}Mg half-life measurements 3. In this presentation, the new high-precision half-life measurement for ^{22}Mg and its implications for testing the isospin symmetry breaking corrections in superallowed Fermi β decays will be discussed.

1 J. C. Hardy *et al.*, Phys. Rev. Lett. **91**, 082501 (2003).
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3 M. R. Dunlop *et al.*, Phys. Rev. C **96**, 045502 (2017).

T4-2 Quantum Optics and Trapped Ions (DAMOPC) | Optique quantique et ions piégés (DPAMPC) / 2161**

Improved estimates of the collisional frequency shift for a trapped-ion atomic clock (G)*

Author: Jack Davis[1]

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The best trapped-ion atomic clocks today are accurate to better than one part in 10^{18} 1. To improve their accuracy even further, we must consider small perturbations of the clock frequency due to collisions between the clock ion and background gas atoms. Our group has recently developed a simple analytic formulation 2 to evaluate the collisional frequency shift (CFS) based on a quantum-channel description of the ion-atom scattering process. In this talk, I will present an extension of this formalism. The extended formalism estimates the CFS more accurately by considering effects such as inelastic scattering due to spin-orbit mixing, and the quantized motion of the trapped ion. Improved estimates of the CFS systematic error could lead to ion clocks that are more accurate by an order of magnitude.

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1 Nisbet-Jones, P. B. R., et al. "A single-ion trap with minimized ion–environment interactions." Applied Physics B 122.3 (2016): 57.
2 Vutha, Amar C., Tom Kirchner, and Pierre Dubé. "Collisional frequency shift of a trapped-ion optical clock." Physical Review A 96.2 (2017): 022704.

W3-8 Nuclear Structure II (DNP) | Structure nucléaire II (DPN) / 2162

Enhanced α-Transfer population of the 2^+_{ms} mixed-symmetry state in ^{52}Ti

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Co-authors: Dennis Muecher [2]; V. Bildstein [3]; Paul Garrett [2]; Carl Svensson [2]; B. Alex Brown [4]; J. D. Holt [5]; A. I Kilic [2]

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The residual nucleon-nucleon interaction plays a crucial role in nuclear structure physics. In spherical even-even nuclei the quadrupole interaction leads to characteristic low-lying 2+ states of proton-neutron mixed symmetry character, decaying via M1 transitions to the proton-neutron symmetric states. We have calculated the associated M1 transition strengths in the ^{52}Ti nucleus within the ab initio valence-space in-medium similarity renormalization group based on NN and 3N forces from chiral effective field theory. In this framework we also construct an effective valence-space M1 operator, which captures nonperturbatively many-body excitations outside the valence space. Our calculations well describe the established mixed-symmetry state in ^{52}Ti nucleus. Thus, ab-initio calculations are able to describe fundamental low-lying collective excitaitons in nuclei.\\
In order to investigate the microscopic structure of the mixedsymmetry state in ^{52}Ti nucleus even further, we run an experiment on the ^{52}Ti nucleus, populated via the alpha transfer reaction ^{48}Ca(^{12}C,^{8}Be)^{52}Ti using a ^{48}Ca beam from the Maier-Leibnitz-Laboratory in Munich. Gamma rays of populated states were detected with the high-granularity MINIBALL array of HPGe detectors, and charged particles were detected using a highly segmented DSSD silicon detector, allowing to select the channel of interest via a multiplicity coincidence condition. In first order, ^{52}Ti can be described as the coupling of a ^{4}He nucleus to the doubly-magic ^{4}8Ca core. In the frame work of the interacting boson model 2 (IBM-2), Alonso $et\ al.$1 have shown that the population of the MS 2^+_{ms} state is strictly forbidden.

This prediction is also confirmed in our new shell model calculation using the full fp space and effective interactions. Alpha transfer spectroscopic factors were evaluated with a cluster model using the oxbash shell model code. In contrast to the theoretical predictions, we experimentally find an exceptionally strong population of the well-established $2^+_{m.s}$ mixed-symmetry state in ^{52}Ti relative to the population of the 2^+_1 state. We discuss the impact of our findings to our microscopic understanding of the proton-neutron interaction and shell structure in this interesting region of the nuclear chart.
References
1 C.E. Alonso and J.M. Arias, Phys. Rev. C 78, 017301 (2008).

M2-4 DPMB 101 (DPMB) | (DPMB) / 2163

Random walkers & electrodiffusion: A primer (I)

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As part of the 2018 Congress for the Canadian Association of Physicists (CAP), the Division of Physics in Medicine and Biology (DPMB) is hosting a "DPMB 101" session. The purpose is to present "primer" talks that provide an overview of salient topics broadly relevant to the meeting. The intended audience is expected to be diverse, ranging from the relative novice (e.g., a curious undergraduate or graduate student) to experts. This particular talk will focus on the notion of biological transport, chiefly the concepts of diffusion and the movement of charged particles across cell membranes. Specific topics include: Fick's law, ensembles of random walkers, derivation of the diffusion equation, the Nernst-Plank equation, steady-state electrodiffusion, the generation of the membrane resting potential, circuit models for the cell membrane, and the Hodgkin-Huxley model for action potentials in neurons.

M2-3 Particle Physics II (PPD) | Physique des particules II (PPD) / 2164

The HELIX Cosmic-ray Experiment (G)*

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The High-Energy Light-Ion eXperiment (HELIX) is designed to measure the fluxes of light cosmic-ray nuclei at energies of a few GeV per nucleon. The primary goal is to study the evolution of the ratio of Be-10 to Be-9 between 0.2 GeV/n and 3 GeV/n. The former is a radioactive 'clock isotope' while the latter is stable, so the ratio contains information about how far and through what the cosmic rays have been propagating. Better knowledge of our local environment within the Galaxy has become important in understanding the increase with energy of the positron flux seen in new data from the AMS-02 detector installed on the International Space Station. Is it from dark-matter annihilation or from more conventional astrophysical phenenomena?

HELIX is a balloon-borne detector based on a 1 T superconducting solenoid. A drift chamber will be used to measure particle momenta while time-of-flight counters will determine the velocities at low energies. At higher energies a ring-imaging Cherenkov counter based on aerogel tiles and silicon photomultipliers will take over. A 14-day circumpolar flight launched from McMurdo Station on the coast of Antarctica has been scheduled for the 2019/20 season.

W1-4 Translational Research in Medical Physics Symposium (DPMB/DAPI) | Symposium de recherche translationnelle en physique médicale (DPMB/DPAI) / 2165

CT imaging in small animal research: Have we reached the limit? (I)

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X-ray computed tomography (CT) imaging is an integral part of small animal research. It is not only used for diagnosis of disease and monitoring of disease progression, but also for targeting of radiation therapy of cancer in image-guided small animal irradiators. CT imaging in small animals, known as microCT imaging, differs from clinical CT imaging in a number of aspects. Since smaller objects are imaged, the required spatial resolution is an order of magnitude higher. This has some implications on image acquisition technique as well as x-ray interactions in the small animal. X-ray source, detector, and imaging geometries for small animal microCT imaging will be discussed and methods for quality assurance developed at the University of Victoria in collaboration with AAPM will be presented. A Monte Carlo model of microCT imaging of the Small Animal Radiation Research Platform (SARRP) that was used to study various imaging parameters will be shown.
Since x-ray CT has a low sensitivity for contrast imaging, a novel microCT imaging technique, x-ray fluorescence CT (XFCT), will be introduced. XFCT imaging has the potential to be used for high-sensitivity molecular imaging of high-atomic number elements, such as gold nanoparticles. Recent advances in XFCT imaging in terms of x-ray source and detector technology will be discussed, as well as L-shell and K-shell XFCT reconstruction techniques. Simulation and experimental data will be presented to demonstrate the capability of XFCT to image gold nanoparticles at low concentration and to perform multiplexing (imaging multiple probes at once). Finally, a short study on proton beam XFCT of gold will be presented.

T4-7 Physics of Biosensing (DPMB) | Physique de la biodétection (DPMB) / 2166

2H NMR Studies of Bacterial Membranes Disruption Resulting from the Interaction with Antimicrobial Peptides (G)*

Authors: Nury P. Santisteban[1]; Michael Morrow[1]; Valerie Booth[1]

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Antimicrobial Peptides (AMPs) are small chains of between 10 and 50 amino acids with the ability to kill pathogens such as bacteria, fungus, viruses, and even cancer cells. AMPs are one of many mechanisms that living organism have developed to protect themselves from pathogenic microorganisms. Most research in AMPs is focused on understanding the mechanism or mechanisms that AMPs use to kill pathogens. In the case of bacteria, it is widely accepted that AMPs are able to disrupt the bacterial cell membrane more specifically, the lipid bilayer. In order to fully understand how AMPs are able to kill bacteria, it is also important to understand the role of other components of the bacterial cell envelope such as the lipopolysaccharides and the peptidoglycan (PGN) layer. 2H NMR is a technique that can be used to study the fluidity of lipid bilayers assemblies. In particular, 2H NMR can be used to identify order parameter changes resulting from the interaction between lipid vesicles with AMPs. Our group and others have developed methods to grow 2H-membrane-enriched bacteria. In this research, We observe the changes in the 2H NMR spectrum of different bacterial strains (*E .coli* LA8, *E. coli* JM109 and *B. subtillis*) in the presence and absence of different AMPs (MSI-78, CAME and BP100). Additionally, exploring the importance of the PNG layer in the interaction between the MSI-78 and BP100 with the lipids in the bacterial cell membrane of B. subtillis, we discovered that the removal of the PGN layer does not generate changes in the 2H NMR spectrum of B. subtillis.

Moreover, the level of disruption observed on the lipid bilayer of B. subtillis caused by MSI-78 and BP100 does not change after the partial removal of the PGN layer.

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T4-7 Physics of Biosensing (DPMB) | Physique de la biodétection (DPMB) / 2167

Single-Particle Tracking Reveals Diverse Diffusion Regimes of Individual M2 Receptors and Gi Proteins in Live Cells (G)

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G protein coupled receptors (GPCRs) are a superfamily of membrane receptors known for high signal transduction efficiencies. One of the key aspects of the GPCR signaling mechanism is the coupling interaction between the receptor and the G protein in response to external stimuli. We examined the pre-stimulus receptor-G protein coupling state by single-particle tracking (SPT) of M_2 muscarinic receptors and G_i proteins in live cells.
M_2 receptors and G_i proteins were genetically fused with fluorescent proteins (GFP and/or mCherry), expressed in CHO cells, and imaged on a Total Internal Reflection Fluorescence (TIRF) microscope. Single particles were identified in each frame of the TIRF movies and tracked using the TrackMate software. Mean-squared displacement (MSD) functions were computed for each single-particle trajectory. The diffusion parameters for receptors and G proteins were obtained by fitting their MSD functions to appropriate diffusion models.
Both the M_2 receptors and the G_i proteins exhibited significant fractions of confined diffusion (compatible with the membrane compartment formed by actin microfilament-based meshwork) and active transportation (compatible with the rate of myosin trafficking along actin microfilaments). The motions of the M_2 receptors and of the G_i proteins were distinctive from each other in the basal state of receptors, but they became similar when the receptors were activated by the agonist. Corroborated with dual-color fluorescence correlation spectroscopy measurements performed on the same samples, the SPT results supported a transient recruitment model without a stable pre-stimulus coupled complex.

W3-2 Energy Storage 3 (DCMMP) | Accumulation d'énergie 3 (DPMCM) / 2168

Advances in Alloy Negative Electrodes for Li-ion Batteries (I)

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There are a number of opportunities to increase Li-ion battery energy density. At the negative electrode, Si alloys can store much more lithium than graphite, which is currently in use. As a result, utilizing Si alloys in Li-ion cells has been shown to increase energy density by about 20%. However, there are many challenges for the utilization of Si alloys in practical Li-ion batteries. These are primarily related to internal phase changes within the alloy during lithium insertion, the volume expansion encountered during lithium insertion and interactions at the alloy surface with battery

electrolyte. Advances in materials, electrolytes, electrode formulations and binders for enabling the use of Si alloys in practical cells will be discussed.

T3-2 Thin Films, Magnetism and Solar Cells (DCMMP) | Films minces, magnétisme et piles solaires (DPMCM) / 2169

Optical investigation of low-dimensional purple and blue bronzes (G)

Author: mohammad ahmadi[None]

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The molybdenum oxide bronzes are a family of low-dimensional materials exhibiting interesting behavior including superconductivity, charge-density wave states, and metal-insulator transitions. After considerable study, there is still no firm consensus regarding a theory to explain their unique features. We have synthesized single crystals of blue bronzes A0.3MoO3 (A=K, Rb) and purple bronzes A0.9Mo6O17 (A=Li, Na, K) using a gradient flux technique and have investigated the optical properties of these materials along different crystallographic axes using optical reflectance spectroscopy. We have taken advantage of annealing the single crystals in various gas flows to analyze changes in their properties after annealing in hopes of contributing to the understanding of the mechanisms at play in these low-dimensional materials. Changes in their structural and magnetic properties upon annealing were investigated via X-ray diffraction and magnetization measurements and will also be reported.

W3-6 Particle Physics VIII (PPD) I Physique des particules VIII (PPD) / 2170

Withdrawn Exploring Multi-scatter Signatures in Dark Matter Searches (G)

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Extensive effort in the hunt for particle dark matter continues to explore WIMP-nucleon cross sections for the typical weak-scale masses below $10^5 \mathrm{GeV}/c^2$. Extension of the canonical WIMP exclusion limit to superheavy masses becomes an inaccurate description when the cross section rises high enough for relic particles to scatter multiple times within the depth of a detector. These multi-scatter events are cut in traditional WIMP searches, where the weak cross section makes negligible the probability of multiple interactions. Current low threshold dark matter searches with sufficient position resolution can explore new parameter space pushing towards Planck-scale masses, by examining multi-scatter events. Motivation and sensitivity in this region, in the context of the PICO dark matter program, will be presented.

M1-5 Nuclear Astrophysics (DNP) | Astrophysique nucléaire (DPN) / 2171

Evolution of the N = 32 shell closure in neutron-rich Ti & V isotopes at TRIUMF. (G)*

Author: Eleanor Dunling[1]

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A striking example of quantum behaviour in the nucleus are the nuclear shells, analogous to the electron shell system in atomic physics, at well-known magic numbers of protons/neutrons. Nuclear shells can evolve with changing proton and neutron count as shown in the emergence of the N = 32 shell closure. This changing nuclear structure can directly affect nuclear properties like masses (separation energies) and half-lives. Investigations of neutron-rich 51-55V and 51-55Ti isotopes were performed at TRIUMF. Half-lives were measured with the ISAC Yield Station and high precision mass measurements were performed with TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN), employing for the first time the TITAN Multiple-Reflection Time-Of-Flight Mass Spectrometer (MR-TOF-MS). In the results, weak shell effects were observed in Ti isotopes. In this talk, these observed shell effects will be discussed in context of the evolution the N = 32 shell closure.

M1-2 Particle Physics I (PPD) | Physique des particules I (PPD) / 2172

Research and Development for the NEWS-G Dark Matter experiment

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NEWS-G (New Experiments With Spheres-Gas) is a direct dark matter detection experiment using Spherical Proportional Counters (SPCs). SPCs are gaseous detectors, where different gases can be use to optimise sensitivity for different dark matter masses. First results using Neon in the prototype SEDINE at Laboratoire Sousterrain de Modane (LSM) were presented at the 2017 CAP Congress.
I will describe the development work performed at Queen's University to improve this technology. The improvement will be implemented at a larger experiment planned to run at SNOLAB at the end of 2018. I will show how we improved the electric field with new sensors. I will show how we purify the gas and precisely monitor its composition. I will also show how we improved our understanding of the detector using radioactive sources and a calibration laser.

DAPI Poster Session & Finals: Poster Competition and Mingle Session with Industrial Partners/Employees (3)| Session d'affiches DPIA et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (3) / 2173

POS-42 Evaluation of approaches to reduce a characteristic measurement time in MRI of sprays

Authors: Shahla Ahmadi[1]; Igor Mastikhin[2]

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A spray is a dynamic collection of drops dispersed in a gas. Various experimental techniques have been developed to study these parameters. MRI is a new promising technique to study sprays: it does not require optical transparency, unlike most other techniques, and its non-invasive nature does not interfere with sample. Studying sprays with MRI has its own challenges. One of them is related to resolution vs time: sample speed changes from approx. 1 m/s to 25 m/s over 1-cm length. We are interested in measuring velocity inside the nozzle and in the near-nozzle regions. In the

previous measurements, velocity mapping inside the orifice was shown to be incorrect, most likely due to the sample's acceleration issue during our characteristic measurement time. Therefore, we need to reduce the characteristic measurement time.
In the motion-sensitized SPRITE, two stages occur at the same time: motion-encoding stage and detection stage. If we separate the motion-encoding and detection, we can use a shorter detection technique. In this work, we use a Time-of-Flight (TOF) approach for preparation and a ramped SPI sequence for detection. In the TOF approach, a portion of the liquid is excited before the nozzle, and its movement is observed by changing a time delay between the excitation and the detection. By combining the TOF with a tagging sequence, it is possible to track the motion of the liquid. The tagging sequence consists of RF pulses to modulate nuclear magnetization in a striped pattern. The motion of the liquid inside the nozzle can then be tracked quite readily, as the movement of the material is reflected by the deformation of the strips between excitation and the detection stages.

T3-4 Gravity and Cosmology (DTP/DHP) | Gravité et cosmologie (DPT/DHP) / 2174

Is there a cosmological constant problem? (G)*

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The cosmological constant problem is described as one of the greatest crises of modern physics. The conventional problem is posed in the framework of quantum fields on a fixed background and their semiclassical backreaction on gravity. In this talk, expanding on a recent proposal, I will argue that this problem does not arise in a fully non-perturbative gravity-matter framework. I will show how vacuum energy density depends on a choice of global time and physical Hamiltonian, and how it varies from one choice to another.

M1-1 Ultrafast EM waves I: Materials Science (DAMOPC/DCMMP) | Ondes EM ultrarapides I: Sciences des matériaux (DPAMPC/DPMCM) / 2175

Simultaneous Adiabatic Rapid Passage in Multiple Quantum Dots (G)

Author: Ajan Ramachandran[1]

Co-authors: Reuble Mathew [1]; Allister Mason [1]; Sabine Freisem [2]; Dennis Deppe [2]; Kimberley Hall [1]

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The initialization and control of the quantum states of excitons in semiconductor quantum dots (QDs) may be achieved using coherent optical pulses, making these systems of interest for solid state approaches to quantum simulators 1 and single photon sources 2. Quantum state control via adiabatic rapid passage (ARP), which is insensitive to variations in the QD parameters (dipole moment, transition energy) provides an effective strategy for achieving robust quantum state inversion, and has been the subject of intensive study in recent years [3,4]. Robust state inversion is essential for the development of triggered single and entangled photon sources [2,5] and all optical switches utilizing quantum dot states [6]. The extension of ARP to the control of ensembles of QDs would be beneficial for parallel state initialization [7], and may enable the formation of a Bose-Einstein condensate in a quantum dot ensemble [8]. Building on previous demonstrations of ARP in a single quantum dot using subpicosecond pulses [9] and simultaneous deterministic control of excitons in multiple

quantum dots [10,11], we demonstrate simultaneous adiabatic rapid passage in multiple quantum dots and evaluate the inversion efficiency of ARP for a range of control pulse parameters.

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M3-4 Cold and Trapped Atoms, and Tests of Fundamental Symmetries I (DNP/DTP/PPD/DAMOPC) | | Atomes froids et piégés, et tests de symétries fondamentales I (DPN/DPT/PPD/DPAMPC) / 2176

Measurement of the 1S-2S Transition in Antihydrogen

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The precise measurement of the 1S-2S transition in atomic hydrogen via 2-photon spectroscopy determines the value of the Rydberg and constrains our knowledge of the fundamental constants. The prospect of such a measurement in antihydrogen to test CPT motivated the construction two decades ago of the CERN AD and its initial program . The ALPHA collaboration has now measured this transition in antihydrogen with a precision of a few parts per trillion. Its comparison with the hydrogen value is a strong test of CPT symmetry. This talk will discuss the considerable challenges we were faced with, both in the production of the antihydrogen and in spectroscopy in the environment containing the trapped particles. Prospects for improved precision will be presented.
[2]ALPHA collaboration http://alpha-new.web.cern.ch: M. Ahmadi, B.X.R Alves, C.J.Baker, W. Bertsche, A. Capra, C. Carruth, C.L. Cesar, M. Charlton, S. Cohen, S. Eriksson, A.L. Evans, N. Evetts, A. Evans, J. Fajans, T. Friesen, M.C. Fujiwara, D.R. Gill, J.S. Hangst, W.N. Hardy, M.E. Hayden,, C.A. Isaac, M.A. Johnson, J.M. Jones, S.A. Jones, S. Jonsell, A. Khramov, P. Knapp, L. Kurchaninov, N. Madsen, D. Maxwell, J.T.K. McKenna, S. Menary, T. Momose, J.J. Munich, K. Olchanski, A. Olin, P. Pusa, C. Ø. Rasmussen, F. Robicheaux, R.L. Sacramento, M. Sameed, E. Sarid, D.M. Silveira, C. So, T. D. Tharp. R.I. Thompson, D.P. van der Werf, J.S. Wurtele.

T1-4 Mathematical Physics (DTP) | Physique mathématique (DPT) / 2177

An Analytic Approach for the Energy Eigenvalues Solutions in a Double-Well Potential

Authors: Sree Ram Valluri[1]; Ken Roberts[2]; Pranawa Deshmukh[3]; Harsh Narola[4]; Rob Scott[5]; Shantanu Basu[2]

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Studies on scattering of longitudinally and transversely incident beam of electrons by hollow cylindrical potential and coaxial cylindrical potentials have shown the presence of quasi bound "whispering"modes [1,2]. The realization of Levinson's theorem [3,4] has been studied for some scattering potentials and results are widely available.

Roberts and Valluri [5] presented a geometric analytic technique, which utilizes conformal mapping W->Z=WeˆW between two complex domains to solve the 1-dimensional finite square well potential. The symmetry of the hollow cylindrical potential can be used to solve the Schrodinger equation as a 1-dimensional finite square well potential in the radial direction. This leads to the possible generalization to a concentric double walled cylindrical potential by considering it as a double well finite potential in the radial direction. The number of bound states of such a potential can be counted using the Lambert W formalism, as it is a geometric method, and the relation to the scattering phase shift can be established.

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R3-3 Particle Physics X (PPD) | Physique des particules X (PPD) / 2178

Astroparticle physics with neutrinos at the South Pole (I)

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The IceCube Neutrino Observatory, located deep underground at the geographic South Pole, is the largest neutrino detector in the world. The experiment uses over 5,000 photo-sensors to monitor a volume of one cubic kilometer of pristine ice, recording the Cherenkov light emitted by neutrino interaction products. By studying these signals, IceCube has demonstrated the existence of astrophysical neutrinos at very high energies, measured atmospheric neutrino oscillations, and searched for exotic physics beyond the standard. A summary of the status of the experiment, the most recent results, and the potential of proposed detector upgrades will be discussed.

T4-3 Particle Physics V (PPD) | Physique des particules V (PPD) / 2179

Pulse Shape Discrimination Studies with CsI(Tl) for Improving High Energy Hadron Identification (G)*

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We study the potential for using CsI(Tl) pulse shape discrimination in order to improve particle identification at high energy electron-positron collider experiments such as the Belle II experiment. Using neutron and proton testbeam data collected at the TRIUMF Proton Irradiation Facility we analyze the scintillation pulse shape differences between photon and hadron energy deposits and demonstrate that the pulse shape variations in CsI(Tl) for hadronic energy deposits can be characterized using an additional scintillation component for CsI(Tl) 1. Using this new pulse shape characterization techniques for computing the pulse shapes for CsI(Tl) are develop and applied to GEANT4 simulations. With these simulations comparisons are made with testbeam data and predictions for the performance of CsI(Tl) pulse shape discrimination for separating high energy electromagnetic and hadronic showers will be presented. Ongoing work to incorporate pulse shape discrimination into the Belle II experiment will also be discussed.

1 S . Longo and J . M . Roney, "Hadronic vs Electromagnetic Pulse Shape Discrimination in CsI(Tl) for High Energy Physics Experiments", arXiv: 1801.07774

T4-6 DASP General Contributions II (DASP) | DPAE: contributions générales II (DPAE) / 2180

WaMI: The Waves Michelson Interferometer (G)*

Author: Samuel Kristoffersen[None]

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The Waves Michelson Interferometer (WaMI) is designed to make wind measurements of the atomic oxygen green line (557.7 nm) emission, a molecular oxygen line at 1264 nm, and a hydroxyl line at 1315 nm. These emissions provide a capability for probing the dynamics of the middle atmospheres of the terrestrial planets. The special feature of the design of this instrument is that the back mirror is a quad mirror configuration. As a result four fringe phase images can be generated simultaneously thereby eliminating the effects of irradiance variations during the integration time. The WaMI is currently set-up in a laboratory environment, with a retro-reflective wheel used to simulate Doppler winds. Results of the step size calculations, as well as, wind wheel measurements will be presented. These validate the use of this instrument as a monolithic instrument capable of measuring winds without mirror scanning for ground based and satellite applications.

M3-5 Magnetism (DCMMP) | Magnétisme (DPMCM) / 2181

Neutron scattering study of skyrmions in MnSi thin films

Authors: Simon Meynell[1]; Wilson Murray[1]; Kathryn Krycka [2]; Brian Kirby[2]; Helmut Fritzsche[3]; Theodore Monchesky[1]

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Chiral interactions in magnetic materials are unique in their ability to stabilize static magnetic solitons, known as skyrmions. At surfaces and interfaces, the chiral interaction results in novel magnetic surface states 1. These surface twists help to further stabilize skyrmions in thin films 2, together with the influence of epitaxy induced magnetocrystalline anisotropy. These interactions play a crucial role in determining the observed magnetic textures, and lead to dramatically different behaviour in films as compared to bulk crystals.

The magnetic structure of MnSi thin films has been highly controversial. Our group was the first to report in-plane skyrmions 4, and the suppression of skyrmions out of plane [5], in contrast to reports from other groups. To resolve the controversy, we measured the magnetic structure of the in-plane skyrmions in epitaxial MnSi/Si(111) thin films, probed in three dimensions by the combination of polarized neutron reflectometry (PNR) and small angle neutron scattering (SANS) [6]. We demonstrate that skyrmions exist in a region of the phase diagram above a temperature of 10 K. PNR shows the skyrmions are confined to the middle of the film due to the potential well formed by the surface twists.

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M3-5 Magnetism (DCMMP) | Magnétisme (DPMCM) / 2182

Reversibility of Magnetic Behavior in High Entropy Oxides (G)

Author: Tahereh Afsharvosoughi[1]

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High entropy materials are a group of materials that can be potentially used in extreme temperature applications and have interesting properties such as hardness, toughness, and corrosion resistance. In particular, high entropy oxides have attracted attention due to intriguing properties such as colossal permittivity and superionic conductivity. Since high entropy oxides are achieved from entropy driven reaction so they undergo reversible phase transition from multiphase to single phase by sintering at high temperature. In this experimental work, we have shown that this is not the case for their magnetic properties. The magnetization of a sample resintered at 700oC after sintering at 1100oC was entirely different from the sample sintered at 700oC, but not sintered at 1100oC. The multiphase resintered sample's magnetization was very similar to the single-phase sample's magnetization. We have found that there is a close connection between the structural and magnetic properties which can explain the difference in magnetic behavior of multiphase samples.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2183

How molecular crowding controls the spatial organization of biopolymers in a confined space

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In a crowded space, a long chain molecule can be phase-separated into a condensed state, redistributing the surrounding crowders. Here we discuss how crowding influences the spatial organization of a ring polymer, consisting of two "arms," in a cylindrical space. In a parameter space of biological relevance, the distributions of monomers and crowders follow a simple relationship: the sum of their volume fractions rescaled by their size remains constant. Beyond a physical picture of molecular crowding it offers, this finding explains a few key features of what has been known about chromosome organization in an *E. coli* cell. For instance, it is consistent with the observation that crowding promotes clustering of transcription-active sites into transcription foci. Finally, crowding is essential for distributing the two arms in the way observed with *E. coli* chromosomes.

M2-1 Ultrafast EM Waves II: THz Science (DAMOPC/DCMMP) | Ondes EM ultrarapides II: Science des THz / 2184

Carrier Spin Relaxation in 2D Ruddlesden-Popper Perovskite Semiconductors (G)

Authors: Drew Riley[1]; Seth Todd[1]; Ramachandran Ajan[1]; Charlotte Clegg[1]; Ali Binai-Motlagh[1]; Sam March[1]; Ian Hill[1]; Kimberley Hall[1]

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Research into organo-halide perovskites has flourished due to their unprecedented success as an absorbing layer in solution processed solar cells. Theoretical studies have shown these materials exhibit intriguing optical properties such as large spin-orbit coupling, photo-induced magnetization, and spin-dependent optical Stark effect, leading to potential spintronic applications. However; very few spin-related experimental studies have been reported. Here we report circular-polarized pump-probe studies of the 2D perovskite butylammonium methylammonium lead iodide. These results indicate a strong influence of Rashba spin-splitting on the carrier kinetics, consistent with our recent four-wave mixing studies of bulk $CH_3NH_3PbI_3$.

R1-4 Inclusive Science Education (Part 2) (DPE/CEWIP) I Éducation scientifique inclusive (2ième partie) (DEP/CEFEP) / 2185

Gender Diversity in Sciences: Challenges and Benefits (I)

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Why are there so few women in some disciplines of sciences and engineering (SG)? What can we do to change the numbers? How can we improve the inclusion and well-being of female students in these disciplines? Why should we care? In this presentation, we will explore these questions.

Through her life, from a young child to an adult on the labor market, a woman encounters some barriers that may prevent her from studying in SG or from having a happy and successful career in SG. As parents, teachers, colleagues or employers, we can take some actions to reduce or eliminate these barriers. And, although dealing with diversity is often uncomfortable, it is worth.

M1-2 Particle Physics I (PPD) | Physique des particules I (PPD) / 2186

Past, present and future activities of NEWS-G at the LSM and SNOLAB

Authors: Quentin ARNAUD[1]; NEWS-G Collaboration[None]

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New Experiments With Spheres-Gas (NEWS-G) is a dark matter direct-detection experiment using spherical proportional counters (SPCs) with light noble gases. First results obtained with a SPC prototype operated with Ne gas at the Laboratoire Souterrain de Modane (LSM) have already placed NEWS-G as a leader in the search for low-mass WIMPs. The forthcoming next phase of the experiment consists of a large 140 cm diameter SPC to be operated at SNOLAB with H and He gas. The use of lighter targets, improved thresholds and detector performance together with a significant reduction of the background levels will allow for unprecedented sensitivity to sub-GeV WIMPs down to 0.1 GeV. A status report on the research project at SNOLAB is given. Recent improvements in detector performance and data quality with the experiment at the LSM are also discussed.

T3-3 Particle Physics IV (PPD) | Physique des particules IV (PPD) / 2187

A Novel Approach to Account for the Fano Factor (G)*

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As first discussed by U. Fano in the 1940's, the statistical fluctuation of the number of e-/ion pairs produced in an ionizing interaction is known to be sub-Poissonian, the dispersion being reduced by the so-called "Fano Factor". Despite this knowledge, the Poisson distribution is commonly used to model the quantization of ionizing processes while the effect of the reduced dispersion is folded in with other processes affecting energy resolution. While this approximate treatment is valid down to relatively low energies, experiments now have energy thresholds low enough such that more accurate modeling on the order of a few pairs has become necessary.

We propose a new approach to this problem using a novel discrete probability distribution not well-known in the field of particle physics. The validity of this treatment is supported with calibration data obtained with a spherical proportional counter from the NEWS-G dark matter search experiment. As an application of this, the potential impact of the Fano Factor on sensitivity to low mass WIMPs is discussed as well.

T2-6 Experimental Techniques (DCMMP) | Techniques expérimentales (DPMCM) / 2188

Submolecular scale mapping of the Hubbard U

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When orbitals are already occupied by one electron, the addition of a second charge to that position in space entails overcoming the Coulomb repulsion between the charges. This on-site Coulomb repulsion is often characterized by the so-called Hubbard U: the energy difference between the doubly negative and charge neutral state. As charges move from site to site in a material they must overcome this interaction, and when U is large compared to hopping parameters these effects influence transport, breakdown single particle theories, and lead to low temperature phase transitions into distinct electronic states. As these effects are inherently local, and orbital dependent, a real-space tool to measure this on-site Coulomb interaction has the potential to offer new insight into interaction-driven and correlated electron behavior.

Here we provide a new sub-nanometer scale view into this old problem via noncontact atomic force microscopy. Our observations of singly charged 3,4,9,10-peryelene tetracarboxylic dianhydride (PTCDA) molecules on bilayer NaCl on an Ag(111) surface show bias-dependent transient charging behavior. Electrostatic force spectroscopy (EFS) shows distinct jumps at the energies corresponding to Hubbard states previously identified by scanning tunneling spectroscopy (STS) 1 and are indicative of transitions between the 0, 1-, and 2- states. Using pixel-by-pixel EFS in tandem with STS we can locally map this charging energy required to overcome the on-site Coulomb repulsion providing a direct characterization of the Hubbard interaction. Our measurements indicate that the Hubbard U varies spatially depending on the local environment of 2-dimensional clusters of PTCDA molecules and even on submolecular length scales associated with the spatial extent of the half-filled orbital. This new visualization tool has the potential to be applied to a wide range of materials providing opportunities open up new perspectives in this key underpinning of correlated electron behavior.

1 K. A. Cochrane, A. Schiffrin, T. S. Roussy, M. Capsoni & S. A. Burke, Nat Commun, 8, 8312 (2015)

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2189

POS-68 Stress Relaxation Mechanism of Single Collagen Fibrils and Relaxation Induced Morphological Changes (G)

Authors: S M Asif Iqbal[1]; Dr. Laurent Kreplak[1]

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The collagen fibrils are the main building block of connective tissues in mammals where they fulfill both structural and mechanical roles. The structure of a fibril is based on collagen molecules that self-assemble into micro-fibrils and sub-fibrils stabilized by hydrogen bonds and covalent crosslinks. The non-integer staggering of collagen molecules results in a characteristic D-band pattern along the fibril with a periodicity of 67nm. Besides this natural variation, localized damaged sites have been observed along the length of mechanically overloaded fibrils 1, which suggests the inherent existence of structural inhomogeneity along collagen fibrils. To explore this further we are using an atomic force microscopy (AFM)-based manipulation technique that allows us to perform tensile tests on a single fibril in bowstring geometry 2. In this work, we are investigating the potential impact

of structural inhomogeneity on the viscoelastic properties of single fibrils. Fibrils were extracted from bovine extensor tendons, around 50 microns long segments were isolated (n=20), imaged with AFM before manipulation and then stretched to the range of strain between 5% and 20%, held at that strain for 150 seconds(n=13), 1 second (n=3), and 1500 seconds(n=3) then released. There was also one fibril that has been pulled and released very slowly in controlled way for comparison. Comparison between AFM image of the manipulated fibrils and pre-manipulated fibrils demonstrated height fluctuations occurring along the fibril length in the micrometer range. We propose that the inherent structural heterogeneity along the length of the fibril becomes a prominent feature after stress relaxation providing a new mechanism for probing morphological changes in fibril level after stress relaxation.

1 Veres, S.P. and Lee, J.M. Biophys. J. 2012, 102: 2876-2884.
2 Quigley, A. S. et al. PLoS One. 2016, 11: e0161951.

W1-3 Particle Physics VI (PPD) I Physique des particules VI (PPD) / 2190

SNO+ Calibration with the 16N Source (G)*

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SNO+ is a multi-purpose scintillator based neutrino experiment located 2 km underground at SNOLAB, Sudbury, Ontario. SNO+ reuses the Sudbury Neutrino Observatory (SNO) detector, consisting of a 12 m diameter acrylic vessel that will be filled with 780 tonnes of ultra-pure organic liquid scintillator. The primary goal of the experiment is a search for neutrino-less double beta decay with ^{130}Te loaded into the liquid scintillator. In addition, SNO+ aims to measure low energy solar neutrinos, reactor anti-neutrino oscillations, geo-neutrinos as well as the neutrinos from a possible galactic supernova. The detector has been filled with ultra-pure water since May 2017 in preparation for the scintillator phase.
The reconstructed energy scale, energy resolution, reconstructed position resolution and detection efficiency of the detector are measured using calibration sources deployed into the detector. During the water phase the primary calibration source is the de-excitation of ^{16}O from the decay of ^{16}N. The ^{16}N gas is transported to the detector and injected into a suspended decay chamber all the while undergoing β decays. Decays within the source chamber are detected and tagged through a PMT and plastic scintillator enclosure. The ^{16}O decay product is in excited state and emits 6.1 MeV γs that can penetrate through the container. The source can be positioned along three axes, x, y and z, using the side ropes and the umbilical retrieval mechanism. A full ^{16}N scan has been performed in November 2017 and calibration data has been taken for 72 different locations inside the acrylic vessel. This presentation will describe the ^{16}N calibration for SNO+, and furthermore discuss the calibration results in greater detail.

T2-7 Testing Fundamental Symmetries II (DTP/PPD/DNP) I Tests de symétries fondamentales II (DPT/PPD/DPN) / 2191

Hadronic effects in parity-violating electron-proton scattering at low energies (I)

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Precision low-energy experiments in electroweak electron-proton interactions are a vital complement to direct tests of the Standard Model. They also give information about the structure of the proton. In parity-violating electron-proton scattering, recent results reported by the Qweak collaboration, and the proposed Møller experiment at Jefferson Lab, have the potential to give constraints on physics beyond the Standard Model, provided that critical hadronic radiative corrections involving the strong interaction are under control. In this talk I will give an overview of recent theoretical progress in our understanding of these important corrections, and of the future opportunities to exploit measurements to calibrate the theoretical predictions.

W1-3 Particle Physics VI (PPD) I Physique des particules VI (PPD) / 2192

Quenching factor for NEWS-G (G)*

Author: Marie Vidal[None]

NEWS-G (New Experiments With Spheres-Gas) is a rare event search experiment using Spherical Proportional Counters (SPCs). Primarily designed for the direct detection of dark matter, this technology also has appealing features for Coherent Neutrino-Nucleus Scattering (CEνNS) studies using nuclear power plants as a neutrino source.
For both applications, an important property of the gas to characterize is the quenching factor, defined as the ratio of the measured energy induced by a nuclear recoil to that of an electron of the same energy. Quenching factor measurements in Ne and He based gas mixtures are being performed at TUNL (Triangle Universities Nuclear Laboratory) using a neutron beam and an array of backing detectors. We present the set-up and measurement technique, and report on the most recent results.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2193

On the Validity of High-Temperature, Quasi-Periodic Solutions in AdS_4 (G)*

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The stability of asymptotically AdS_{d+1} spacetime under arbitrarily small perturbations of a minimally coupled scalar field has been examined via dual lines of inquiry. The first, undertaken by Bizon and Rostworowski in 2011, was concerned with numerical solutions to the fully nonlinear system. This and subsequent work led to the determination that AdS was generically unstable to Gaussian initial data. The other line of inquiry was through the perturbative description of the linearized system. The perturbative description illuminated the method that led to gravitational collapse in the full system: the weakly turbulent cascade of energy to short length scales. Development in both the numerical and perturbative theories has uncovered a class of initial data, known as islands of stability, that resist gravitational collapse.

The development of the Two-Time Formalism (TTF) by Balasubramanian *et al.* provides a description of the leading nonlinear perturbative effects, and establishes the existence of inverse energy cascades which allow for stability islands. Following the development of quasi-periodic (QP) solutions to the truncated TTF system —also by Balasubramanian *et al.* —a further class of (perturbatively) stable solutions was conjectured that were connected to known QP solutions. These solutions, called high-temperature QP solutions due to their large value of the ratio of the conserved quantities $E/N = T$, are found from successive energy perturbations of known QP solutions.

In this talk, we discuss the process of verifying that a QP solution to the truncated theory can be extended to the full TTF theory. In particular, we test the persistence of solutions in the limit of a large number of eigenmodes; furthermore, we present evidence that high-temperature solutions can be sensitive to the choice of truncation value. We then use the TTF theory to examine the direct and inverse energy cascades in truncated QP solutions. Finally, we investigate if these QP solutions can be extended to solutions of the fully nonlinear scalar-metric system.

T1-2 Special CAP Plasma Physics Session: in Memory of Prof. Akira Hirose (DPP) l Session spéciale en physique des plasmas: À la mémoire du prof. Akira Hirose (DPP) / 2194

Fueling and Momentum Injection into the STOR-M tokamak (I)

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In a magnetically confined fusion reactor, the density and the temperature profiles are highly peaked at the core of the reactor and the fusion reactions occur mostly at the center. Unlike the fission reactors with the fuel bundle inserted in the reactor core, the fusion fuels have to be continuously injected from the outside to maintain the desired density in the reactor. The primary objective of the study of compact torus injector at the University of Saskatchewan is to investigate the feasibility of direct central fueling of a tokamak by CT injection and to study its effects on the tokamak discharge in our STOR-M tokamak, the only operating tokamak in Canada today. Compact torus is formed in a magnetized coaxial gun and is confined by the magnetic field self-induced by the current in CT. CTs can be accelerated to velocities 1-2 orders of magnitude higher than the fuel velocities currently achievable by any other fuel delivery technologies. In addition, CTs can be formed only one at a time. To maintain steady-state operation of a fusion reactor, repetitive CT operation is needed. In this talk, recent experimental results on repetitive and reproducible CT operation and momentum injection into the STOR-M tokamak by CT injection will be presented.

T4-4 Films, surfaces and composites (DCMMP) | Films, surfaces et composites (DPMCM) / 2195

Imaging and Preventing the Corrosion of Nitinol (G)

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Nitinol (nickel-titanium) alloys have a unique property, superelasticity, which allows the manufacture of minimally invasive self-expanding stents. Nitinol is approximately composed of 50% nickel, which is known to be toxic. Therefore, corrosion resistance is key to the good biocompatibility of this material, especially considering the aggressive environment of the body. We tested the effects of the surface roughness and different passivation techniques on the corrosion resistance of nitinol using potentiodynamic measurements. Furthermore, we applied environmentally friendly treatments to nitinol, boiling in hydrogen peroxide and boiling in distilled water, which substantially improved the corrosion resistance. The effects of these treatments on the oxide layer composition and morphology was investigated using x-ray photoelectron spectroscopy, grazing incidence x-ray diffraction, and scanning electron microscopy. We found that due to these treatments a more homogeneous titanium dioxide oxide layer was formed. The pitting corrosion of nitinol was also observed in real time using a microscope. This gave us novel information about the spatial distribution of corrosion.

W2-3 Particle Physics VII (PPD) | Physique des particules VII (PPD) / 2196

Detection of proton recoils with the PICO-0.1 test bubble chamber (G)*

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PICO is a bubble chamber experiment for the direct detection of dark matter, and currently holds the world-leading limits in the spin-dependant WIMP (dark matter particle candidate) interaction sector. In order to search for low mass WIMPs (˜ GeV scale), scattering on light target nuclei - especially protons - would substantially improve the sensitivity reach of PICO.

In this talk I will present work done with the PICO-0.1 calibration chamber for the detection of proton recoils in this type of detector. First, using C2ClF5 as the active fluid, the reaction ˆ{35}Cl (n_th, p) ˆ{35}S was studied by detecting the 600 keV protons via their acoustic signature. In a follow-up experiment using superheated C2H2F4, we could observe for the first time the elastic scattering of low energy 22 keV neutrons and protons. Finally, I shall discuss the sensitiviy reach of the PICO-40L detector filled with hydrogenated target fluids.

W1-2 Strategies and Good Practices for Teaching Atomic, Molecular and Optical Physics (DAMOPC/DPE) | Stratégies et bonnes pratiques d'enseignement de la physique atomique, moléculaire et optique (DPAMPC/DEP) / 2197

Antihydrogen 1S-2P Spectroscopy (G)*

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Antihydrogen and hydrogen are simple atomic systems which provide an ideal platform to study differences between antimatter and matter; current theories predict that the universe should be composed of equal quantities of matter and antimatter but cosmological observations place the ratio of the two near 10ˆ-4. The ALPHA (Antihydrogen Laser PHysics Apparatus) collaboration at CERN studies the atomic structure of antihydrogen through electromagnetic interactions. The second generation of experimental hardware used by ALPHA, called ALPHA2, produces antihydrogen by mixing samples of antiprotons and positrons, using a Penning trap, inside a minimum B trap; the antiatoms that have a low enough kinetic energy can the confined and studied. This talk will report on recent measurements related to our ongoing studies of 1s-2p spectroscopy of antihydrogen.

M3-5 Magnetism (DCMMP) | Magnétisme (DPMCM) / 2199

Ultralow Thermal Conductivity and Novel Thermoelectric Materials

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More than half of the energy produced worldwide is currently lost as heat and recovering even a fraction of that would be beneficial for global climate change. Toward this aim, thermoelectric materials can recover waste heat and convert it to useful energy. However, thermoelectrics are not widely commercially applied due to high cost and low efficiency. The search for new high-performance thermoelectric materials is challenging because they require enhanced electrical properties and low thermal conductivity. A potential route to discover novel high-performance thermoelectric materials can be provided by first-principles calculations [Chen, Pöhls *et al. JMCC*, 2016].

While the electronic properties can be predicted with a high accuracy, accurate prediction of the heat transport is currently not feasible. However, insight of the heat transport can be provided by computing the minimum thermal conductivity. In this study, a new model of minimum thermal conductivity was developed in which the thermal energy is transported between entities of phonons vibrating in a range of frequencies and limited by the phonon mean speed. This model was motivated by understanding the lowest experimental thermal conductivity to date for a fully dense solid (PCBM, $\kappa = 0.07\ \mathrm{W\,K^{-1}\,m^{-1}}$ at 300 K), which agrees with the present model [Pöhls *et al. PCCP*, 20161].

In a high-throughput screening within 'The Materials Project'the electronic properties of ~48,000 compounds were calculated and two novel high-performance thermoelectric classes, XYZ_2 (X,Y: rare earth or transition metals, Z: Group VI element) and metal phosphides, show promise. A variable relaxation time was developed using a semi-empirical approach to accurately calculate the temperature-dependent electronic properties.

Three compounds of the XYZ_2 class were synthesized and their computed thermoelectric properties were compared to experiments [Zhu *et al. JMCC*, 2015; Aydemir, Pöhls *et al. JMCA*, 2016]. All compounds exhibited extremely low thermal conductivity and a maximum figure of merit of ~0.73 was found. Enhanced electronic properties and low heat transport were also predicted for metal phosphides. As an example, NiP_2 was synthesized indicating good agreement with computation and the present model of minimum thermal conductivity [Pöhls *et al. JMCC*, 2017].

T4-4 Films, surfaces and composites (DCMMP) | Films, surfaces et composites (DPMCM) / 2200

Wrinkling and Buckling in Freestanding Bilayer Films (G)*

Authors: John Niven[1]; Gurkaran Chowdhry[1]; Kari Dalnoki-Veress[1]

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Periodic wrinkling of a rigid capping layer on a deformable substrate is a ubiquitous example of pattern formation in nature. Many experiments have studied wrinkle formation during the compression of thin rigid films on relatively thick pre-strained elastic substrates. The resulting wrinkling wavelength and amplitude can be predicted by minimizing the bending energy of the rigid film and the deformation energy of the soft substrate. To date, most wrinkling studies have focused on the regime where the substrate thickness can be considered semi-infinite relative to that of the rigid film. In this work we use optical and atomic force microscopy to study the wrinkling behaviour of thin rigid films upon compression by a pre-strained freestanding elastic substrate which cannot be considered semi-infinite. As the ratio of substrate to rigid film thickness is decreased, the system transitions from the semi-infinite wrinkling regime to one in which the entire bilayer film buckles upon compression. This transition is found to be strongly dependent on the pre-strain in the elastic film.

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 2201

Holographic Thermodynamics of Accelerating Black Holes (I)

Authors: Robert Mann[1]; Andres Anabalon[2]; Ruth Gregory[3]; David Kubiznak[4]; Michael Appels[5]; Ali Ovgun[6]

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One of the more intriguing solutions of General Relativity is the C-metric, which can be interpreted as describing the spacetime of an accelerating black hole. Little is known about the thermodynamics of these objects. Here I present a consistent formulation of the thermodynamics of accelerated black holes, resolving inconsistencies and discrepancies that have appeared in previous investigations of this subject. Their thermodynamic volume obeys the reverse isoperimetric inequality for all values of the parameters. The dual stress-energy tensor for the spacetime corresponds to a relativistic fluid with a non-trivial viscous shear tensor.

M1-3 Theory, Modelling, and Forecasting I (DASP) I Théorie, modélisation et prévisions I (DPAE) / 2202

The impact of the observation of local ionospheric anomalies on our understanding of ionospheric-magnetospheric coupling. (I)

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Ionospheric physics is rich with anomalies that are typically taking place on short temporal and/or spatial scales. Finding suitable explanations for these anomalies is one thing that keeps the field alive, as they lead to new discoveries into the rich ways by which the ionosphe couples with the atmosphere and magnetosphere, particularly when there are large departures of the system from equilibrium. These localized phenomena may play a key role in the way by which turbulence (or perhaps stochasticity/intermittency?) regulates the exchange of particles, momentum and energy between the subsystems. Given the limited amount of time for a presentation such as this, the talk will be limited to only a few noteworthy items, namely, some neutral atmospheric anomalies, hot ionospheric electron temperatures episodes, unexpected/unusual ion velocity and spectral signatures, and the connection of the latter (or lack thereof) with ion upflows and outflows.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2204

Gradient Flow in Holographic Superconductors (G)

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The AdS/CFT correspondence provides an equivalence between a gravity theory in some bulk anti-deSitter spacetime and a conformal field theory (CFT) in one fewer dimensions on the boundary. A superconductor that can be described by a gravity theory through this correspondence is referred to as a 'holographic superconductor'. Gradient flow equations will evolve any given initial field configuration towards one that is a solution to the equations of motion, this allows us to study stability of solutions as well as the behavior of a system far from equilibrium. Through the AdS/CFT correspondence, the gradient flow in the gravity theory should have a corresponding flow in the CFT and vice-versa. We focus on the flow of the matter fields in a gravity theory containing a black hole and a charged scalar field. In this system the flow equations move the system from a configuration with no scalar hair to a hairy black hole solution. We study the corresponding flow on the boundary superconducting theory, where a normal metal state transitions to a superconducting state.

M2-3 Particle Physics II (PPD) | Physique des particules II (PPD) / 2205

ATLAS ITk activities at SFU, TRIUMF and UBC

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In 2024 the Large Hadron Collider at CERN will enter its High Luminosity phase, which will see its instantaneous luminosity reach seven times its design value and will produce pp collisions at 14 TeV with an average of 200 interactions per bunch crossing.
These challenging conditions are beyond the ATLAS design and require an upgrade of the ATLAS tracking system. The ATLAS new Inner Tracker (ITk) will be an all-silicon tracking detector composed of pixel and strip sensors arranged in barrel and end-cap discs.
ATLAS Canada is participating as a whole in the building process of the ITk strip end-cap discs.
As we move towards the production phase of the ITk, a lot of effort has been put in the designing, prototyping and testing of the ITk components.
This talk presents the ITk activities involving the SFU, TRIUMF and UBC ATLAS groups, focusing on the building of the modules, the loading on the supporting structures, the electrical tests and the data taking at testbeam facilities.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2206

POS-12 Calculating the Temperature, Pressure, and Humidity Dependencies of the Michelson Interferometer for Airglow Dynamics Imaging (MIADI)

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The Michelson Interferometer for Airglow Dynamics Imaging (MIADI) is a field widened Michelson interferometer which provides images of wind using Doppler shifts in interference fringes from terrestrial airglow emissions. Although it is thermally compensated by using different glasses, some residual temperature dependence remains. Close examination of the interference fringes using a

fixed source reveals details about the path difference and its dependence on temperature and pressure. The phase of the interference patterns should remain constant over time in an ideal environment. By monitoring the phase of the interference pattern along with the environmental temperature and pressure the sensitivity of the instrument to temperature, pressure, and humidity can be determined. Several time series of the interferometer phase as a function of vary conditions have been undertaken in our lab at the University of New Brunswick. Multiple regression analyses of the dependencies of phase on environmental conditions were calculated. In this paper, an overview of the process to determine the temperature, pressure, and humidity dependencies of the Michelson Interferometer for Airglow Dynamics Imaging (MIADI) and their implications are presented. Since the observed dependencies do not match theoretical expectations determining the different environmental dependencies will allow for corrections to be made in the design of new wind imaging instruments.

W3-8 Nuclear Structure II (DNP) | Structure nucléaire II (DPN) / 2207

High-Precision Branching Ratio Measurement for the Superallowed Fermi Beta Emitter 22Mg

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High-precision measurements of the ft values for superallowed Fermi beta decays between 0^+ isobaric analogue states have provided invaluable probes of the Standard Model (SM) description of the electroweak interaction. These measurements confirm the CVC hypothesis to 1.2 parts in 10^4, set the tightest experimental limits on the existence of scalar currents in the electroweak interaction (under the assumptions of time-reversal invariance and maximum parity violation also common to vector currents), and set a strict upper limit on the existence of induced scalar currents.

To provide these stringent tests, theoretical corrections must be applied to the experimentally determined ft values obtained from precise measurements of the half-lives, branching ratios, and Q values of the decays. Of particular interest is the isospin symmetry-breaking correction (δ_C), which is model-dependent; several theoretical approaches can and have been used to calculate these corrections. In the most recent world survey of the superallowed Fermi β emitters 1 the choice of δ_C correction used depended, at least in part, almost entirely with four of the least precisely determined corrected-ft values of the well-determined cases, ^{22}Mg, ^{38}Ca, ^{62}Ga, and ^{74}Rb.

In light of this, we have performed both a half-life and branching ratio measurement for ^{22}Mg to improve the precision of the ^{22}Mg ft value by a factor of 2. These results will play a major role

in discriminating between different theoretical approaches to the δ_C corrections in superallowed decays.

The goal of the experiment performed at TRIUMF's ISAC facility in 2017 using the GRIFFIN spectrometer was to measure the ^{22}Mg branching ratio to a precision of $\pm$0.15%. Taking advantage of GRIFFIN's very high γ-detection efficiency allows us to measure the branching ratio using a novel technique based on γ-γ coincidences that eliminates the need for high-precision efficiency calibrations that plagued previous measurements.

This presentation will discuss preliminary branching ratio results for ^{22}Mg as well as comparing these results to previous measurements.

1 J.C. Hardy and I.S. Towner, Phys. Rev. C 91, 025501 (2015).

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R2-3 Laser Physics and Spectroscopy (DAMOPC) | Physique des lasers et spectroscopie (DPAMPC) / 2208**

Withdrawn Hyperfine splitting in atomic hydrogen and two photon processes in CARS and cosmic blackbody radiation (G)

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Single photon absorption and decay is the process where an atom emits or absorbs a single photon whose energy is equal to the energy difference between atomic energy levels. In two photon processes, an atom emits or absorbs two photons whose energies sum to the energy difference between atomic energy levels. The study of two photon processes has multiple applications in several fields of laser physics and astrophysics. Specifically we will be reporting results on fundamental two photon processes involving the hyperfine splitting of the ground state hydrogen. We will apply our calculations to Raman scattering processes, including Coherent Anti-Stokes Raman spectroscopy (CARS), and to two-photon absorption from the cosmic blackbody radiation.

W2-4 General Relativity II (DTP) | Relativité générale II (DPT) / 2209

The nuts and bolts of higher curvature gravity (G)*

Author: Robie Hennigar[1]

Co-authors: Robert Mann [1]; Pablo Bueno [2]; Pablo Cano [3]

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I will discuss recent work constructing Taub-NUT/Bolt solutions in general higher curvature theories of gravity. A broad class of theories known as generalized quasi-topological gravities (that include general relativity as a special case) allow for results non-perturbative in the higher curvature couplings, and we see a number of interesting differences compared to general relativity. General

results can be obtained, valid for any theory of gravity, and I will comment on their implications in light of the AdS/CFT correspondence.

T2-4 Medical Imaging 1 (DPMB) | Imagerie médicales 1 (DPMB) / 2210

Plastic scintillators as in-vivo dosimeters for photons and electrons in external beam radiation therapy: Angular dependence of response (G)

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Plastic scintillation detectors (PSD) are excellent candidates for in-vivo dosimetry due to their small size, sensitivity and potential for real time readout. One challenge associated with PSD dosimetry is the contamination of the scintillation signal with Cerenkov radiation and fluorescence. An implicit assumption made with PSDs is that the spectral components of the scintillator and fiber response are invariant between calibration and measurement conditions. In this study this assumption was tested by measuring the spectral content of the emissions of the scintillator and the optical fiber as a function of the angle of incidence of a radiation beam on a PSD. We studied two different Kuraray plastic scintillators coupled to Mitsubishi Eska optical fiber. The spectral content of the PSD emissions was measured with a spectrophotometer. The PSDs were placed both at the surface and at depth in a solid water phantom in different orientations in the beam. The gantry angle was varied between 0^0 and 45^0. The normalized emission spectra of the scintillators and the fibre were compared for different orientations and gantry angles. Photons of energy 6 MV and electrons of energies 6 MeV and16 MeV were investigated. On the surface, the relative contributions of Cerenkov and fluorescence vary as a function of gantry angle when the PSD is oriented in the plane of gantry rotation. For 6 MV, 6MeV and 16MeV, we found a variation of 2.5, 4.5 and 5.5 % in the peak emission of optical fiber and 2.5, 7.3, and 9.3 % in the emission of the scintillator respectively. The variability in decreased with depth. The effect of this variability on dose prediction (with assumption of spectral composition invariability) was studied.

R3-2 Light-Matter Interactions II (DAMOPC/DCMMP) | Interactions lumière-matière II (DPAMPC/DPMCM) / 2211

Control of plasmon modes of metallic nanoantenna arrays on metal-insulator transition material substrate using thermo-optical switching mechanism (G)

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We numerically study plasmonic and photonic mode properties of arrays of strip-like metallic nanoantenna on Vanadium dioxide (VO2) substrate. VO2 features a semiconductor to metal phase change characteristic below and above a critical temperature that leads to an abrupt change in the particle' s optical properties. These VO2 optical variations lead to alter this martial from a relatively transparent semiconductor to an opaque metal in the infrared region. In this work, we implement of a number of steps to have self-consistent solution to the coupled electromagnetic (EM) and the heat transfer (HT) problem. Our results show that when the intensity of the incident laser light reaches

to critical values the created photo-thermal energy in the proposed structure leads to a phase transition from semiconductor to metal in VO2 substrate. This phase transition drastically changes the plasmonic modes (cavity modes) dictated by the periodicity of the array as well as the extinction profile of the structure over a broad wavelength spectrum. The proposed nanostructure system may open up new avenues for highly tunable ultrafast devices.

M2-1 Ultrafast EM Waves II: THz Science (DAMOPC/DCMMP) | Ondes EM ultrarapides II: Science des THz / 2212

Four-wave mixing studies of carrier dynamics in CH3NH3PbI3 organic-inorganic Perovsite (G)

Author: Samuel March[None]

Co-authors: Drew Riley ; Charlotte Clegg ; Daniel Webber ; Xinyu Liu ; Margaret Dobrowolska ; Jacek Furdyna ; Ian Hill ; Kimberley Hall

Solar cells based on CH3NH3PbI3 (MAPI) have reached efficiencies comparable to the best polycrystalline silicon solar cells in just 9 short years 1. Despite the unparalleled increase in efficiency, the fundamental photo physical properties in this archetypical perovskite material system are not yet well understood. In order to further optimize device performance, it is essential to determine the fundamental processes that govern carrier generation, and transport. Here we have utilized four-wave mixing spectroscopy to study the optical response of MAPI thin films with excitation densities comparable to solar cell operating conditions, revealing weaker carrier-carrier and exciton-carrier scattering in the perovskite system compared to GaAs 2, exciton binding energies for bound and unbound excitons in the low temperature phase 3, and a measurement of the carrier diffusion length at room temperature by implementing the transient grating four-wave mixing technique 4.

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DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2213

POS-33 Standing helimagnons in MnSi thin films

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A number of recent calculations and experiments have identified that strain and finite size effects are important contributions that influence the stability of the magnetic textures in MnSi thin films. Both

of these effects play an important role in MnSi films grown on Si substrates and have an important influence on the magnetic phase diagram. However, there continues to exist controversy over the interpretation of the phase diagram. With insights from ferromagnetic resonance, magnetometry, Hall effect and polarized neutron reflectometry in out-of-plane fields, a consistent picture emerges with the cone phase as the sole equilibrium phase below the saturation field. We present numerical modelling of spin-orbit torque induced ferromagnetic resonance experiments. Micromagnetic calculations reveal standing helimagnons and excitations of the surface twists in the film that explain the data.

W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2214

Critical failure can be tuned by material rheology: A model and a case study.

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The total energy of acoustic emission (AE) events in externally stressed materials diverges when approaching macroscopic failure. Avalanche models explain this accelerated seismic release (ASR) as the approach to a critical point that coincides with ultimate failure. However, not all empirical mechanical processes are critical at failure. As a case study, we show how the soft uniaxial compression of nanoporous materials exhibits ASR but, instead of a singular critical point, the distribution of AE energies is stationary and variations in the activity rate are sufficient to explain the presence of multiple periods of ASR leading to distinct brittle failure events. We propose that critical failure is suppressed in the AE statistics by mechanisms of 'transient hardening'. The same mechanisms can explain the reported temporal correlations between AE events. We compare the experimental results with a solvable mean field model of rheological fracture. This model exemplifies how criticality and temporal correlations are tuned by rheology, effectively acting as a mechanism of transient hardening. The statistical properties depend only on the distance to a critical point, which is universal for any parametrization of the transient hardening in a whole category of fracture models.

R3-2 Light-Matter Interactions II (DAMOPC/DCMMP) | Interactions lumière-matière II (DPAMPC/DPMCM) / 2215

Experimental results and calculations for carbon monoxide in the fundamental band

Author: Predoi-Cross Adriana [1]

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This presentation is a continuation of spectroscopic results presented last year. We have completed our investigation of 27 spectra of carbon monoxide and of carbon monoxide mixed with air recorded over a range of temperatures at the former Fourier transform spectrometer located at Kitt Peak, Arizona. The spectra were analyzed using the speed-dependent Voigt and speed dependent Rautian profiles with weak line mixing components. The speed dependence parameters were either fitted or, for weak transitions they were fixed to calculated values obtained for an effective molecular potential of fifth order. The fits performed using the speed dependent Rautian profile were performed using a calculated value for the narrowing parameter, the same value for all transitions. Semi-classical theoretical calculations for self- and nitrogen-broadened line widths were performed at the temperatures of spectra using published potential energy surfaces and a Tipping-Herman intermolecular potential. Our experimental results will be compared with the calculations results and earlier published results.

R2-4 Theoretical and computational biophysics (DPMB) | Biophysique théorique et calculatoire (DPMB) / 2216

Ratcheting of spherical particles in simple microfluidic devices: making particles move against the direction of the net force

Authors: Gary W. Slater[1]; Hanyang Wang[1]; Hendrick W. de Haan[2]

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We examine the electrophoresis of charged spherical particles in microfluidic devices made of alternating wells and narrow channels, including a system previously used to separate long DNA molecules. Our computer simulations predict that such systems can be used to separate spherical particles of different sizes that share the same free-solution mobility. Interestingly, the electrophoretic velocity shows an inversion as the field intensity is increased: while small particles have higher velocities at low field, the situation is reversed at high fields with the larger particles then moving faster. The resulting nonlinearity allows us to use asymmetric pulsed electric fields to build separation ratchets: particles then have a net size-dependent velocity in the presence of a zero-mean external field. Exploiting the inversion mentioned above, we show how to design pulsed field sequences that make a particle move against the mean field (an example of negative mobility). Finally, we demonstrate that it is possible to use pulsed fields to make particles of different sizes move in opposite directions even though their charge have the same sign.

M3-1 Stochastic Biology (DPMB) I Biologie stochastique (DPMB) / 2217

Probing the network structure of health deficits in human aging (I)

Authors: Spencer Farrell[1]; Arnold Mitnitski[1]; Olga Theou[1]; Kenneth Rockwood[1]; Andrew Rutenberg[1]

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Human aging leads to the stochastic accumulation of damage. We model an aging population using a stochastic network model. Individuals are modeled as a network of interacting nodes, representing health attributes. Nodes in the network stochastically damage and repair, with rates dependent on the state of their neighbors. Damaged nodes represent health deficits. Overall damage in the network is measured with the Frailty Index (FI), a quantitative measure of deficit accumulation used in observational studies of aging to assess health and predict mortality. We use our understanding of the mechanisms of aging in our model to understand observational health data where the mechanisms are unknown. With stochastic simulations and mean-field theory we show how the underlying network structure controls the behaviour of the FI and how damage propagates within the network, leading to individual mortality.

M1-6 Biophysics, microscopy and diseases (DPMB) / Biophysique, microscopie et maladies (DPMB) / 2218

Polarization based imaging of amyloid in the retina gives a biomarker of severity of Alzheimer's disease

Author: Melanie Campbell[1]

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The retina, with its neural tissue, also acts as a window on the brain. Alzheimer's disease is currently only definitively diagnosed after death from an analysis of deposits of amyloid beta (plaques) in the brain. Retinal function has been reported to be directly affected by the disease and neurotoxic effects of amyloid beta have been demonstrated in the retina. We were one of the first groups to find amyloid deposits in association with neural cells in *ex vivo* retinas of those with Alzheimer's disease. Using Mueller matrix polarimetry, and taking 16 images as we rotate quarter wave plates with respect to linear polarizers within a polarization state generator and analyzer, we can identify the presence of the disease with high sensitivity and specificity without the use of a dye. A number of interactions of the deposits with polarized light differ from those of the surrounding tissue. One of the largest differences is in the birefringence of the amyloid deposits. This gives rise to relative retardation of two perpendicular linear polarizations and contrast in cross polarization. In our hands, polarization imaging of the retina provides a noninvasive, less expensive and simple method of detecting and tracking amyloid deposits. In addition, we have shown that the number of deposits can predict the severity of Alzheimer's disease. Here we will describe the similarity of polarimetry measurements on pure amyloid beta and deposits in retinal tissue. We will then describe our intended instrument configuration for imaging these deposits in the living eye.

W1-3 Particle Physics VI (PPD) I Physique des particules VI (PPD) / 2219

Bubble growth dynamics in the PICO bubble chambers (G)*

Author: Alexandre Le Blanc[1]

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Astronomers have observed, through observations of galaxy rotation curves and luminous mass, that our understanding of the dynamics at the scale of galaxies is incomplete; they were the first to challenge the standard model and notice there's something missing or lacking in our understanding. A possible solution to their observation was adding invisible mass which came to be called dark matter. The most accepted theory proposes the existences of a Weakly Interacting Massive Particle (WIMP) that would have the properties of dark matter. As its name implies WIMP searches would fall under the category of rare event searches which require extremely low and well understood backgrounds. PICO is one of many direct dark matter search experiments, it utilizes the acoustics of growing bubbles nucleated from minute energy depositions within a superheated liquid to detect particle interactions. It was observed that bubbles nucleated from alpha particle interactions were louder than bubbles nucleated from neutron particle interactions; which lead to the development of the Acoustic Parameter, known as the AP. Through the analysis of bubble growth dynamics we will attempt to answer the questions of why and how different particles have different acoustics. The answer resides in examining the excess energies deposited by alphas and neutrons to form mono-nucleated bubbles and the thermodynamic conditions of the detector.

T3-5 Hadronic Physics (DNP) | Physique hadronique (DPN) / 2220

Geochemical measurement of the half-life for the double-beta decay of 96Zr (G)*

Author: Adam Mayer[1]

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Double-beta (ββ) decay measurements are a class of nuclear studies with the objective of detecting the neutrinoless (0ν) decay variants. ^{96}Zr is of particular interest as a ββ decay candidate as it has one of the shortest ββ decay half-lives and largest Q-values. A geochemical measurement of its ββ decay half-life was previously performed by measuring an isotopic anomaly of the ^{96}Mo daughter in ancient zircons. This measurement yielded a value of 0.94(32)x10^{19} a 1. More recently, the NEMO collaboration measured the half-life by a direct count rate measurement to be 2.4(3)x10^{19} a 2, twice as long as the geochemical measurement. ^{96}Zr is also distinctive in that it can undergo a highly forbidden single β decay to ^{96}Nb, which then immediately decays to ^{96}Mo, with a theoretical half-life > 10^{20} a. The geochemical measurement of the ^{96}Zr half-life does not discriminate between these two decay channels, and thus could provide a way to measure the single-beta decay rate.
We aim to study this system through a series of experiments combining nuclear physics and geochemical techniques. We are measuring the amount of daughter product of the decay of ^{96}Zr→^{96}Mo in 2.72 Ga zircons ($ZrSiO_4$). The zircons, which have remained a closed system over their lifetimes, are especially suitable for this investigation due to their high Zr content and low natural Mo content. This makes it possible to detect the small amount of accumulated decay product as an excess compared to the natural Mo isotopic composition.
A discussion of advances in the techniques required for the geochemical measurement will be presented. These advancements have enabled us to produce the first measurements of Mo isotope composition from 2.76 Ga zircons using MC-ICP-MS. The implications for the single and double β decay half-life will be discussed along with future directions.
1 Wieser and De Laeter (2001), Phys. Rev. C 64, 024308.
2 NEMO-3 Collaboration (2010) Nucl. Phys. A 847, 168-179.

W2-1 Pattern Formation 2 (DCMMP) | Formation de motif 2 (DPMCM) / 2221

Unveiling criticality in noisy nonequilibrium systems (G)*

Authors: Daniel Korchinski[1]; Javier Orlandi[1]; Rashid Williams-Garcia[2]; Joern Davidsen[3]

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Neuronal systems have become emblematic of nonequilibrium biological systems with complex behaviour. Owing to observations of apparently scale-free cascades of causal activity (avalanches) in neural cultures, it has become a popular hypothesis that neural systems operate close to a nonequilibrium phase transition. That neural systems should operate at a critical point is supported by theory, which suggests that criticality is optimal for information processing and storage. A reduced framework, in terms of a branching process tuned to the critical point, is enough to reproduce the power-laws observed in experiments. However, this description fails to capture much of the relevant biological details of neuronal systems, like self-organization mechanisms, and ignore the role of spontaneous activity. In real neuronal systems, neurons will spontaneously fire, and can create avalanches that overlap both in space and time. This destroys the separation of time scales between initiation and propagation of new avalanches, an assumption that is implicit in the classical definition of avalanches. Simulating large ensembles of realistic neurons we demonstrate that the classical definition of the neuronal avalanche fails to describe the statistics of the system. However, by taking into account the ground-truth connectivity of the system, we employ "causal webs"to disentangle concurrent but independent cascades of activity. We show that this procedure can be generalized for when the connectivity map is not available (as is the case for most experimental conditions) and still recover the underlying statistics of the system under study.

W3-4 Soft matter and molecular dynamic (DPMB/DCMMP) | Matière molle et dynamique moléculaire (DPMB/DPMCM)) / 2222

Voltage-driven translocation through a nanopore: How can we define the capture radius? (G)*

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In most polyelectrolyte translocation studies, regardless of the shape of the pore and the strength of the driving force, the polymer chain has to go through three basic steps: (i) diffusion; (ii) capture; (iii) threading. The capture process remains rather ill-understood because it cannot easily be visualized or inferred from the blockage current measured across the nanopore. To estimate the size of the so-called capture zone, a capture radius R_C is generally defined as the radial distance from the pore center where diffusion-dominated polymer dynamics (at large distance) cross over to drift-dominated dynamics (closer to the pore). However, some of the definitions for R_C are ambiguous and over-simplified. In this talk, we propose several different approaches to define and estimate the value of R_C for the case of a charged particle diffusing in a liquid and attracted to the entrance of the nanopore by the presence of an electric field. The inhomogeneous electric field outside the nanopore is calculated by analytically solving the Laplace equation in Elliptical Coordinate, instead of using a point-charge approximation. We present a theoretical analysis of the P\'eclet number (Pe) as well as 2D Lattice Monte Carlo (LMC) simulations with different simulation protocols, including (i) dynamic simulations of the capture of a single particle by a nanopore situated on a reflecting wall and, (ii) the evolution of the concentration of particles in the presence of reservoir-like boundary conditions.

Moreover, we study the effects of particle-wall hydrodynamic interactions on the capture radius by modifying the diffusivity of the particle near the wall.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2223

POS-34 Synthesis of inverse tetragonal Heusler alloys

Authors: David Kalliecharan[1]; Jason McCoombs[1]; Theodore Monchesky[1]

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The broken inversion symmetry in non-centrosymmetric magnetics produces a chiral interaction responsible for the formation of stable nanoscale magnetic solitons in these materials, known as skyrmions. The inverse tetragonal Heusler alloys possess a D2d point group symmetry that gives rise to antiskyrmions, recently discovered in Mn1.4PtSn 1. We are investigating the related family of compounds, Mn2-δZGe (where Z is a group 9 or 10 transition element), which are well lattice matched to Si(001). We present preliminary results of the combinatorial synthesis of Mn2-δZGe films prepared by magnetron sputtering and rapid thermal annealing. The stability of the tetragonal phase is explored with X-ray diffraction, X-ray photoelectron spectroscopy and wavelength dispersive spectroscopy.

1 A. K. Nayak et al. Nature (2017).

W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2224

Icicle Ripples: examining a phase transition with impurities (G)*

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Icicles are an ideal test-case for understanding the free-boundary shape of "wet" ice growth. Icicles observed in nature and the laboratory often exhibit ribs or ripples with a wavelength close to 1cm around their circumference. Previous experiments on laboratory-grown icicles have shown that the existence of these ripples depends on the presence of (very small) concentrations of impurities in the feed water. However, all existing theoretical models of the icicle ripple instability have ignored the purity of the water.

We have presented a model of solid icicle growth incorporating the effects of impurities on the freezing point. This model is based on previous work that assumed a thin-film flow over solid ice. We introduced realistic, physically derived boundary conditions for both heat transfer and impurity concentration.

Linear stability analysis shows that this more physically complete one-sided model of solid icicle growth cannot account for the 1cm wavelength of the ripple instability, because the effects of impurities are inherently too weakly coupled to the freezing dynamics. This suggests that more complex

physics are involved, possibly so-called "spongy" ice. Models of the freezing and growth of spongy ice are more strongly affected by impurities in the water.

We present our latest experimental results investigating the nature of ice in laboratory-grown icicles.

R2-4 Theoretical and computational biophysics (DPMB) | Biophysique théorique et calculatoire (DPMB) / 2225

Failure of the Ogston Model: Systems with Anisotropic Obstacles and Inhomogeneous Diffusivity

Authors: Mehran Bagheri[None]; Gary W. Slater[None]

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Diffusion plays a critical role in many biological processes, but also in a wide range of experimental devices such as gel electrophoresis and sieving. The well-known Ogston model predicts that the diffusivity of a migrating particle through a random network of fibers (e.g., a gel matrix) is proportional to the fractional volume available to the migrating particle in the given medium. As such, the Ogston model is essentially a mean-field model. Despite wide acceptance of this model in the biological sciences and many studies that investigated the diffusion of various particle shapes, a comprehensive understanding of how the gel architecture and the shape of the obstacles impact the overall diffusion constant of a free particle is still lacking. In this talk, we will present computational studies of 2D systems consisting in anisotropic rod-shape obstacles with various correlated and uncorrelated orientations, a toy model that allows us to examine the impact of microscopic details on the global diffusivity of particles in structured and random porous systems. First, we show that how the diffusivity of particle in systems with identical free volume fractions would vary as a function of the obstacles orientation when the latter is controlled using an \textit{Ising}-like phase transition. We then explore systems containing zones with different obstacle orientations and therefore, different diffusivities. Having calculated the exact diffusivity for individual zone and the overall system, we show how these individual diffusivities contribute to the overall diffusivity of a particle in the system.

M1-4 Quantum Theory (DTP) | Théorie quantique (DPT) / 2226

Vortices and the fine structure of quantum light-cones (G)*

Authors: Wyatt Kirkby[1]; Jesse Mumford[1]; Duncan O'Dell[1]

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We identify the light-cone-like structures present following quenches in spin-chains as quantum caustics. These are discrete versions of the singularities classified by catastrophe theory. From this identification follows: local universality

T3-6 Developing Scientific Practices in the Laboratory (DPE) | Exercice de la science en laboratoire (DEP) / 2227

Evaluation of Traditional Labs As Effective Content Delivery In A High-Enrollment IPLS Course. (G)*

Authors: Matt Steffler[1]; Joanne O'Meara[1]; Martin Williams[1]

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Recent studies have suggested that structured laboratory activities may not be the most effective way of teaching content and concepts to first year physics majors. We examine and extend that investigation to a high-enrollment Introductory Physics for the Life Sciences course. Using a varied laboratory curriculum, we correlate quiz marks, exam marks, and student attitudinal data to determine whether specific concepts were reinforced by laboratory activities. We also attempt to ascertain what additional skills are delivered by labs; whether they should be considered conceptual instruction tools, focused on practical skills, research or data analysis skills, a hybrid of all, or something else entirely. Initial results suggest that a highly scaffolded lab that limits inquiry in favour of specific content instruction may not be the most effective tool for content reinforcement.

R2-3 Laser Physics and Spectroscopy (DAMOPC) | Physique des lasers et spectroscopie (DPAMPC) / 2229**

Room temperature study of nitrous oxide in the bending band

Author: Adriana Predoi-Cross[1]

Co-authors: Robab Hashemi [2]; Malathy Devi [3]; Hossein Naseri [2]; Mary Ann Smith [4]

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Nitrous oxide is of interest for atmospheric composition studies. Spectroscopic remote sensing studies rely on the availability of accurate sets of line parameters for molecular atmospheric constituents. In this study we have extended the set of line parameters for nitrous oxide obtained using the speed-dependent Voigt line profile with a weak line mixing component. We have used five room temperature spectra recorded at Kitt Peak, AZ. An extension of this study over a range of temperatures is underway using spectra recorded at the same facility and preliminary results will be presented as well. In addition, we compare our measurement results with published results obtained using different spectral line profiles.

T2-3 Ground-based and in Situ Observations II (DASP) l Observations terrestres et In situ II (DPAE) / 2230

Science Highlights from the Swarm Electric Field Instruments

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After four years in orbit, the Swarm Electric Field Instruments have contributed to dozens of scientific studies on topics that include the electrodynamics of auroral arcs, supersonic flow channels associated with region 1/2 currents and sub-auroral ion drifts, polar cap patch dynamics, Poynting flux, and magnetosphere-ionosphere coupling via Alfven waves. This talk will overview capabilities and accomplishments of these instruments and highlight future opportunities as the Swarm mission is extended into the next four years.

M1-4 Quantum Theory (DTP) | Théorie quantique (DPT) / 2231

Thermalization by Rapid Bombardment (G)*

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Imagine a quantum system placed within a thermal gas, which is itself composed of many quantum systems e.g. atoms/molecules. As the constituents of the environment scatter off of the system, it is natural to expect that the system will reach a thermal equilibrium with its environment. Moreover one may expect that the ultimate thermalization of the system is largely independent of the coupling between the system and its environment, H_{SE}, and of the time scale of the scattering.

We show that if the scattering time scale is sufficiently small, then the final temperature of the system is generically not the temperature of its environment, $\beta_S(\infty) \neq \beta_E$. Instead we find equilibrium of the form $E_S\beta_S(\infty) = f(H_{SE}, E_E\beta_E)$ where E_S and E_E are the energy scales of the free system and environment respectively.

W2-3 Particle Physics VII (PPD) | Physique des particules VII (PPD) / 2232

PICO40L neutron background simulation (G)*

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The PICO40L bubble chamber is a threshold detector filled with C_3F_8 located at SNOLAB and design to perform direct dark matter searches. During the construction of this detector, a very careful screening of the materials allowed the selection of materials containing low amount of neutron emitting isotopes. By using GEANT4, GDML and McCAD, a simulation of the expected neutron background events in the PICO40L detector was obtained. This approach has reduced the time required to build geometries by translating STEP files directly in GDML by using McCAD. Going forward in the future, it is critical for the PICO collaboration to perform the same work in order to have a detailed neutron background budget before embarking into the construction of the next detector, PICO 500.

T4-8 Novel Approaches to Promoting Engagement in Physics Classes (DPE) | Nouvelles approches pour promouvoir l'engagement dans les classes de physique (DEP) / 2233

Reflections on implementing physclips and physlets in undergraduate physics courses

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I will present my perspective on using physlets and physclips in introductory physics courses. The physclips have been developed at the School of Physics, University of South Wales, Australia, along with other multimedia resources. The physclips were downloaded from open sources such as: http://www.compadre.org/physlets/ or were available as PhET simulations in textbooks' online resources. Observed changes in students' performance and in the type of skills that they developed will be discussed. I will also comment on ways in which such resources could be incorporated in "scale-up" or project-based teaching environments.

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 2234

Black Hole Biochemistry (G)*

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In the context of black hole chemistry, We study the thermodynamics of asymptotically de Sitter Black holes with conformal scalar hair in Einstein gravity. The hair parameter allows us to reach thermodynamic equilibrium between the event horizon and the cosmological horizon. We find that these hairy black holes undergo a new phase transition that resembles the phase transtions of denatured proteins.

T4-6 DASP General Contributions II (DASP) | DPAE: contributions générales II (DPAE) / 2235

Observing the Dynamics of the Martian Atmosphere (I)

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The Martian atmosphere exhibits more dynamical variability than the terrestrial atmosphere with large amplitude tides and gravity waves in addition to the seasonal dust storms. To date, there have not been dedicated wind measurements from orbit around Mars and there is some evidence that the winds do not match expectations from models. As with the terrestrial atmosphere, airglow is one means to observe Martian atmospheric dynamics. The field-widened Michelson imaging interferometer is one technique with which wind and temperature measurements can be made. The O2 IR atmospheric band is an extremely bright emission in the Martian dayglow and allows observations to be made from close to the surface to ˜50 km. In this paper, our current understanding of the dynamics of the Martian atmosphere will be reviewed and the ability of an imaging Michelson interferometer to probe the dynamics of the atmosphere presented.

M1-4 Quantum Theory (DTP) | Théorie quantique (DPT) / 2236

Gravity in quantum systems: lessons from spectroscopy

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The goal of this project is to make progress in quantum gravity by studying gravity in quantum mechanical systems at atomic scales. We compare approaches to the generation of gravitational waves and gravitons from quantum mechanical systems such as the ammonia molecule. The approach is guided by the strong analogy between classical electromagnetism and classical general relativity. We evaluate the semi-classical Einstein equations based upon their predictions for gravitational wave generation.

W3-5 Quantum Sensors and Quantum Technology (DAMOPC) | Détecteurs quantiques et technologie quantique (DPAMPC) / 2237

Autler-Townes quantum memory for broadband light storage and manipulation

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Using the well-known Autler-Townes effect, we have implemented a novel quantum memory in our laboratory in a medium of laser-cooled rubidium atoms. This new method relies on the absorption of the signal over a wide spectral region, making it inherently broadband and well-suited to quantum memory applications. This Autler-Townes splitting (ATS) protocol facilitates dynamical control of coherent optical signals for the storage and manipulation of broadband optical pulses. We experimentally demonstrate the proof-of-principle of this technique for several applications in a laser-cooled sample of ^{87}Rb atoms: the storage of short ($\geq$20 ns) optical signals; the compression and stretching of optical pulses in both time and frequency domains; coherent temporal beamsplitting operations; and wavelength conversion. Additionally, weak optical pulses with less than one average photon per pulse can be stored and retrieved with this method, demonstrating the potential for a broadband quantum memory. Our simulations of this protocol, using the Maxwell-Bloch equations, show that the ATS memory has significant technical advantages over previous techniques, as it is less demanding of resources like laser power or atomic optical density. Furthermore, this protocol is readily generalized to any three-level system and should prove useful across domains of quantum technology.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2238

**** Withdrawn *** Entanglement harvesting in Anti-de Sitter space and beyond (G)

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The AdS_4 spacetime is of much interest to physicists, because of its relevance to the AdS/CFT duality. Very little is known
about how to extract quantum correlations from the AdS vacuum, a procedure called entanglement harvesting.
Using a new and general theorem, we calculate the entanglement harvested by a pair of Unruh-DeWitt detectors coupled to a conformal scalar vacuum of AdS_4, in two physical scenarios: one where both detectors are in geodesic motion, and one where both detectors are static. As in flat space, we find that for any separation, there exists an energy for which entanglement harvesting is possible. We also characterize the dependence of the entanglement harvested on separation in time and space, for different values of curvature. Our calculations demonstrate that the theorem may be used effectively to simplify calculations in much more general spacetimes.

R1-3 Particle Physics IX (PPD) | Physique des particules IX (PPD) / 2239

Performance of Canadian-made muon chambers for the ATLAS experiment Phase-1 upgrade.

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The planned luminosity increase of the LHC will allow the precise measurement of Higgs boson properties and extend the search for new physics phenomena beyond the standard model. To maintain excellent detection and background rejection capability in the forward region of the ATLAS detector, part of the muon detection system is scheduled to be upgraded during the LHC long shutdown period of 2019-2020. This upgrade consists in the complete replacement of the two ATLAS muon
small wheels. The new muon small wheels will be partly made of Thin Gap Chambers
(TGC), approximately one third of which are been built and tested in Canada. A
description of the chamber testing infrastructure at McGill University will be presented as well as preliminary results of the performance of Canadian-made muon chambers.

W2-6 Inclusive Science Education (Part 1) (DPE/CEWIP) I Éducation scientifique inclusive (1ère partie) (DEP/CEFEP) / 2240

Report on the 2018 Canadian Conference for Undergraduate Women in Physics (CUWiP) and evolution of an APS-CAP partnership

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The fifth edition of the Canadian Conference for Undergraduate Women in Physics (CUWiP) series was held at Queen's University on 12-14 January 2018. A conference report for this 2018 edition will be presented. The second part of this talk will report on the evolution of a partnership between CAP and the US American Physical Society (APS) as part of the organization of this conference series.

T2-3 Ground-based and in Situ Observations II (DASP) l Observations terrestres et In situ II (DPAE) / 2241

Assessment of Swarm ionospheric flow measurements by inter-satellite comparisons

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We present recent results from a preliminary inter-satellite comparison of ionospheric flow measurements from the European Space Agency Swarm mission. Swarm consists of three identical satellites in near-polar circular orbits in the topside F region ionosphere. Each spacecraft carries a set of two orthogonal thermal ion imagers designed to measure full ion flow vectors twice per second. The thermal ion imagers are beset by a measurement anomaly caused by water contamination, which has precluded routine automated determination of ion flows. An extensive experimental campaign to understand and fix the anomaly has revealed several mitigation strategies that enable daily operations that return high quality scientific flow data. The aim of the present work is to assess the validity of these flows by comparing similar measurements from the different satellites. Preliminary results reveal both highly correlated ion flows, as well as intriguing differences suggestive of spatial-temporal inhomogeneities, as determined with pairs of the Swarm satellites.

R1-7 Neutrons (DNP) | Neutrons (DPN) / 2242

Neutron electric dipole moment measurement: systematics and magnetic field control

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The search for a permanent electric dipole moment (EDM) of the free neutron is a high precision measurement. Its outcome has high impact on subatomic physics since it's linked to violation of CP symmetry, and to the Baryon Asymmetry of the Universe.
The TUCAN collaboration (TRIUMF UltraCold Advanced Neutron source) aims to build a world leading facility for the production of Ultracold Neutrons (UCN), which are particularly suited for the neutron EDM search. Furthermore, the collaboration aims at achieving an unprecedented measurement sensitivity of 10ˆ-27 ecm –about 30 times better than the current upper limit of 3 x 10ˆ-26 on the neutron EDM.
The difficulty of this measurement lies mostly in having sufficient control over systematic uncertainties and the best available magnetic field stability and homogeneity at the UCN measurement cell.

This talk will give an introduction to standard neutron EDM measurement techniques and systematics, as well as focus on the research and development efforts of the TUCAN collaboration with respect to magnetic field control. The current developments at TRIUMF will be highlighted.

R1-7 Neutrons (DNP) | Neutrons (DPN) / 2243

Quantum Vortex Limitations to Ultracold Neutron Production

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The TRIUMF Ultracold Advanced Neutron (TUCAN) collaboration uses a neutron source based on superfluid helium to produce ultracold neutrons. Superfluids are usually thought of as having infinite thermal conductivity. But at the operating temperature and heat flux for our source, the transport of heat in the superfluid is expected to be limited by quantum vortices. In the two-fluid model, the heat is transported by the normal fluid component, which experiences mutual friction with the vortices. Based on this theory, temperature gradients in the superfluid will rise as the cubed power of the heat flux. Previous measurements have tended to support the theory, but our UCN source parameters (temperatures of less than 1 Kelvin) lie in an unmeasured regime where the normal component is less than a percent of the superfluid component. This motivated measurements conducted using our existing UCN source, which will be reported. Further measurements are planned to better constrain the design of our future UCN source.

Herzberg Memorial Public Lecture | Conférence commémorative publique Herzberg (Nergis Mavalvala, MIT) / 2244

The Warped Universe: the one hundred year quest to discover Einstein's gravitational waves

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The recent announcements of the first ever detections of gravitational waves from colliding black holes and neutron stars have launched a new era of gravitational wave astrophysics. Gravitational waves were predicted by Einstein a hundred years earlier. I will describe the science, technology, and human story behind these discoveries that provide a completely new window into some of the most violent and warped events in the Universe.

W3-7 Applied Physics Instrumentation (DAPI) | Instrumentation de physique appliquée (DPAI) / 2245

Cryogenic Energy Storage in Conjunction with Mine Chilling a Co-generation System (I)

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Cryogenics is a mature yet growing industry and cryogenic liquids are in increasing demand as global industrialisation continues to expand, especially with the increase in liquid natural gas projects, which is providing mutually beneficial advances in cryogenic equipment. In this paper we discuss the use of cryogenic liquids as an energy storage vector, which has implications on the energy profile of the mine especially if renewable energy sources are involved. The generation of electricity in an underground facility simultaneously produces chilling in a two stage process. The liquid delivered from the surface plant to the underground site firstly undergoes a change of state, which absorbs heat from the mine air, next the air expands, absorbing more heat, through a turbine to generate electricity. In a 1 MWe generator the chilling is variable depending on the temperatures and configuration, but a continuous supply of approximately 1.5 MWr would be typical. The use of cryogenic chilling is complimentary to the increasing aspiration of the industry to replace diesel powered vehicles with electric vehicles. The use of electric vehicles introduces a potential for a substantial reduction in ventilation airflow, which increases the susceptibility of the airflow to injected heat during charging and operation of electric vehicles. The ability of large scale chilling systems to respond to variations in heat load on a given level is limited or non-existent unless the entire mine is affected. The cryogenic systems are capable of chilling on demand because a liquid flow can be delivered to individual levels and temperatures on a given level can be adjusted by changing the liquid flow rate. The thermodynamics of the electrical/chilling co-generation system will be discussed and the implications of standalone systems for remote off grid applications will be outlined.

M3-5 Magnetism (DCMMP) | Magnétisme (DPMCM) / 2246

Frustrated magnetic pyrochlore thin films (I)

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Motivated by the recent experimental realizations of pyrochlore thin films, I will explore in this talk some of the promising facets offered by the slab geometry. Thin films are a natural platform to study the confinement of spin-liquid gauge fields and the evolution from three to two dimensional spin textures. In spin ice films for example, monopole excitations may crystallize on the surfaces, thanks to the long-range Coulomb potential between them. Depending on the type of substrate, interactions on the surfaces can be varied away from their bulk values. This offers a tuning parameter allowing for a new degree of frustration when spatial invariance is lost. More generally, I will discuss a sample of models and materials to illustrate how the mechanism ordering changes from the surfaces to the bulk and over what length scale this happens. Beyond the physics of films, the results of this research may apply to surface effects in single crystals.

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2247

POS-60 Polymer dynamics in a gel network: the effect of confinement (SMC Poster)

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The dynamics of polymer chains in confined environment are relevant in understanding diffusion of macro-molecules in real systems such as biological cells. Macromolecular diffusion in cytoplasm exhibits a sharp reduction in diffusivity with increasing molecular weight; a sieving mechanism has been suggested for the same. We present pulsed field gradient NMR experimental studies of the diffusion of Polyethyleneglycol (PEG) in network-forming Agarose gels. The agarose gels are prepared by microfluidic methods that are thought to enhance the homogeneity of the network structure.The volume fraction of Agarose gel is used to control the network pore size, Rp, and the PEG molecular weight is used to vary the PEG radius of gyration Rg. Both are used to systematically vary the ratio Rg/Rp, and examine the polymer diffusivity as a function of this ratio.

M1-6 Biophysics, microscopy and diseases (DPMB) / Biophysique, microscopie et maladies (DPMB) / 2248

Bayesian Estimation of Photobleaching Steps with Physical Priors

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Counting photobleach steps lets us infer the number of oligomeric subunits of fluorescently-labelled protein complexes. While ad hoc step-counting algorithms are adequate for low noise imaging with small numbers of steps, noise increases with the number of fluorophores and introduces bias when the intensity trace is filtered to reduce noise. We present a principled Bayesian approach with a prior distribution that incorporates the statistics of photobleaching and that does not require filtering. Our physics-based prior leads to a simple and efficient numerical scheme for maximum a posteriori probability (MAP) estimates of the initial fluorophore number n0. We illustrate how experimental data can be used to calibrate the photophysics. Using simulated data where n0 is known, we show that the bias of our MAP estimate remains minimal as the number of fluorophores increase. We investigate how our errors scale with n0, with the signal-to-noise ratio (SNR), and with the camera exposure time t or, equivalently, the illumination intensity. We find that the dimensionless ratio of camera exposure time to the average time to the first bleach step controls the imprecision of the MAP estimation. Many short exposures are recommended with our approach.

M3-5 Magnetism (DCMMP) | Magnétisme (DPMCM) / 2249

Confinement of magnetic monopole quasiparticles in a quantum spin ice (I)

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We report direct spectroscopic evidence of correlations between monopoles in a quantum spin ice. A hierarchy of unequally spaced magnetic excitations has been observed via low energy inelastic neutron spectroscopy in Pr2Sn2O7, resembling the confinement of spin defects in low-dimensional quantum magnets.1,2 Using a simple linear potential model to fit the excitations, we have estimated the monopole pair creation energy, and calculated a lower bound for the tension between monopole-like quasiparticles. The linear potential model provides a natural explanation as to why detection

of these correlations have been so elusive in the canonical dipolar spin ices. This is the first spectroscopic measurement of an effective "Dirac string"between magnetic monopoles.

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DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2250

POS-58 Study of a field-tunable colloid-polymer solution (SMC Poster)

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In a colloid-polymer mixture, non-adsorbing polymer controls the magnitude as well as the range of the interaction between the colloidal particles. In such a system, a network forming gel phase can be observed due to the adsorption of polymer on micrometer-sized colloidal particles. With tunable interactions, such systems could also be used for qualitative studies of phase transition kinetics.An easy and externally controllable tuning can be achieved by the application of AC external electric field to the colloid-polymer system. The external AC electric field induces dipolar interaction in a colloidal suspension which is an important driving force for nanoparticle self-organization. We will report the effect of an AC external field on the Brownian colloidal particles suspended in a polymer solution. Study of such tunable system can lead to the development of switchable and responsive materials.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2251

Collagen fibril's plastic damage: the rope and tube duality (I)

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Collagen is the protein building block of most mammalian tissues such as tendon, arteries, skin and bone. In its triple helical form, collagen assembles into fibrils with tensile properties comparable to the strongest man-made polymer materials. Structural characterization of collagen fibrils using X-ray scattering and electron microscopy led to a picture where long triple helices form a paracrystalline array with a distorted hexagonal radial packing, a slightly lower density of molecules in the fibril centre, and some moderate molecular tilt at the fibril surface. Here I will present some recent single collagen fibril mechanical testing experiments that highlight both their rope-like and tube-like nature. I will also discuss how this rope-tube duality may be modulated by intermolecular crosslinks.

M1-6 Biophysics, microscopy and diseases (DPMB) / Biophysique, microscopie et maladies (DPMB) / 2252

Biophysics approaches to study molecular mechanism of Alzheimer's disease.

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Alzheimer's disease (AD) is a neurodegenerative disease characterized by dementia and memory loss for which no cure or prevention is available. Amyloid toxicity is a result of the non-specific interaction of toxic amyloid oligomers with the plasma membrane.
We studied amyloid aggregation and interaction of amyloid beta (1-42) peptide with lipid membrane using atomic force microscopy (AFM), Kelvin probe force microscopy and surface Plasmon resonance (SPR). Using AFM-based atomic force spectroscopy (AFS) we measured the binging forces between two single amyloid peptide molecules. Using AFM imaging we showed that oligomer and fibril formation is affected by surfaces, presence of metals and inhibitors. We demonstrated that lipid membrane plays an active role in amyloid binding and toxicity: changes in membrane composition and properties increase amyloid binding and toxicity. Effect of lipid composition, the presence of cholesterol and melatonin are discussed. We discovered that membrane cholesterol creates nanoscale electrostatic domains which induce preferential binding of amyloid peptide, while membrane melatonin reduces amyloid-membrane interactions, protecting the membrane from amyloid attack. Using AFS we that novel pseudo-peptide inhibitors effectively prevent amyloid-amyloid binding on a single molecule level, to prevent amyloid toxicity. These findings contribute to better understanding of the molecular mechanisms of Alzheimer's disease and aid to the developments of novel strategies for cure and prevention of AD.

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R3-5 Multimodal and Nonlinear Imaging in Biological Systems (DPMB) | Imagerie multimodale et non-linéaire dans les systèmes biologiques (DPMB) / 2253

Interferometric Second Harmonic Generation Microscopy and applications. (I)

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Over the years, Second Harmonic Generation (SHG) microscopy has emerged as an effective tool in biology. Like in two-photon excited fluorescence (2P), this type of laser scanning microscopy is characterized by an intrinsic 3D sub-micron resolution that is robust upon light scattering and which allows for higher image depth when compared to confocal microscopy. SHG is a nonlinear optical process in which highly polarizable and non-centrosymmetric structures emit photons at exactly half the excitation wavelength. The emitted light results from the coherent sum of the electromagnetic field generated by every single SHG emitter and thus scales quadratically with the number of aligned molecules sharing the same polarity. Indeed, adjacent molecules of the same polarity will emit strong SHG signals due to constructive interference while the SHG signal will almost vanish in the case of adjacent molecules of opposite polarity. Furthermore, by measuring the square of the SHG amplitude, structures of opposite polarity cannot be distinguish using this imaging technique.

Originally developed to characterize non-centrosymmetric crystals, interferometric SHG (I-SHG) microscopy is based on the measurement of the phase of the SHG signal. In the past years, its potential for tissue imaging has been demonstrated with different proteins, such as myosin from skeletal muscle 1 and collagen from tendon and cartilage [2,3]. Having recently solved one of the main drawbacks of I-SHG, namely the long imaging time, we have recently demonstrated the possibility to use I-SHG to record the dynamical evolution of microtubule polarity in mitotic spindles from live zebrafish embryos 4.

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Soft Matter Canada 2018 | Matière molle Canada 2018 / 2254

Probing the structure of electrochemically aggregated collagen

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The internal structure of porous materials and membranes plays a critical role in their mechanical and biochemical properties, especially if they are targeted for cell growth in tissue healing and regeneration applications. Collagenous membranes are a class of proteinaceous materials that has been targeted for cell scaffolding studies because collagen is a structural protein found in many tissues. Collagen's aggregation in a hierarchical fibrillar structure can be stimulated and controlled in vitro to create products that function similarly to those produced in vivo. This can be accomplished merely by changing pH and temperature, even in the absence of growth factors and enzymes that

are present during in vivo growth.
Scaffolds can interact with cells by serving as a structure for their attachment, or as a matrix for introducing nutrients, antibiotics, and other molecules to the cells. In this way, the 3D structure and mechanical properties of a scaffold can influence how cells move within and interact with it. In earlier work, we showed that electrochemically produced type I collagenous membranes can control cell proliferation to mimic their behaviour in vivo, unlike collagen fibrilized by standard thermal methods.[1,2] Furthermore, the electrochemically assembled collagen has proven to be a better matrix for osteoblast differentiation relative to other types of common scaffold materials. Since these findings show that matrix composition alone does not explain cell response, we continue to study the 3D structure of the electrochemically produced collagen scaffold prepared under different conditions.
It is challenging to assess the internal structure of a membrane, such as the sizes and connectivity of its pores, since traditional optical or scanning probe imaging methods do not allow access to internal voids within the material. SPT is a passive microrheological technique 3 that we used to follow the diffusion of individual fluorescent particles that were suspended in the collagen membrane during its electrochemical formation. Each sphere samples its local rheological environment, which makes SPT well-suited for assessing the degree of heterogeneity in a system. While there have been bulk rheological studies of collagen-based matrices and at least one diffusion study within individual collagen fibrils, there is a surprising absence of microrheological studies of collagen-based scaffolds.
Earlier work from our group showed that preparing these membranes in the presence of different cations led to different degrees of collagen fibrillation and aggregation as well as differences in membrane stiffness.4 Our preliminary SPT results show that all of these electrochemically produced collagen membranes have a very compartmentalized structure, regardless of their stiffness. Our findings suggest that electrochemically induced aggregation can independently affect the structure, stiffness, and fluid viscosity of collagen membranes, which offers interesting future opportunities in cell scaffold design.
1 Gendron, R.; Kumar, M. R.; Paradis, H.; Martin, D.; Ho, N.; Gardiner, D.; Merschrod S., E. F.; Poduska, K. M. Controlled cell proliferation on an electrochemically engineered collagen scaffold. Macromol. Biosci. 2012, 12, 360–366.
2 Nino-Fong, R.; McDuffee, L. A.; Esparza Gonzalez, B. P.; Kumar, M. R.; Merschrod S., E. F.; Poduska, K. M. Scaffold Effects on Osteogenic Differentiation of Equine Mesenchymal Stem Cells: An In Vitro Comparative Study. Macromol. Biosci. 2013, 13, 348–355.
3 Oppong, F. K.; Rubatat, L.; Frisken, B. J.; Bailey, A. E.; de Bruyn, J. R. Microrheology and structure of a yield-stress polymer gel. Phys. Rev. E 2006, 73, 041405.
4 Kumar, M. R.; Merschrod S., E. F.; Poduska, K. M. Correlating Mechanical Properties with Aggregation Processes in Electrochemically Fabricated Collagen Membranes. Biomacromol. 2009, 10, 1970–1975.

M3-1 Stochastic Biology (DPMB) I Biologie stochastique (DPMB) / 2256

Stochastic models in quantitative biology: how they fail and why we need them (I)

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Many biological processes in cells are complex yet sparsely characterized. Constructing physical models of such systems then often requires making many assumptions based on guesswork. Instead of ignoring or guessing unknown details in complex processes we have derived universal balance relations to rigorously characterize stochastic fluctuations in incompletely specified systems. Specifying some features of a system while leaving everything else unspecified then allows us to establish physical performance bounds for classes of intracellular processes. Additionally, we can turn general network invariants into experimental data analysis tools. For example, exploiting naturally occurring cell-to-cell variability allowed us to test specific hypotheses about gene expression, showing

that observed fluctuations in *E. coli* contradict the majority of published models of stochastic gene expression.

T1-3 Ground-based and In Situ Observations I (DASP) l Observations terrestres et In situ I (DPAE) / 2257

Unique local results from a polar cap event with an extremely strong electric field of long duration.

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On 12 September 2014 the IMF turned very strongly northward for a prolonged period of time, reaching up to 28 nT at some point. Clauer et al (JGR, Space Physics, 121, 5422, 2016) showed from RISR-N Incoherent Scatter Radar (ISR) data at Resolute Bay that the convection on the sunward side of the polar cap was very strong and sunward during this exceptional event, with a convection electric field exceeding 150 mV/m at the peak of the event. The very strong electric fields were sustained for so long that we could determine from the ISR observations the anisotropy of the ion temperature in the F region. In particular, the perpendicular to parallel (to the geomagnetic field) temperature ratio for O+ ions undergoing resonant charge exchange with atomic oxygen could be derived. Preliminary results at the time of abstract submission indicate that this ratio was actually larger than expected from theoretical calculations involving published cross sections, with important implications for transport calculations involving collisions between ions and neutrals. The unique data set from the event also produced several large E region electron temperature (Te) measurements reaching up to almost 4000K through plasma wave heating. This temperature is one order of magnitude greater than found for electric fields weaker than 40 mV/m. Foster and Erikson (GRL, 27, 3177, 2000) have suggested that Te could be used to infer the electric field strength, based on rare electric field observations going up to 125 mV/m. The Sept 2014 data set allowed us to (1) make an alternate determination of the electric field from simultaneous E and F region ion drift measurements on nearby magnetic field lines to confirm the validity of other electric field determinations and (2) to make a substantial addition to the number of observations of Te as a function of electric field strength under very strongly disturbed conditions. We have found no evidence for a limit in the wave-induced electron heating, with an electron temperature that increased basically linearly with electric field strength all the way to 150 mV/m.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2258

MacSANS: a new Small Angle Neutron Scattering facility at McMaster University

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MacSANS is a new small angle neutron scattering (SANS) beamline currently under construction at the McMaster Nuclear Reactor, a 5 MW research reactor based at McMaster University in Hamilton, Ontario. This beamline is designed to study a broad range of nanostructured materials, including biological membranes, polymers, superconductors, and novel magnets. In particular, MacSANS will

allow users to probe the structure and magnetism of materials on length scales ranging from ˜0.5 to 125 nm. MacSANS will be the only instrument of its kind in Canada, and is scheduled to begin commissioning experiments in the spring of 2019. In this presentation we will provide an overview of the instrument design and technical specifications, and discuss several potential applications in the field of soft matter physics.

W1-4 Translational Research in Medical Physics Symposium (DPMB/DAPI) | Symposium de recherche translationnelle en physique médicale (DPMB/DPAI) / 2259

Binary Collimation for Multiple Brain Metastases Radiosurgery (G, I)

Authors: R Lee MacDonald[1]; Christopher Thomas[2]; Lucy Ward[2]; Alasdair Syme[2]

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Purpose: A novel system of algorithms has been developed that allows for automated planning of conformally collimated radiotherapy plans for the treatment of multiple brain metastases with various prescription doses. This study uses simulated annealing to optimize the collimation to subsets of targets at specified incident radiation angles, along with modulation of dose, to achieve prescription target dose coverage and healthy tissue sparing.
Methods: At each discretized location in the treatment (control point), the system aims to optimize the number of targets treated, the rotation angle of the collimator, the collimator leaf positions, and the number of monitor units (MU) delivered. A novel optimization cost function (OF) was designed for this study using a linear-quadratic metric penalty function, with a generic form applied to healthy organ maximum doses and clinical target metrics. This OF is used as a minimization metric in a simulated annealing procedure to define the intra-arc binary collimation (iABC) pattern. In iABC, each target can either be conformally treated or entirely shielded by the MLC at each control point. Seven multiple metastases cases previously treated at the Nova Scotia Health Authority were anonymized and re-planned with iABC using consistent planning methods, and compared to the clinical standard.
Results: Treatment plans generated with iABC used an average of 3044 (37%) fewer MU in the total plan than VMAT ($p = 0.026$). All healthy tissue metrics for all plans and all patients were within clinical acceptability. No statistically significant difference was observed for any normal tissue metrics. Normalized prescription target coverage accuracy for all targets was 4.0% better on average for VMAT plans when compared to iABC ($p = 0.016$), and 14.8% better on average for iABC when compared to DCA ($p = 0.041$).
Conclusion: Intra-arc binary collimation has the potential to improve treatment delivery to multiple metastases treatment plans with multiple unique prescriptions with a statistically significant improvement to target coverage accuracy when compared to conventional DCA. Additionally, this method retains the majority of MU sparing inherent in DCA (37% when compared to VMAT) without a statistical significant difference in normal tissue dose when compared to VMAT.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2260

A dispersion relation for conformal theories (I)

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Dispersion relations, often called Kramers-Kronig relations, exploit analyticity to reconstruct the real part of a scattering amplitude from its imaginary (or absorptive part), which is often easier to measure and or to compute. I will present a generalization which reconstructs complete four-point correlators in any conformal field theory, starting with only very limited information about their "absorptive" part. Interesting applications range from three-dimensional critical phenomena to the gauge-gravity (AdS/CFT) correspondence.

W2-5 COMP Special Session (DPMB) | Session spéciale de l'OCPM (DPMB) / 2261

Monte Carlo simulations for magnetic resonance guided radiation therapy dosimetry (I)

Authors: Victor N. Malkov[1]; David W. O. Rogers[1]

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Image Guided Radiation Therapy (IGRT) technologies aim to improve the accuracy of the delivery of radiation with the hopes of decreasing damage to healthy tissues and sensitive organs. Synergetic MRI-Radiation therapy machines are a developing technology that can provide improved tumour tracking during treatment to help accommodate for patient motion or unaccounted for bodily changes over the full course of treatment. Porting the advantages of MRI technology into IGRT comes with the cost of introducing a magnetic field around the patient while a radiation beam is present. This magnetic field (MF) causes curvature in the charged particle trajectory, and can lead to significant variations in dose distributions, particularly at tissue-air interfaces, and lead to changes in the dose response of detectors. Here the influence of the MF on dosimetry systems and dose distribution is explored using the EGSnrc Monte Carlo code system.

W3-5 Quantum Sensors and Quantum Technology (DAMOPC) | Détecteurs quantiques et technologie quantique (DPAMPC) / 2262

Towards Microwave to Telecom Wavelength Quantum Information Transfer using Cavity Optomechanics (I)

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The past few years have seen the rapid maturation of quantum information processors, particularly in the category of superconducting microwave circuits. With claims from leading companies that they will commercialize quantum processors in the next five years, we must wonder what quantum technologies should be developed in tandem to fully utilize these processors. For example, we are all acutely aware that while our personal computers are powerful, they are considerably more useful and interesting when networked together. So how can we likewise network quantum processors? Especially since the microwave signals of superconducting processors cannot be transmitted at room temperature without thermal decoherence. What if instead, one could link superconducting processors together through existing fiber-optic networks, which are already capable of long distance quantum information transfer? Hence the development of a transducer of quantum information from the microwave to telecom domain has become highly desirable. I will describe the current state of microwave to optical transducers, and how our lab is working towards this goal. Specifically, I will discuss the progress and challenges associated with the development of fiber-coupled telecom-wavelength cavity optomechanical resonators, and 3D superconducting microwave cavities, operating at millikelvin temperatures. I will also discuss ongoing collaborations

that could enable implementation of quantum information transducers in a large-scale fiber network in Alberta.

R2-3 Laser Physics and Spectroscopy (DAMOPC) | Physique des lasers et spectroscopie (DPAMPC) / 2263**

Applications of Auto-locked Laser Systems for Precision Metrology (I)

Authors: H.C. Beica[None]; A. Pouliot[None]; A Carew[None]; A Vorozcovs[None]; P Dowling[None]; G Carlse[None]; B Barron[None]; A Kumarakrishnan[1]

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We discuss applications of a versatile, auto-locking laser system consisting of an external cavity diode laser and waveguide amplifier. The diode laser, which is capable of being vacuum-sealed, can be frequency stabilized with reference to atomic, molecular, and solid state spectra using a digital controller that relies either on a pattern-matching algorithm or on first or third derivative feedback. We review the performance characteristics of this continuous wave laser system and describe its suitability for accurate measurements of gravitational acceleration that are relevant for the exploration of natural resources. We show that a pulsed laser system based on this design can be used for industrial magnetometry and for realizing a new class of lidar transmitters. We also discuss the possibility of using this laser system for realizing a precise measurement of atomic lifetimes using coherent transient effects.

- Work supported by CFI, OIT, NSERC, OCE, and York University

M3-1 Stochastic Biology (DPMB) I Biologie stochastique (DPMB) / 2264

*** Withdrawn *** Soma-dendrite interaction enhances noisy signal encoding

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Dendrites are often excitable structures involved in the signal processing of almost all neurons. We find that when an active dendrite has a greater intrinsic variability and a longer refractory period than the soma, it will determine spike times for weak inputs but be entrained by somatic spikes for strong inputs. This produces an input-dependent gating of dendritic noise. As a result, populations of dendrite-soma systems improve transmission of sub- and suprathreshold signals for a large range of intrinsic dendritic noise. This novel mechanism suggests a functional role for active dendrites.

link.aps.org/pdf/10.1103/PhysRevX.7.031045

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2265

Electrochemical gelation of telechelic protein polymers (I)

Authors: Yinan Lin[1]; Bo An[1]; Mehran Bagheri[2]; David L. Kaplan[1]; James L. Harden[2]

[1] *Tufts University*

[2] *University of Ottawa*

Amphiphilic secondary structures are ubiquitous in native proteins, where they serve a wide variety of functions from specific binding ligands to structural elements in supramolecular assemblies. This talk describes the use of amphiphilic coiled-coil motifs in modular protein polymers as a strategy to achieve electrochemical gelation capabilities. Our de novo electrogelation protein is a telechelic, triblock design comprised of a central spider silk glue motif flanked by terminal pH-triggered coiled-coil domains. The coiled-coiled domains were designed to form intramolecular helix bundles below a sharply-defined pH-trigger point, while the pH-responsive spider silk glue sequence serves both as an anionic electrophoretic transport element at neutral and elevated pH and as a disordered linker chain between the associated helix bundles at reduced pH. In an electrochemical cell, a solution of these telechelic proteins migrates toward the anode where the terminal coiled-coil domains are triggered to form coiled-coil assemblies that act as transient crosslinks for the e-gel state. Upon cessation of the current, the coiled-coil domains denature gradually and the e-gel transforms back into a fluid solution of polypeptides in a fully reversible manner. This simplified triblock protein design mimics many of the characteristics of more complex electrogelation proteins, such as silk fibroin. We discuss experimental and computational studies the physical properties of this protein and the potential for biomedical applications of electrochemically triggered gelation.

DAPI Poster Session & Finals: Poster Competition and Mingle Session with Industrial Partners/Employees (3)| Session d'affiches DPIA et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (3) / **2266**

POS-43 Experimental Classification of Unknown Tripartite Entanglement on Spin Ensemble using NMR

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Experimental generation and detection of the entanglement is at the heart of, most if not all, the quantum computational tasks. In general, to determine whether a given state is entangled or not is an open and exigent problem in quantum mechanics. Here we give an experimental implementation of the scheme for tripartite entanglement detection on spin ensemble using NMR. This protocol not only detects the entanglement but also classify it into six in-equivalent classes of three qubit entangled states. Only four observables suffice to experimentally differentiate the six classes. Experimental realization is achieved in an NMR scenario by mapping the desired observables, to Pauli's z-operators of the third qubit, followed by measuring the ensemble average in the state under investigation. Results have been substantiated with direct full quantum state tomography as well as negativity calculations and the comparison suggests that indeed the demonstration is a success.

R3-5 Multimodal and Nonlinear Imaging in Biological Systems (DPMB) | Imagerie multimodale et non-linéaire dans les systèmes biologiques (DPMB) / **2267**

Surface Enhanced Stimulated Raman Spectroscopy using CW sources (I)

Author: Kevin Hewitt[1]

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We successfully demonstrate Surface Enhanced-Stimulated Raman Scattering (SE-SRS) using Oxonica (now Cabot securities) nanoparticles for particle concentrations as low as 10 picomolar using peak power densities that are three-to-four orders of magnitude smaller than that required for conventional SRS. These reduced incident powers are possible because the laser field is significantly enhanced within the gold nanoparticle dimer crevices, where the molecular species of interest is attached. Diminishing the incident laser power requirements meant that CW lasers of low power focused to tens of microns in diameter can be used to generate SE-SRS; enabling the detection of nanoparticles at picomolar concentrations. Because of the concentration dependence of SRS, the technique should be applicable to molecular tracking of species of higher concentrations (e.g. the nanomolar or micromolar concentrations of signaling proteins in cells).
In particular, SE-SRS is demonstrated for two different nanoparticle types, using two Ti:sapphire lasers producing a pump (785 nm, 100 mW) and appropriately varying probe/Stokes beams (860 – 870 nm, 120 mW). The Ti-Sapphire lasers are co-pumped by a 10 W low noise 532 nm Millenia laser. Pulsed SE-SRS is also demonstrated using a Coherent Chameleon Ultra laser for the Stokes/probe (863-871 nm) beam and a Coherent Ultra II as the pump laser (785 nm). In both cases lock-in techniques are used to extract the small signal (1 in 10^8) successfully.

W3-2 Energy Storage 3 (DCMMP) | Accumulation d'énergie 3 (DPMCM) / 2268

Interface Controlled Anode-Free Sodium Batteries (I)

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The traditional battery configuration incorporates a negative electrode, or anode, which acts as a host insertion material for alkali metal ions. This host anode is necessary due to the unstable metal plating chemistry, especially for lithium, in known electrolyte media. In this talk, I will discuss our recent efforts to develop the anode-free battery, or a full-cell battery configuration that relies on metal plating directly on the negative electrode current collector. However, since the reduction potential for Na/Na+ is less negative than that for Li/Li+, this provides a unique opportunity for an anode-free sodium battery that cannot be realized with a lithium battery since sodium metal plating can be stable in a glyme-based electrolyte. Our observations have demonstrated a correlation between the Coulombic efficiency of a sodium plating/stripping process and the characteristics of the material onto which plating is achieved. In turn, we show that rethinking common host anode materials to instead act as ultrathin nucleation layers bridging the interface between the electrolyte and current collector can lead to Coulombic efficiency exceeding 99.9%. Further, we demonstrate coupling of this anode free approach with two host insertion cathodes including (1) sodiated iron disulphide, which is a low-cost and earth abundant material, and (2) and sodium vanadium phosphate (Na3V2(PO4)3), which is a cathode material with nearly ideal flat voltage profiles. Our results demonstrate the capability to reach high cell-level energy density (400 Wh/kg based on active materials) and/or high round-trip energy efficiency exceeding 98%, which in the latter case will be an important criteria for future large-scale consumer energy storage installations. Finally, I will close with some highlights of our recent research efforts noting that the intersection of (1) understanding the physics of nucleation at heterogeneous interfaces and how this mechanistically controls chemical processes in this system, and (2) engineering approaches in the host cathode assembly to compensate for losses during the cycling lifetime of the battery, can provide an exciting route to low-cost, highly durable, and high energy density batteries specifically tailored for grid-level storage applications.

W3-5 Quantum Sensors and Quantum Technology (DAMOPC) | Détecteurs quantiques et technologie quantique (DPAMPC) / 2269

Graphene Lubrication and Wetting Transparency Evaluated through Nanoscale Friction (I)

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Friction reducing, two-dimensional dry lubricants, such as graphene, boron nitride, and molybdenum disulphide, have been shown to have a number of interesting frictional characteristics, such as a dependence on the number of layers, an exceptional dependence on the surface adhesion properties of the underlying substrate, and environmental stability. We explored the frictional properties of these two-dimensional films under varied relative humidities and enviromental exposure times in an atomic force microscope and through molecular dynamics simulations A hysteresis in friction was observed in load-dependent friction measurements, whereby friction was observed to increase upon unloading versus loading. The friction hysteresis increased with relative humities but decreased with exposure time. This effect was linked to the wetting transparent property of two-dimensional materials, where the strength of this effect evolves with exposure to the ambient environment. Furthermore, our results suggest that the layer dependent reduction in friction observed for two dimensional films is, at least in part, a result of wetting transparency and an evolution of surface energy with time. Atomistic modeling of comparable surfaces, matched in terms of materials, surface energy, and structure, is used to explain the experimental observations of the influence of surface energy on friction and adhesion.

W4-5 Education Research-informed Physics Teaching (DPE) | L'enseignement de la physique enrichi par la recherche en éducation (DEP) / 2270

Bringing sound pedagogy beyond the first and second year

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A substantial amount of the evidence-based pedagogies developed for lower level physics classrooms can be adapted to senior undergraduate and even graduate level classes. In this talk I will describe the use of in-class worksheets to foster deeper understanding and content proficiency in senior level electromagnetism, senior level special relativity, and graduate level classical mechanics courses. Preliminary evidence shows considerable improvement in student engagement in these higher-level courses. This presentation will focus on how these worksheets are constructed, and discuss how their efficacy could be explored beyond the anecdotal level.

W3-3 Fields and Strings II (DTP) | Champs et cordes II (DPT) / 2271

From the Chiral Lagrangian to the EFT on a Single M5-Brane (I)

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The CHY technique for computing scattering amplitudes has been used in a large variety of theories ranging from Einstein gravity to the Chiral Lagrangian. Many of these theories have in common that they are effective field theories (EFTs) of spontaneously broken symmetries. In this talk I will review recent results relating these effective field theories including the recent formula for the tree level S-matrix of the ETF on a single M5-brane obtained by Heydeman, Schwarz and Wen.

R1-6 Quantum Computing and Communication (DAMOPC/DTP/DCMMP) | Calcul et communication quantiques (DPAMPC/DPT/DPMCM) / 2272

Building synthetic quantum systems with atoms and photons — from waveguide QED with neutral atoms to "gauged" quantum materials with cavity-dressed Rydberg polaritons. (I)

Author: Kyung Soo Choi[1]

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An exciting frontier in quantum information science is the creation and manipulation of quantum systems that are built and controlled quanta-by-quanta. In this context, there is active research worldwide to achieve lithographic quantum optical circuits, for which atoms are trapped in nanoscopic dielectric structures and wired by photons propagating through complex circuit elements. I will discuss a designer's method to create synthetic quantum matter utilizing neutral atoms embedded in photonic crystal waveguides. The strong interplays between quantum excitations of spins, light, and sound are all utilized to create the effective "gauge" bosons that mediate arbitrary Hamiltonians in the spin matter. I will also discuss a new regime of analog quantum spin-ice models and more generally string-net models that are accessible by strongly-coupled cavity Rydberg polaritons. In the pursuits of both research directions, I will complement the theoretical descriptions with the experimental progresses in the Laboratory of Ultracold Quantum Matter & Light (UQML) at the University of Waterloo.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2273

Water Models: adventures in parametrization (G)

Author: Yuriy Khalak[1]

Co-authors: Tonalli Rodríguez-López [2]; Björn Baumeier [3]; Mikko Karttunen [4]

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Water is the most important solvent in biological systems. Yet majority of its properties are poorly reproduced by the most commonly used models. An ideal water model needs to accurately capture

both structure and dynamics over a wide range of thermodynamic conditions.
To create such a model we attempted both coarse grained¹ and atomistic parametrizations. Our experience shows the need for fitting to multiple target properities at different state points for the model to be both accurate and transferable.

1. Rodríguez-López, T., Khalak, Y., & Karttunen, M. (2017). Non-conformal coarse-grained potentials for water. *The Journal of chemical physics*, 147(13), 134108.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2274

POS-15 Digital photocorrosion of GaAs/AlGaAs: a quest for fabrication of defect-free III-V nanostructures

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Instability of GaAs and AlGaAs in an aqueous environment increases drastically following illumination with photons of energy exceeding bandgap of these materials. We have investigated the dynamics of photon-induced dissolution of GaAs/AlGaAs nano-heterostructures in deionized water (DI H2O) and ammonium hydroxide (NH4OH) environments by employing inductively coupled plasma mass spectrometry (ICP-MS). The samples were irradiated with a 660 nm light-emitting diode delivering 16 or 20 mW/cm2 of a uniform radiation and their photocorrosion was monitored in situ with the photoluminescence effect. Consistent with the calculated concentrations of ions released by dissolving GaAs/Al0.35Ga0.65As nano-heterostructures up to approximately 60 nm thick, the ICP-MS results confirmed the expected presence of As3+ ions in the photocorrosion products. Some accretion of Ga2O3, Al2O3 and Al(OH)3 has been observed on the surface of thicker samples, as evidenced by the Fourier transform infrared absorption spectroscopy, X-ray photoelectron spectroscopy and atomic force microscopy data. These results have been corroborated by the ICP-MS analysis that revealed reduced concentrations of As3+ and Ga3+ ions released to the photocorrosion product by nano-heterostructures thicker than ˜ 60 nm. The photocorrosion in NH4OH environment allowed to alleviate, partially at least, the problem of an excessive accumulation of oxides. We discuss the conditions that needs to be met to allow digital photocorrosion of GaAs/Al0.35Ga0.65As nano-heterostructures thicker than 100 nm.

T2-7 Testing Fundamental Symmetries II (DTP/PPD/DNP) I Tests de symétries fondamentales II (DPT/PPD/DPN) / 2275

Particle Physics at the Precision Frontier (I)

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We know that the Standard Model of Particle Physics is incomplete - for example, we still do not understand the nature of dark matter, matter- antimatter asymmetry or hierarchy of the three generations of elementary particles. There is a wide spectrum of experiments searching for new particles beyond the Standard Model (BSM), broadly defined by three domains - Energy, Cosmic and Precision

frontiers. The Energy frontier concentrates on the high-energy production of BSM particles, the experiments at the Cosmic frontier are dedicated to astrophysical searches of the products of the decays of BSM particles, and the Precision frontier is focused on low-energy but high-precision searches mostly in parity-violating high-intensity scattering. At the Precision frontier, we look for the BSM particles acting as the interaction carriers, having a small, but potentially detectable impact on the scattering observables. The talk will outline the latest advances in the precision parity-violating BSM physics searches in both theory and experiment.

T2-1 Ultrafast EM waves III: Quantum Control (DAMOPC/DCMMP) | | Ondes EM ultrarapides III: Contrôle quantique (DPAMPC/DPMCM) / 2276

Room-temperature quantum fluids of light (I)

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In the strong light-matter coupling regime, energy is reversibly exchanged between the electromagnetic field and the polarization field. A microscopic description of this regime is usually presented in terms of hybrid light-matter quasiparticles called polaritons. These quasiparticles have a number of fascinating properties such as an ability to undergo Bose-Einstein condensation at high densities and possess very strong optical nonlinearities due to their matter component. For nearly two decades, the platform of choice for studying polaritons has been planar semiconductor microcavities composed of group III-V quantum wells. Unfortunately in these materials, exciton binding energies are well below kT and most polaritonic phenomena can only survive at low-temperatures.

We will describe semiconductor microcavities composed of organic semiconductors and two-dimensional (2D) materials where polaritonic phenomena can survive at room-temperature. Using these, we have recently demonstrated a broad range of nonlinear phenomena such as Bose-Einstein condensation of polaritons, room-temperature superfluidity, tunable third harmonic generation and polariton diodes. We will showcase some of the recent demonstrations and outline future steps for realizing polariton devices based on a room-temperature semiconductor platform.

W3-1 Creating Authentic Physics Learning Experiences (DPE) | Créer d'authentiques expériences d'apprentissage en physique (DEP) / 2277

This machine has no brain, use your own. Canada's synchrotron as a classroom resource (I)

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The Canadian Light Source is the country's national synchrotron research facility. At its core is the largest particle accelerator in Canada –a 174m circumference storage ring, housed in a building the size of a football stadium. As is usual for facilities of this type, we have hosted thousands of researchers from all over the country and around the world. What is somewhat less usual is that these numbers include more than 1200 high-school students, each one having taken part in an actual hands-on experiment using our facilities. The experiments are student-driven –within the limits of safety and possibility the students make all the decisions No demonstration experiments allowed – and no try-outs for the teachers in advance. Right from the outset our programs were inclusive –we don't target the high-flyers, but instead challenge teachers to choose the students who would most benefit. We use our facilities –our big machine –to attract students into our programs, but ultimately it is they who perform the science. They must use their brains because, of course, our machine has none.

W3-1 Creating Authentic Physics Learning Experiences (DPE) | Créer d'authentiques expériences d'apprentissage en physique (DEP) / 2278

Stars for Everyone –Astronomy Outreach Doubling Physics Enrollments (I)

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The sky on a clear night is one of the most fascinating natural sights, providing multiple (and free!) promotion opportunities for physics. The talk will describe the recent astronomy-related outreach activities at the Grenfell Campus if the Memorial University of Newfoundland, leading to more than doubling enrollments in our physics courses, as well as several methods ensuring that the students will stay fascinated with physics.

W2-6 Inclusive Science Education (Part 1) (DPE/CEWIP) I Éducation scientifique inclusive (1ère partie) (DEP/CEFEP) / 2279

Fostering Physics Identity to Support Young Women in Physics Education (I)

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This talk presents a study that qualitatively investigated how young women in Ontario experience barriers in their high school physics education. The basis of the research is the long-standing issue of underrepresentation of women in physics in Canada and around the world. The study asked questions aimed at better understanding this issue: What barriers do young women in high school physics experience? What meanings do these students attribute to the barriers encountered in their physics education? The concept of physics identity was used as a lens through which students' experiences of barriers could be understood. Findings from focus group and interview data include themes concerning students'perceptions, experiences, and their identity and gender throughout the high school physics experience. The study yielded (a) a research-based understanding of young women's experiences of barriers in high school physics, and (b) practice-oriented recommendations for physics educators to support young women's success and continuation in physics education and the field. Along with thematic findings and recommendations for physics educators presented in this talk, a moving narrative–curated from participant voices–is also shared, which explores young women's journey with physics identity in high school physics.

T1-6 Topics in medical physics and biophysics (DPMB) / Sujets en physique médicale et biophysique (DPMB) / 2280

*** Not in competition ***Competition During Reprogramming Gives Rise to Deterministically Elite Clones. (G)

Authors: Sophie McGibbon-Gardner[1]; Nika Shakiba[2]; Peter Zandstra[3]; Sidhartha Goyal[4]

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Cellular reprogramming is a source of induced pluripotent stem cells, but this process remains incompletely understood. The current theory of equipotency during reprogramming, in which all cells are equally inducible, argues that clone size distributions arise only from stochasticity in the system. However, large variability is seen in experiments. Our null, stochastic model, does not agree with barcoding experiments and shows that the equipotency theory may not be correct. To better explain these distributions we introduce multiple populations with different reprogramming parameters. Reprogramming is driven by a few dominant clones, a feature that will be captured by this mixed population model. Furthermore, barcoding experiments show correlation in clone sizes in repeated trails, indicating that there is heterogeneity in the reprogramming potential of clones. We will develop a stochastic model informed by experimental evidence that the cells that are derived from the neural crest have a proliferative advantage. This approach also introduces heritable reprogramming potential into our model. An accurate model of the reprogramming process can inform our understanding of the path to pluripotency, and increase the yield of reprogramming protocols.

R3-2 Light-Matter Interactions II (DAMOPC/DCMMP) | Interactions lumière-matière II (DPAMPC/DPMCM) / 2281

Cavity Spintronics (I)

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Cavity spintronics (also known as spin cavitronics) is a newly developing, interdisciplinary field that brings together microwave and optical communities with researchers in spintronics and magnetism. The field started around 2014 when it was found that ferromagnets in cavities hybridize with both microwaves and light by light-matter interaction 1. Since then, the emergence of cavity spintronics has attracted broad interest from groups studying quantum electrodynamics, cavity polaritons, optomechanics, superconductivity, plasmonics, and phononics. At the center stage of the topic is the physics of magnon-photon coupling: Via the quantum physics of spin-photon entanglement on the one hand and classical electrodynamic coupling on the other, magnon-photon coupling connects some of the most exciting concepts in modern physics, such as quantum information and quantum optics, with one of the oldest sciences on earth, magnetism.

This talk aims to provide an introduction to this new frontier of condensed matter physics to researchers working in magnetism, spintronics, quantum information, and microwave technologies. Recent experiments focusing on the development of new cavity-mediated techniques, such as indirect coupling of magnetic moments, distant manipulation of spin current, qubit-magnon coupling, and conversion between optical and microwave photons, will be highlighted.

1 Can-Ming Hu, "Dawn of cavity spintronics,"https://arxiv.org/abs/1508.01966

W4-2 Nonlinear Optics (DAMOPC) | Optique non linéaire (DPAMPC) / 2282

Material Candidates for Nonlinear Photonic Devices (I)

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Rapid development of nanofabrication has stimulated the growth of the field of nonlinear photonics. Nonlinear photonic devices are finding their applications in more and more areas, including (but not limited to) classical and quantum communications. The material platforms used for nonlinear photonics on-a-chip range from transparent dielectrics with a relatively weak nonlinearity to semiconductor materials with strong nonlinear interactions. Among the materials for nonlinear photonics, III-V semiconductors stand out due to the large variety of compounds suitable for different spectral ranges that can be realized. There is, however, very little information available on the nonlinear optical performance of various III-V semiconductor compounds. There are very few representatives assessed for their nonlinear optical performance (e.g., AlGaAs), and many more materials offering a variety of operation ranges and applications that have never been studied for that role.

In this presentation, I propose the approach towards identifying interesting material candidates suitable for nonlinear photonics, and present the results of some experimental studies performed in this direction. More specifically, I will talk about our studies of GaN waveguides with wide electronic bandgap, suitable for the applications in the visible and near-infrared spectral ranges. I will also present the results of our experimental realization of passive InGaAsP waveguides that have potentials of being used for wavelength conversion to beyond 2 micrometers, thus expanding the operation range of well-established InGaAsP laser sources to the longer wavelengths.

M1-1 Ultrafast EM waves I: Materials Science (DAMOPC/DCMMP) | Ondes EM ultrarapides I: Sciences des matériaux (DPAMPC/DPMCM) / 2283

Waveform control for attoscience in condensed matter (I)

Author: TJ Hammond[1]

Co-authors: Chunmei Zhang [1]; Aleksey Korobenko [1]; Paul Corkum [1]

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We create and control intense transient waveforms by compressing in space and time optical pulses down to a single half-cycle, nearly 1 femtosecond (1 fs = 10^{-15} s) in duration. By measuring the optical waveform using an in-situ attosecond (1 as = 10^{-18} s) technique we confirm the pulse reshaping. We use the intense transient as a source for generating isolated attosecond pulses from both gases and condensed matter. Furthermore, we develop a general single-shot technique to directly and in real-time measure electric field waveforms.

W2-4 General Relativity II (DTP) | Relativité générale II (DPT) / 2284

*** Withdrawn *** Cuscuton Bounce (G)*

Authors: Ghazal Geshnizjani[1]; Hyung Jin Kim[2]; Supranta Boruah[2]

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In general relativity producing a regular bounce entails violation of Null Energy Condition for a dynamical source in the model. That generically indicates existence of ghosts or other instabilities. However, in cuscuton modification of gravity, the correspondence between a background bounce and violation of Null Energy Condition for dynamical sources is broken. Cuscuton is an Infra Red modification and it can make the background go through a regular bounce. At the same time, since it does not contain any dynamical degrees of freedom, it does not lead to ghosts or other instabilities. Here, we present a toy scenario of a regular bouncing cosmology and prove this claim. Our model is presented as a proof of concept at this point and does not aim to explain observations in late time cosmology.

W4-2 Nonlinear Optics (DAMOPC) | Optique non linéaire (DPAMPC) / 2285

Customizing quantum light sources for emerging quantum technologies (I)

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Light is our best medium for sending information over long distances—it moves at nature's speed limit, and doesn't degrade for hundreds of kilometers. As quantum technologies become more prevalent, we will strive to transmit quantum information, and for this, we will require high quality sources of quantum light.

Sources of quantum light based on nonlinear optical processes, which mediate interactions between photons, are becoming an established standard for generating single photons and other important quantum states of light. While existing sources were sufficient for proof-of-principle experiments, and to demonstrate the feasibility of optics for quantum technologies, significant progress in the field will require a much higher degree of control over quantum light. In this talk, I will discuss theoretical work that expands the capabilities of nonlinear optics by offering this higher degree of control. In particular, I will introduce novel techniques—such as customized poling, Moire gratings, and engineered loss—for shaping the spectrum of quantum light at the source.

M3-2 General Contributions I (DASP) l Contributions générales 1 (DPAE) / 2286

Coastal fog microphysics in Atlantic Canada (I)

Authors: Rachel Chang[1]; Patrick Duplessis[1]; Sean Hartery[2]; Sonja Bhatia[1]; Michael Wheeler[3]; Anne Marie Macdonald[3]

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Fog reduces visibility, causing delays in transportation by land, sea and air. It is also a safety hazard that results in accidents and sometimes even death. Like cloud droplets, fog droplets form on cloud condensation nuclei, existing aerosol particles in the atmosphere that have the ability to activate into droplets. As such, fog droplets provide a unique, in situ method of studying the process of aerosol activation. The interactions between aerosols and water vapour can determine the formation and

persistence of fog, which makes fog forecasting challenging. Current parameterizations within models suffer notably from unresolved microphysical problems such as neglecting droplet concentration, which leads to large errors in droplet density predictions and therefore visibility. This study presents results from fog studies conducted on the eastern coast of Canada in Nova Scotia. Observations of aerosol size distributions and chemical composition were conducted using a ground-based counter flow virtual impactor, which allowed the droplet residuals to be measured directly. Fog droplet size distributions, visibility and other meteorological variables were also measured at the same time. Aerosol and droplet microphysical parameters will be presented including the influence of air mass history. Preliminary results show that aerosol growth may be contributing to the dissipation of fog under some conditions, suggesting that despite the importance of atmospheric dynamics on fog formation and dissipation, aerosols can also play an important role in the life cycle of fog.

M1-2 Particle Physics I (PPD) | Physique des particules I (PPD) / 2287

Standard Model and Higgs results from ATLAS (I)

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Standard Model processes are at the core of the physics programme of the ATLAS Experiment. In this talk, a review of recent measurements is presented: the production cross-sections of vector bosons in association with jets; the mass of the W boson; processes yielding jets of hadrons in the final state; strong and electroweak production modes of the top quark and its properties; the production cross-section of the Higgs boson and of its couplings to other particles.

T2-1 Ultrafast EM waves III: Quantum Control (DAMOPC/DCMMP) | | Ondes EM ultrarapides III: Contrôle quantique (DPAMPC/DPMCM) / 2289

Multidimensional coherent spectroscopy of semiconductor excitons, biexcitons and polaritons (I)

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Three-pulse multidimensional coherent spectroscopy allows for isolation of zero-, one- and two-quantum pathways for separate and coupled, as well as their homogeneous and inhomogeneous linewidths 1. Excitons and biexcitons are examined in semiconductor quantum wells to determine the lineshapes and quantum pathways associated with the optical excitation. These result are compared and contrasted with those from a semiconductor microcavity where the excitons form polaritonic modes due to normal-mode splitting 2. One-quantum rephrasing spectroscopy maps the detuning dependence of the exciton-polariton branches. Increasing detuning moves all features to higher energy and the expected anti-crossing is observed. An isolated biexciton is seen only at negative detuning, separated by a binding energy of approximately 2 meV. For positive detuning, the spectral weight of the off-diagonal features swap, as the lower polariton branch and biexciton come into resonance. This indicates that the off-diagonal features are sensitive to the interactions including two-quantum contributions and that a situation similar to a Feshbach resonance exists. Polarization dependence of two-quantum contributions show spin sensitive two-polariton and new biexciton correlations. The latter likely influence the Feshbach resonance between biexcitons and two-polariton states. The two-quantum signatures also demonstrate that biexcitons perturb the light-matter coupling in the microcavity to reduce the mixed two-polariton contributions. Detuning dependence of zero-quantum contributions show Raman-like coherences that are enhanced near zero detuning.

Asymmetry of the Raman coherences are indicative of many-body interactions, which also grow stronger as the light-matter interactions are enhanced near zero detuning.
1 Bristow et al, Rev Sci Instrum 80, 073108–8 (2009).
2 Wilmer et al, Phys. Rev. B 91, 201304(R) (2015).

DPMB Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (9) | Session d'affiches DPMB et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (9) / 2290

POS-59 Effect of diffusion of cell lysate in a model polymer, via pulse gradient NMR (SMC Poster)

Authors: Yanitza Trosel[1]; Valerie Booth[1]; Anand Yethiraj[1]

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Nonspecific interactions of macromolecules in the cell interior lead to a phenomenon known as macromolecular crowding. Interactions between a molecule of interest and the many molecules in the cell interior can modify its characteristics. For example, crowding can cause changes in biomolecules including protein structure, enzyme kinetics and protein-protein interactions. The effect of crowding is of concern because these biological molecules are normally studied in dilute solution, rather than their real biological environment inside crowded cells. Thus, it is important to understand the behavior of such biomolecules in the presence of proteins, enzymes and DNA as the crowders.
Traditionally, biophysical studies of crowding have used simple crowding agents like dextran and ficoll and have explored their effects on the polymer polyethylene glycol. In order to move beyond simple crowding agents, we will measure the translational diffusion of polyethylene glycol, using pulsed gradient NMR, in the presence of a more realistic crowder, cell lysate, the mixture resulting when cells are sheared open. These results will provide a better understanding of complex crowding systems such as the interior of real cells. Also, the work will provide insight into parameters to optimize to obtain quality data of proteins via in-cell NMR.

W2-2 Light-Matter Interactions I (DAMOPC) | Interactions lumière-matière (DPAMPC) / 2291

Intense Laser Solid State Physics: Bridging the Gap between Attosecond Science and Solid State Physics (I)

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Over the last several years, there has been a growing interest in ultrafast, intense-laser driven processes in solids. Recent high harmonic generation (HHG) experiments in dielectrics 1 and in semiconductors 2 have revealed ways to transfer attosecond technology from atomic gases to solids. This has given birth to attosecond condensed matter physics. Further, experiments on intense laser driven dielectrics have revealed population transfer to the conduction band to be oscillatory in time 3; this is in stark contrast to ionization in semiconductors 4. The oscillatory response of dielectrics to intense lasers can be exploited to optically modulate conductivity. This effect has opened the possibility to extend ultrafast electronics into the PHz domain [5]. Here we will discuss some theoretical aspects of ionization [6] and HHG [7] in solids exposed to intense laser fields.

1 T. T. Luu et al., Nature 521, 498 (2015).
2 S. Ghimire et al., Nat. Phys. 7, 138 (2011); M. Hohenleutner et al., Nature 523, 572 (2015); G. Vampa et al., Nature 522, 462 (2015).
3 M. Schultze et al., Nature 493, 75 (2013).
4 M. Schultze et al., Science 346, 6215 (2014).
[5] A. Schiffrin et al., Nature 493, 70 (2013); A. Sommer et al., Nature 534, 86 (2016).
[6] C. R. McDonald, G. Vampa, P. B. Corkum and T. Brabec, Phys. Rev. Lett. 118, 173601 (2017).
[7] G. Vampa, C. R. McDonald, G. Orlando, D. D. Klug, P. B. Corkum and T. Brabec, Phys. Rev. Lett. 113, 073901 (2014).

T4-2 Quantum Optics and Trapped Ions (DAMOPC) | Optique quantique et ions piégés (DPAMPC) / 2292**

How to simulate models from high energy physics in atomic physics experiments (I)

Author: Christine Muschik[1]

Co-authors: Peter Zoller ; Rainer Blatt ; Esteban Martinez ; Marcello Dalmonte ; Phillip Hauke ; Philipp Schindler ; Thomas Monz ; Daniel Nigg ; Alexander Erhard ; Markus Heyl

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Gauge theories are fundamental to our understanding of interactions between the elementary constituents of matter as mediated by gauge bosons. However, computing the real-time dynamics in gauge theories is a notorious challenge for classical computational methods. In the spirit of Feynman's vision of a quantum simulator, this has recently stimulated theoretical effort to devise schemes for simulating such theories on engineered quantum-mechanical devices, with the difficulty that gauge invariance and the associated local conservation laws (Gauss laws) need to be implemented. Here we report the first experimental demonstration of a digital quantum simulation of a lattice gauge theory, by realising 1+1-dimensional quantum electrodynamics (Schwinger model) on a few-qubit trapped-ion quantum computer. We are interested in the real-time evolution of the Schwinger mechanism, describing the instability of the bare vacuum due to quantum fluctuations, which manifests itself in the spontaneous creation of electron-positron pairs. To make efficient use of our quantum resources, we map the original problem to a spin model by eliminating the gauge fields in favour of exotic long-range interactions, which have a direct and efficient implementation on an ion trap architecture. We explore the Schwinger mechanism of particle-antiparticle generation by monitoring the mass production and the vacuum persistence amplitude. Moreover, we track the real-time evolution of entanglement in the system, which illustrates how particle creation and entanglement generation are directly related. Our work represents a first step towards quantum simulating high-energy theories with atomic physics experiments, the long-term vision being the extension to real-time quantum simulations of non-Abelian lattice gauge theories.

T4-5 Neutrinoless Double Beta Decay (DNP) | Double désintégration bêta sans neutrinos (DPN) / 2293

nEXO: a tonne-scale next-generation double-beta decay experiment

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The nEXO Collaboration is developing a proposal for a 5-tonne experiment with initial neutrinoless double-beta decay sensitivity approaching to 10^{28} years. The nEXO detector will be a homogeneous liquid xenon (enriched to 90% in ^{136}Xe) time projection chamber inspired by the highly successful EXO-200 detector. Energy resolution, event topology, and event localization in the large homogeneous detector will work in concert to simultaneously minimize and characterize backgrounds. In this talk we will describe the detector design choices and show the sensitivity that the detector can reach using only materials for which radiopurity has already been demonstrated.

T3-1 Photonics (DAMOPC / DCMMP) | Photoniques (DPAMPC / DPMCM) / 2294

On-chip Fabry-Perot microcavity arrays for cavity QED (I)

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We describe a monolithic thin-film buckling process used to fabricate arrays of high-finesse, tunable, curved-mirror Fabry-Perot cavities on a chip. Arrays of small-mode-volume cavities exhibit good uniformity and nearly reflectance-limited finesse. The process has been adapted to a variety of thin film material combinations, for operation throughout the visible and near-infrared regions. Ongoing efforts to integrate gas-phase, liquid-phase and solid-state light emitters, and to integrate cavity resonance tuning mechanisms, will also be described.
For cavity QED applications, these cavities offer an intriguing mix of potential advantages. Their monolithic fabrication by buckling self-assembly results in smoothly curved mirrors forming a 'self-aligned'cavity with highly predictable Gaussian mode properties. Furthermore, the cavities have a hollow core which is effectively enclosed by upper and lower Bragg mirrors. This can lead to significant inhibition of background emission for emitters embedded within the air core, particularly if the Bragg mirrors have sufficiently high index contrast to provide an omnidirectional reflection band. Preliminary results from a theoretical study of dipole emission inside cavities with Si/SiO2-based omnidirectional Bragg mirrors will be presented. Using parameters extracted from previously fabricated cavities (operating in a fundamental spatial mode regime at ˜ 1550 nm with modest Q ˜2000 and low mode volume on the order of one cubic wavelength), and an optimally located emitter, we predict simultaneous Purcell enhancement of emission into the cavity mode by ˜120 and suppression of background emission by ˜25. These results imply a potential for high cooperativity and a near-unity spontaneous emission coupling factor, even for a relatively broad line-width emitter.

W4-5 Education Research-informed Physics Teaching (DPE) | L'enseignement de la physique enrichi par la recherche en éducation (DEP) / 2295

Retrospective View of PER-Informed Teaching in Introductory Physics (I)

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After 22 years of teaching first-year university introductory physics, this past year marks the foreseeable end to this aspect of my academic career with my move to become a Graduate Studies Dean and AVP Research. This milestone provides opportunity to reflect upon this journey, and hope to provide some useful insight to others of you who remain intimately embroiled in the challenge of being a "successful" (however we define that!) instructor of introductory physics courses. I will review my path from zero-experience rookie learning from superb mentors at Florida State University

who introduced me to the existence of Physics Education Research, into my own attempts to implement aspects of PER-inspired techniques into my own courses for the latter 17 years at Saint Mary's. While my passion in this area was recognized with various levels of teaching/educational-leadership awards, reflection upon "what really changed" over those years is instructive. I will also discuss the various levels of success in having lasting impact within my (former) department following my departure, and the real pragmatic challenges involved for any department managing the response to a high-profile teaching zealot in their midst.

M3-2 General Contributions I (DASP) l Contributions générales 1 (DPAE) / 2296

Influence of Thunderstorms on the Structure of the Ionosphere over North America

Author: Omar Nava[1]

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Accurate characterization of the ionosphere in response to thunderstorms has important implications for the effective use of high frequency (HF) communications in civilian and military operations, to include emergency services, amateur radio, aviation, and over-the-horizon radar. This study investigates changes in the structure of the ionosphere due to strong convective activity and cloud electrification associated with thunderstorms over North America. Superposed Epoch Analysis (SEA) is applied to surface weather observations and ionosonde data at Eglin Air Force Base, Boulder, and Millstone Hill from 2010 to 2017. Initial findings indicate that lightning significantly modifies the structure of the ionosphere, generating statistically different measurements of several key parameters compared to clear-sky observations. The influence of seasonal and diurnal variations is also presented. Results of this research may eventually lead to the development of a parameterization scheme to incorporate thunderstorm and cloud electrification effects into global and regional ionosphere models. Because troposphere-ionosphere coupling has been poorly addressed, analysis of the electrodynamic connection between the lower and upper atmospheres has important implications for both space physics and atmospheric science communities.

T4-2 Quantum Optics and Trapped Ions (DAMOPC) | Optique quantique et ions piégés (DPAMPC) / 2297**

Schrödinger cats in quantum optics (I)

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Superpositions of macroscopically distinct quantum states, introduced in Schrödinger's famous Gedankenexperiment, are an epitome of quantum "strangeness" and a natural tool for determining the validity limits of quantum physics. The optical incarnation of Schrödinger's cat –the superposition of two opposite-amplitude coherent states –is also the backbone of quantum information processing in the continuous-variable domain. The talk will cover recent experimental progress on preparing such states, applying them in quantum technology and communications, and increasing their amplitudes.

M3-1 Stochastic Biology (DPMB) I Biologie stochastique (DPMB) / 2299

Spontaneous development of drug resistance caused by a common gene regulatory network (I)

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The development of drug resistance is a serious problem that reduces therapeutic susceptibility and complicates the treatment of infectious disease and cancer. To explore non-genetic causes of spontaneous drug resistance in rapidly proliferating cell populations, we constructed a set of synthetic transcriptional regulatory networks in yeast Saccharomyces cerevisiae to control the expression of the pleiotropic drug resistance gene PDR5. This gene is a conserved homologue of a human multidrug resistance gene (MDR1) that protects cells from many first line chemotherapies and implicated in the development of drug resistant cancers. For this reason, we hypothesized that transcriptional regulation may contribute to drug resistance and examined how certain transcriptional regulatory network features, or motifs, contribute to cell survival in the presence of a cytotoxic drug. Our results reveal that the coherent feedforward motif can enhance cell survival in the presence of the drug by allowing rapid and prolonged activation of gene expression, and that combining coherent feedforward and positive feedback motifs leads to increased drug resistance. These observations provide direct evidence that certain gene network motifs cause reduced susceptibility to drug treatment and underscore the importance of regulatory network interactions in the development of non-genetic drug resistance.

T4-8 Novel Approaches to Promoting Engagement in Physics Classes (DPE) | Nouvelles approches pour promouvoir l'engagement dans les classes de physique (DEP) / 2300

Ice Hockey: a Sport Full of Physics (I)

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One way to motivate students to learn physics is to use examples of daily life where it applies, and sports are a good example. Ice hockey is particularly rich in the variety of physics elements it contains, from the biomechanics of skating, to shooting and puck aerodynamics, to player collisions. With the help of physics and statistics, I will tackle fun questions like Can a hockey puck become airborne? Why is ice so slippery? From how far away can goalies stop pucks travelling at 160 km/h? Why are NHL goalies becoming taller? Are collisions at mid-ice more dangerous than against the board? and Do NHL teams tend to play better or worse after losing several games? These questions and others will be taken from my books Slap Shot Science and The Physics of Hockey.

T1-7 Workshop: Preparing Your Teaching Dossier (DPE) | Atelier: Préparation de votre dossier d'enseignement (DEP) / 2301

Teaching Dossier Workshop

Author: Daria Ahrensmeier[1]

[1] *Simon Fraser University*

Corresponding Author: dahrensm@sfu.ca

If you are planning to apply for a faculty position, or for a promotion, or if you are up for tenure, you will likely have to submit your teaching dossier (also known as teaching portfolio) in addition to your CV and research statement. This one-hour workshop will get you started on preparing your dossier. You will learn what information it should include, how to collect and organize evidence for your teaching practice and effectiveness, and how to approach writing your teaching philosophy statement. You will have an opportunity to look at examples –good and not so good –and learn about the criteria committees typically use when reviewing teaching dossiers.

T2-2 Round-table Discussion: How can we measure good teaching? (DPE) | Table ronde: Comment mesurer le bon enseignement? (DEP) / 2302

Roundtable Discussion: How can we measure good teaching? (I)

Author: Daria Ahrensmeier[1]

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Most departments rely on student evaluations of teaching (SET) when trying to determine an instructor's teaching effectiveness. Some even focus on a single number, the "overall mark" given by students. How can we do better? We want to know which methods you use and why, and if you are satisfied with the information they provide. We especially want to hear from you if you are using Peer Evaluation of Teaching - how do you keep the workload manageable? How do you handle issues of trust? We look forward to having an inspiring conversation with you.

R-PLEN3 Plenary Session | Session plénière - Eric Cornell, Univ. of Colorado / 2303

Looking for Fossils of the Big Bang in Molecular Spectra

Author: Eric Cornell[1]

[1] *University of Colorado*

How can you learn about the early moments of the universe? How can you discover evidence for new sub-atomic particles? We usually think of ever-more exotic telescopes, or of ever-larger particle accelerators. I will talk about the third leg of the stool: precision measurement. We will see that the humble two-atom molecule should be thought of as an ultrahigh-electric-field laboratory.

T-PLEN Plenary Session / Session plénière - Juan Maldacena, Institute for Advanced Study at Princeton / 2304

Black holes, wormholes and entangled states

Author: Juan Maldacena[1]

[1] *Institute for Advanced Studies in Princeton, NJ*

We think that black holes are ordinary quantum systems with a finite number of microstates, when we view them from the outside.

A pair of black holes can then be entangled with each other. A special entangled state of this kind can be described by a geometry similar to the maximally extended Schwarzschild black hole. This geometry is a non-traversable wormhole.

We will discuss how to make the wormhole traversable, viewing the process as an example of quantum teleportation.

W-PLEN1 Plenary Session | Session plénière - Anne Martel, U.Toronto "Machine Learning for Medical Image Analysis" / 2305

Machine Learning for Medical Image Analysis

Author: Anne Martel[1]

[1] *Sunnybrook Research Institute; Department of Medical Biophysics, University of Toronto*

Over the last decade, machine learning (ML) methods have become increasingly important in medical imaging. In addition to more traditional classification tasks, ML is now being used in many other applications including object search and segmentation, image registration and even image reconstruction. Recent advances in deep learning have accelerated this trend and it is now possible to achieve human level performance in several diagnostic tasks where large databases of labelled images are available. This talk will provide an overview of this rapidly changing field and will describe how convolutional neural networks can be used for classification and segmentation in radiology and digital pathology. The challenges associated with translating deep learning applications into clinical practice will also be explored.

M-PLEN1 - Plenary Session (S. Nagler) | Session plénière (S. Nagler) / 2306

Pulsed neutrons, fractional excitations, and quantum spin liquids

Author: Stephen Nagler[1]

[1] *Oak Ridge National Laboratory*

Sixty years ago, Canadian Physicist Bertram Brockhouse pioneered inelastic neutron scattering. His invention, the triple axis spectrometer, enabled direct measurements of phonons, magnons, and other collective elementary excitations in materials. In more recent times the practice of inelastic neutron scattering has been revolutionized by pulsed neutron time-of-flight spectroscopy, enabled in part by the vast increase in available computational power. This has allowed detailed investigations of exotic phenomena including fractionalized magnetic excitations. This talk will begin by surveying some relevant developments in neutron instrumentation, primarily at the accelerator-based Spallation Neutron Source at Oak Ridge. The focus will then shift to the physics of quantum magnets and fractionalized excitations, showing how these are probed by neutron scattering. Next will be a look at the exactly solvable model on a honeycomb lattice proposed by Alexei Kitaev, that exhibits a quantum spin liquid ground state. The talk will conclude with an examination of recent experiments on materials that exhibit mutually competing interactions like those postulated by Kitaev, showing evidence for fractional excitations associated with his eponymous quantum spin liquid.

M3-4 Cold and Trapped Atoms, and Tests of Fundamental Symmetries I (DNP/DTP/PPD/DAMOPC) | | Atomes froids et piégés, et tests de symétries fondamentales I (DPN/DPT/PPD/DPAMPC) / 2307

MUSE-ing about the proton radius puzzle (I)

Author: Evangeline J. Downie[1]

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The proton radius puzzle is the difference between the radius of the proton as measured with electron scattering and atomic hydrogen spectroscopy, and that measured in muonic hydrogen. In 2010, the CREMA Collaboration published their measurement of the proton radius $R_p = 0.8409(4)$ fm, which was made by studying the Lamb shift in muonic hydrogen. Although ten times more precise than the 2010 PDG value of $R_p = (0.877 \pm 0.007)$ fm, the CREMA result is completely incompatible with it. Until that point, the PDG value had been in good agreement with both scattering and spectroscopy results.

Since 2010, there have been many theoretical and experimental efforts to try to resolve the puzzle: the CREMA collaboration have made a series of measurements in light nuclei, the PRad experiment at JLab and Intial State Radiation experiment in Mainz have sought to measure the radius at lower momentum transfer, there have been efforts at the Max Planck Institute for Quantum Optics in Munich to re-measure the hydrogen spectroscopy lines, and meanwhile many theorists have been trying to analyze the issue from multiple perspectives. A future experiment on Muon Scattering has also been funded by NSF and is under construction (the MUon proton Scattering Experiment, MUSE).

We will review the current status of the Proton Radius Puzzle, and give an overview of the ongoing efforts to resolve the puzzle.

W1-2 Strategies and Good Practices for Teaching Atomic, Molecular and Optical Physics (DAMOPC/DPE) | Stratégies et bonnes pratiques d'enseignement de la physique atomique, moléculaire et optique (DPAMPC/DEP) / 2308

Atomic Theory: Drilling Down to New Physics (I)

Author: Gordon Drake[1]

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The helium atom with its nucleus and two electrons provides a prime example of the quantum mechanical three-body problem. It is often used in text books to provide an example of simple approximation methods for atomic structure calculations. However, variational solutions to the three-body Schrodinger equation that are essentially exact for all practical purposes are possible, and they provide a systematic connection with less accurate approximation methods such as configuration interaction and the Hartree-Fock approximation. In addition, the variational solutions provide a firm foundation on which to build higher-order relativistic and quantum electrodynamic corrections. The results provide a valuable teaching tool for the physical phenomena that must be taken into account to reach spectroscopic accuracy, and to search for new physics of fundamental importance.

DASP Poster Session & Finals: Poster Competition & Mingle Session with Industrial Partners (6) /Employers| Session d'affiches DPAE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (6) / 2309

POS-7 NuSTAR Search For Black Holes Within the Galactic Center

Authors: Dong Hoon Lee[None]; Michael Chang[None]

Corresponding Author: palisadesdaily@gmail.com

This investigation reports on the 2016 Nuclear Spectroscopic Telescope Array (NuSTAR) observation of the Galactic Center (GC). Two new transients were identified within the Galactic Center, Swift J174540.7-290015 (Transient 15) and Swift J174540.2-290037 (Transient 37). Having observed the GC for 10 years and detected no prior outburst, it can be concluded that the time between outburst (recurrence time) is longer than 10 years. The recurrence time of a neutron star is less than 10 years, while that of a black hole is assumed to be approximately 100 years. Therefore, it can be concluded that these transients are very likely black hole binaries. Through both spectral fitting and timing analysis, Transients 15 and 37 were identified as black hole candidates. The observed number of transients were used to estimate the existence of 30 black hole binaries within the Galactic Center, 27 still unobserved, indicating the likelihood of a substantive population of black holes within the Galactic Center.

T3-7 Surface Sciences (DSS) I Science des surfaces (DSS) / 2310

Atomically Resolved Dynamics of a Charge Density Wave (I)

Author: Jacob Burgess[1]

Co-authors: Steffen Rolf-Pissarczyck [2]; Mohamad Abdo [2]; Luigi Malavolti [2]; Greg McMurtrie [2]; Max Haenze [2]; Bjoern Schlie [2]; Sebastian Loth [2]

[1] *University of Manitoba*

[2] *Institute for Functional Matter and Quantum Technologies, University of Stuttgart and The Max Planck Institute for the Structure and Dynamics of Matter*

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Advances in THz generation have enabled a wide range of new scientific tools that probe previously inaccessible dynamics in materials. In the area of scanning tunneling microscopy the capability of generating large amplitude THz pulses have enabled practical ultrafast scanning tunneling microscopy experiments. In a THz-coupled scanning tunneling microscope (THz-STM), THz pulses couple to the tip of the microscope and provide a means to modulate the electric field at the microscope's tunnel junction thus allowing ultrafast control of the tunnel current. Using a THz time domain spectrometer, THz pulses can then be used to achieve stroboscopic ultrafast time resolution in STM experiments. The operating principles of a THz-STM will be introduced along with the results of a recent experiment on charge density wave (CDW) state supported by niobium diselenide. In this experiment the response of the CDW state to strong electric field pulses was examined using a THz-STM to extract the response of individual atomic site. This allowed a measurement of the impact a single individual atomic defect has on the dynamic modes of the CDW state.

W2-2 Light-Matter Interactions I (DAMOPC) | Interactions lumière-matière (DPAMPC) / 2311

A theoretical model of the "transverse optical magnetism" phenomenon

Authors: Christopher DiLoreto[1]; Chitra Rangan[1]

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In recent scattering experiments [1,2], high-intensity, short-duration, electromagnetic pulses were scattered off dielectric liquids such as water and carbon tetrachloride. The observed pattern of the scattered light led the authors to propose a theory, based on single-particle, classical electromagnetic scattering, that there was magnetic dipole radiation generated. They called this phenomenon "transverse optical magnetism". This explanation has been challenged in the literature since strong magnetic interactions can be assumed to be negligible in classical electromagnetic scattering. Additionally, the fact that this effect is observed in a variety of liquids, including the highly symmetric CCl_4 (that lacks an electric dipole and quadrupole moment) leads one to look for alternative explanations for the observations.

We have recently demonstrated that a dense ensemble of two-level atoms driven by an electromagnetic field can be modelled by an effective single quantum system that has a time-varying decoherence rate 3. Our effective single particle model provides a way in which computational time can be reduced, and also a model in which the underlying physical processes involved in the system's evolution are much easier to understand. We use this model to provide an elegant theoretical explanation for "transverse optical magnetism". We show that the radiation pattern suggestive of magnetic dipole scattering occurs naturally when the inter-particle interactions caused due to spontaneous emission from individual atoms are taken into account in 3-dimensions. Our effective single particle model's predictions match very well with experimental data.

1 S.L. Oliveira and S. C. Rand, Phys. Rev. Lett., 98:093901, 2007.
2 S. C. Rand, W.M. Fisher, and S. L. Oliveira, J. Opt. Soc. Am B, 25:1106, 2008.
3 C. S. DiLoreto and C. Rangan, Phys. Rev. A 97: 013812, 2018.

W1-2 Strategies and Good Practices for Teaching Atomic, Molecular and Optical Physics (DAMOPC/DPE) | Stratégies et bonnes pratiques d'enseignement de la physique atomique, moléculaire et optique (DPAMPC/DEP) / 2312

Pedagogical development of upper-level electrodynamics as a foundation for AMO Physics

Author: Chitra Rangan[1]

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A strong foundation in upper-level electrodynamics is necessary to learning Atomic, Molecular and Optical (AMO) Physics. But the combination of two features: students having to learn many key concepts, as well as to master the use of mathematical techniques in order to understand the applications, makes this course challenging both for the student and the instructor.

I have re-developed the upper-level electrodynamics course using ideas from Physics Education Research. The interventions used were: linking assessment to learning goals of the course, increasing student engagement via active learning, scaffolding for problem-solving, reducing lecture segments to 20minutes, and frequent testing. Student achievement has improved significantly –the average of final exam scores (closed book exam with all new questions every year) has increased by almost 15%, and the average class grade has gone from C+/B- to a high B+. "Before and after" examples of teaching methods will be presented.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2313

Morphology of ion-conducting polymers (I)

Author: Barbara Frisken[1]

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We study the structure of novel polymers for proton and anion exchange membranes through a combination of experiment and simulations. X-ray and neutron scattering experiments reveal microphase separation and intermolecular order, and interpretation is validated by molecular dynamics (MD) simulations. These studies help us understand the conductivity and swelling of the materials, and inform development of new polymers.

T1-6 Topics in medical physics and biophysics (DPMB) / Sujets en physique médicale et biophysique (DPMB) / 2314

Simulation of Induced Eddy Current and Heat Dissipation of MRI-compatible PET Detector due to an MRI Varying Magnetic Field (G)*

Author: Narjes Moghadam[1]

Co-authors: Roger Lecomte [2]; Réjean Fontaine [1]

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Advances in medical imaging and demands for better diagnoses brought up the idea to combine complementary image modalities with the aim to provide better image quality and more information. Many combined PET/MRI scanners designed for truly simultaneous operation are still in the developing stage. One of the main interferences between PET and MRI arises from the different material magnetic susceptibilities and the presence of metal inside the MRI field of view that could produce eddy current and increase the temperature of PET electronics. In this report, we discuss the effect of MRI gradient on the PET electronics.

We consider a 3 T MRI with an open bore diameter of 50 cm, gradient with slew rate of 200 mT/m/s and RF coil with outer diameter of 30 cm with an avalanche photodiode (APD)-based PET detector located at outer surface of the RF coil. Sensitive materials in PET detectors include application-specific integrated circuits (ASICs) (mainly silicon and copper wiring) of 23.5 × 11.5 mm2 with 0.650 mm diameter ball grid arrays (BGAs) made of SAC305 (Sn96.5Ag3Cu0.5).

Since APD performance is sensitive to temperature and the PET detector electronics are designed in a way that low frequency RF could not disturb its biasing and signaling, the induced eddy current and the associated heat loss in the PET detector have been evaluated using the COMSOL magnetic field module. To model the eddy current and heat loss, we used magnetic vector potential and the skin depth (δ) of materials. The skin depth of copper and SAC305 are 652.3 μm and 1636 μm at 10 kHz, respectively.

The induced current density was simulated in one individual SAC305 sphere and in a detector with 116 spheres as BGAs along with two ASICs in presence of the gradient field. By volumetric integration of current, the induced current density in one BGA was calculated as 0.3 μA.m and the heat loss was 37.3 pW. The total eddy current density norm and heat dissipation for one detector would then be 1.7 mA.m and 0.6 μW, respectively.

Our results show that by using non-ferromagnetic materials in small quantity and low distribution, the induced current and heat dissipation due to gradient changes are so small that they would not raise the detector temperature to a level that would affect the PET performance.

T3-1 Photonics (DAMOPC / DCMMP) | Photoniques (DPAMPC / DPMCM) / 2315

An enhanced Kerr non-linearity using Rydberg electromagnetically induced transparency outside the blockade regime (G)

Authors: Josiah Sinclair[1]; Noah Benjamin Lupu-Gladstein[2]; Kent Fisher-Bonsma[1]; Aephraim Steinberg[1]

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The strong interactions between Rydberg atoms provides an exciting platform for quantum nonlinear optics. Rydberg blockade (where a cloud of many atoms is unable to support more than a single excitation due to dipole interactions) combined with electromagnetically induced transparency (EIT) (where on-resonant absorption is suppressed due to the presence of a second coupling field) has been used to demonstrate single photon generation, strong photon-photon interactions, and quantum memory. Despite these advances, Rydberg blockade is unsuited for other important applications in quantum nonlinear optics, like quantum non-demolition measurements of photon number, and photon-number squeezing. This is because Rydberg blockade treats all photons after the first photon (which caused the blockade) indistinguishably. Here, we report on an experiment far from the blockade regime where weak Rydberg interactions enable an optical pulse propagating through a cloud of atoms to acquire a phase shift proportional to the number of photons in a second optical pulse. We present preliminary observations of the phase shift as a function of photon number and Rydberg principal quantum number. We discuss possible next steps towards harnessing this enhanced Kerr nonlinearity for photon-number squeezing and non-demolition measurement.

W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2316

*** Withdrawn*** Nonlocal models in pattern formation (I)

Author: Theodore Kolokolnikov[1]

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abstract: In the first part of the talk, I will discuss a new agent-based model of wealth distribution in a society which incorporates spatial information. The key feature of the model is formation of wealth "hot-spots", region in space where wealth is concentrated. The continuum limit of this model leads an interesting integral equation.

In the second part of the talk, I discuss how a non-local problem arises when describing the density distribution of vortices in the classical Gross-Pitayevskii model of Bose-Einstein Condensates in the presence of rotation and trap.

R1-4 Inclusive Science Education (Part 2) (DPE/CEWIP) I Éducation scientifique inclusive (2ième partie) (DEP/CEFEP) / 2317

Is closing the gender gap in Physics and Engineering in Ontario possible? (I)

Authors: Martin Williams[1]; Mary Wells[2]

[1] *University of Guelph*

[2] *Dean, College of Engineering and Physical Sciences University of Guelph Chair Ontario Network for Women in Engineering*

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There are more women entering STEM disciplines than ever before. However, despite huge improvement in pedagogy over the last twenty years, both physics and engineering continue to have persistent and entrenched gender divides; only about 20% of Canadian undergraduate and graduate students in both physics and engineering are women. The reasons why relatively few women enter physics and engineering, as well as the factors that deter them, are many and are extensively discussed in the literature. In this talk we will share the latest results on where the greatest loss of women occurs in physics and engineering in Ontario and how physicists and engineers are partnering to develop and test interventions that would rectify this glaring deficit.

M2-1 Ultrafast EM Waves II: THz Science (DAMOPC/DCMMP) | Ondes EM ultrarapides II: Science des THz / 2318

Ultrafast terahertz scanning tunneling microscopy with atomic resolution (I)

Author: Frank Hegmann[1]

[1] *University of Alberta*

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The ability to directly probe ultrafast phenomena on the nanoscale is essential to our understanding of excitation dynamics on surfaces and in nanomaterials. Recently, a new ultrafast scanning tunneling microscope (STM) technique that couples terahertz (THz) pulses to the scanning probe tip of an STM was demonstrated (THz-STM), showing photoexcitation dynamics of a single InAs nanodot with simultaneous 0.5 ps time resolution and 2 nm spatial resolution under ambient conditions. Operation of THz-STM in ultrahigh vacuum now makes it possible to spatially-resolve subpicosecond dynamics of single molecules and silicon surfaces with atomic precision. This talk will discuss how THz-STM works and how it can provide new insight into ultrafast dynamics on the atomic scale, which is essential for the development of novel silicon nanoelectronics and molecular-scale devices operating at terahertz frequencies.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2319

*** Withdrawn *** POS-6 Second-harmonic generation in highly dispersive media: Comparison of a new formalism with experimental data

Authors: Bobby Bourque[1]; Serge Gauvin[1]; Deny Hamel[1]

[1] *Université de Moncton*

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Second harmonic generation (SHG) is a non-linear optical process where two photons from the pump wave interacting with a non-linear material are combined to generate a new photon, with twice the frequency of the initial ones. The use of organic crystals for SHG is appealing, as the nonlinear coefficients of these crystals are much greater than those of standard inorganic materials, especially

when the pump wavelength is close to an optical resonance. However, in such a case, chromatic dispersion must be properly treated.

Indeed, standard formalism for describing the wave equation of SHG in a material has been shown to be flawed in the case of materials with high dispersion. The slowly varying amplitude approximation which is made in the development is not always justified for organic crystals. Solving the equation without this approximation leads to a result with a different amplitude and an additional term, which we refer to as the "zeta term". This term adds an oscillating component in the intensity profile of the second harmonic signal which is not present in standard theory.

Here we experimentally measure the dependence of second harmonic intensity versus pathlength and wavelength in 2-methyl-4-nitroaniline (MNA). Working in photon counting mode, with a motorised translator that allows the sample to be scanned with high reproducibility, we observe what we believe to be a combination of the zeta fringes and an effect caused by multiple reflections, since we are working with thin films. Qualitatively, this agrees with our theoretical predictions and leads us to believe that the standard formalism might lead to significant inaccuracies in the case of highly dispersive materials.

Our results have implications for implementations of non-linear optics in dispersive media, and in the determination of non-linear coefficient with the Maker fringes technique, which relies on the intensity profile of the material.

W1-5 Fields and Strings I (DTP) | Champs et cordes I (DPT) / 2320

A Geometric Theory of Plant Growth

Authors: David Hobill[1]; Juila Pulwicki[2]

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In many cases the leaves and petals of plants form curved two-dimensional surfaces. The development of the curvature of those surfaces (ripples, warps, deformations, etc.) can be described by a time dependent Riemannian geometry. Since many biological and chemical systems evolve according to reaction-diffusion equations, the the geometrical description of growth naturally leads to curvature flow equations where the metric describing the geometry of the surface obeys reaction-diffusion type behaviour.

This presentation will introduce a model of plant growth that incorporates Ricci
flow together with material transport in a set of tensor, vector and scalar equations that lead to growth patterns that can be compared with observations. The first application is found in the growth of roots for which the theory is able to explain an observation that could not be explained by other growth models. In another case the theory was shown to be applicable to the growth of the algae Acetabularia whose cap begins as a positively curved surface and during its growth passes through a flat (zero curvature) state to eventually become negatively curved.

Both the theory and the observational measurements demonstrate that there is an
analogy between plant growth and an expanding universe when one takes into account the Riemannian curvature of the underlying manifold.

M1-1 Ultrafast EM waves I: Materials Science (DAMOPC/DCMMP) | Ondes EM ultrarapides I: Sciences des matériaux (DPAMPC/DPMCM) / 2321

Attosecond-Resolved Soft X-Ray Excitonics (I)

Author: Julien B. Bertrand[1]

[1] *Laval University*

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Attosecond Physics explores ways to follow and control matter with unprecedented temporal resolution (1 attosecond= 10-18 s.). Strong laser fields used to apply forces on the sub-cycle timescale, together with the availability of tabletop attosecond soft x-ray pulses, now open avenues for time-resolving ultrafast dynamics on the unexplored attosecond timescale [1, 2]. In this first attosecond pump - attosecond probe experiment, an isolated 100 eV attosecond pulse initiates an Auger decay followed by an attosecond broadband (250-1100nm) optical pulse. The observable is the soft x-ray absorption spectrum as a function of pump-probe delay. A first experiment in krypton atoms allows us to model the effect of the optical probe as a gate of the Auger electronic dipole, a universal analog to the *frequency-resolved optical gating* technique 3. Applying our attosecond x-ray absorption near-edge spectroscopy (AXANES) to the L-edge of fused silica enables us to directly observe and control sub-femtosecond core-excitons in solids, laying the foundation of soft x-ray excitonics.

1 J. B. Bertrand et al., Nature Physics **9**, 174 (2013).
2 S. R. Leone et al., Nature Photonics **8**, 162 (2014).
3 R. Trebino, FROG, Kluwer Academic Publishers, Boston (2002).
4 A. Moulet, J. B. Bertrand, T. Klostermann, A. Guggenmos, N. Karpowicz, E. Goulielmakis, Science **357**, 1134-1138 (2017).

PPD Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (5) | Session d'affiches PPD et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (5) / 2322

POS-48 Precision Calculation of Parity Violating Asymmetry in Search of New Physics

Author: Christophe Match[1]

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My research is part of an effort by the broader subatomic physics community to understand the fundamental characteristics of particles and their interactions. Currently, the Standard Model of particle physics encompasses the knowledge in this field, developed over the last 60 years. As modern technologies and improved experimental techniques develop, measurements become more precise and may show inconsistencies or new phenomena that are not included in our models. The Q-weak experiment at Jefferson Lab has measured the parity-violating asymmetry (ALR) in polarized electron-proton scattering. Specifically, the determination of the proton's weak charge and the weak mixing angle will be extremely precise at very low momentum transfer (Q2) and forward scattering angles. The goal of our research is to improve the accuracy of theoretical predictions for the fundamental interactions between electrons and protons. Each type of interaction corresponds to a mathematical expression with a parameter that gauges the interaction strength, and may be represented using a so-called Feynman diagram. The interaction strength varies with the energies of the interacting particles, due to processes in which multiple gauge particles are exchanged at one time (i.e. radiative corrections). The full theoretical calculations should account for radiative corrections to the leptonic and hadronic currents, as well as bremsstrahlung.
The mixing of both the electromagnetic force and the parity-violating weak force creates an asymmetry, resulting in different reaction cross sections (i.e. probabilities) depending on the helicity of incident electrons. Our research will focus on one-loop calculations, and involves radiative corrections to the leptonic current, parameterizing the relevant hadronic form factors, and systematically calculating the various Feynman diagrams. The results would improve the accuracy in calculations of the electro-weak interaction, and the coupling strength between the photon and Z-boson gauge particles. We also investigate how the addition of a new theoretical exchange particle (Z') affects the calculated asymmetry (ALR) for polarized electron-proton scattering. Our goal is to test the limits

of the Standard Model in search of new physics by performing high precision calculations of ALR and comparing to recent experimental measurements.

M1-3 Theory, Modelling, and Forecasting I (DASP) I Théorie, modélisation et prévisions I (DPAE) / 2323

GLOBAL MODELLING OF MAGNETOSPHERE-IONOSPHERE COUPLING: EPOP-SWARM OBSERVATIONS (I)

Author: Robert Rankin[1]

Co-author: Dmytro Sydorenko [1]

[1] *University of Alberta*

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We present first results from a comprehensive three-dimensional model of magnetosphereionosphere coupling. The model describes plasma flow produced by global scale (Volland-Stern) convection electric fields that are coupled with a physical model of the ionosphere. The initial magnetospheric plasma density is specified using the Global Core Plasma Model (GCPM), while initial density and temperature profiles of electrons and various species of ions and neutrals are taken from the IRI and MSIS models, respectively. The interaction of magnetospheric plasma with the ionosphere is self-consistent and includes effects of sunlight,ionization and recombination,heating and cooling processes,Hall and Pedersen conductivity altitude dependence,and chemistry.The model has already been used to study the development and erosion of plasmaspheric plumes that exert influence over energetic particle dynamics in the inner magnetosphere. It also describes plasma flow over the entire polar cap, which, when combined with data-assimilation of,for example, SuperDARN data, will eventually lead to improved accuracy of space weather forecasting. The main application of the new model is focused on interpreting measurements from the ePOP/CASSIOPE and SWARM satellite missions, which have combined their operations. First modelling results utilizing observations from this new ESA-Canada joint mission will be presented. The novel Yin-Yang overset grid and flexibility of the model to describe non-dipolar magnetic fields will be briefly described, as well as methodology needed to combine the model with more global models such as the LFM MHD model.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2324

Three-dimensional soft tunable platforms for control of cell-matrix interactions (I)

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The extracellular matrix (ECM), a complex network of proteins including collagen (COL) and fibronectin (FN) couples a cell with its environment and directly regulates the cell's fate via physical and biochemical signals. Although the ECM was often considered a static structure providing cohesion and mechanical integrity to tissues, it has recently been shown that (i) the nano-structure, (ii) the nano/micro mechanics, and (iii) the signaling capacity of the ECM are affected by cell-generated forces. Our work has focused on investigating and controlling the material properties of ECM networks and the synergistic roles of FN and COL in 3D environments. In a first example, I will show how the integrated method used in our lab allows us to diagnose early dysregulation of the ECM materials properties in tumors. In a second example, I will present 3D matrix-mimicking polymeric platforms we developed to control both COL and FN properties over macroscopic volumes. These

platforms enable a better understanding of the critical link between protein structure and function, with the ultimate goal of controlling cellular functions through cell-matrix interactions. As such, they represent a new tool for biological research with many potential applications in basic research, medical diagnostics, and tissue engineering.

W1-2 Strategies and Good Practices for Teaching Atomic, Molecular and Optical Physics (DAMOPC/DPE) | Stratégies et bonnes pratiques d'enseignement de la physique atomique, moléculaire et optique (DPAMPC/DEP) / 2325

Teaching optical physics at the graduate level: research and career objectives help determine content and methods of delivery (I)

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W2-4 General Relativity II (DTP) | Relativité générale II (DPT) / 2326

Surprising consequences of a positive cosmological constant (I)

Author: Beatrice Bonga[1]

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The study of isolated systems has been vastly successful in the context of vanishing cosmological constant, $\Lambda=0$. However, there is no physically useful notion of asymptotics for the universe we inhabit with $\Lambda>0$. The full non-linear framework is still under development, but some interesting results at the linearized level have been obtained. I will focus on the conceptual subtleties that arise at the linearized level and discuss the quadrupole formula for gravitational radiation as well as some recent developments.

R3-1 Nuclear physics, special topics (DNP) | Sujets spéciaux en physique nucléaire (DPN) / 2327

Science and Status of the US Electron Ion Collider (EIC) (I)

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In 2015, the US nuclear science advisory committee (NSAC) in its long range planning exercise strongly recommended the construction of a high-energy high-luminosity electron ion collider (EIC). It was recognized that the EIC, with its polarized electron and light ion beams, and unpolarized heavy ion beams, would be a unique facility to help us study the role of gluons in QCD and answer some of the most compelling questions in QCD that remain unanswered. In this presentation, I will present some of those questions and explain how the EIC will address them. I will summarize with the status of the EIC project in the US.

T4-5 Neutrinoless Double Beta Decay (DNP) | Double désintégration bêta sans neutrinos (DPN) / 2328

Hyperfine spectroscopy (and more) of antihydrogen (I)

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The hydrogen atom has played a fundamental role in the development of our understanding of the universe and of quantum mechanics. This makes antihydrogen a natural candidate for testing symmetries between matter and antimatter. The goal of the ALPHA (Antihydrogen Laser PHysics Apparatus) collaboration is to synthesize, trap, and study antihydrogen atoms. ALPHA has made significant progress recently in measuring the 1S - 2S transition in antihydrogen 1, exciting the 1S - 2P transition (a laser cooling transition), and is currently constructing a new apparatus designed to measure the gravitational free fall of antihydrogen.

In addition, ALPHA is working towards high precision measurements of antihydrogen's ground-state hyperfine splitting frequency. Following an initial proof-of-principle experiment in 2012 2, ALPHA has recently measured the hyperfine splitting in antihydrogen to be 1420.4 +/- 0.5 MHz 3. In this talk, I will present a brief overview of ALPHA's physics program and a detailed summary of our hyperfine splitting experiments.

1 M. Ahmadi et al. (ALPHA collaboration), Nature 541, 506 (2017).
2 C. Amole et al. (ALPHA collaboration), Nature 483, 439 (2012).
3 M. Ahmadi et al. (ALPHA collaboration), Nature 548, 66 (2017).

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2330

Quantitatively Accurate Simulations for Block Copolymer Melts (I)

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Ideally, we would like to have first-principles simulations capable of quantitatively accurate predictions for any block copolymer system. Usually, our choice of model involves balancing the complexity needed to faithfully represent an actual experimental system and the simplicity required to make the simulation tractable. Fortunately, block copolymer phase behavior is believed to become universal in the high molecular-weight limit, which foregoes the need for detailed models. We illustrate how this universality can be used to make accurate predictions for a diblock copolymer melt from simulations using a simple lattice model. Nevertheless, simulations of blends and/or complex architectures are still extremely challenging even with the simplest of models. We conclude by discussing how this last obstacle could be overcome with field-theoretic simulations.

PPD Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (5) | Session d'affiches PPD et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (5) / 2331

POS-49 Improving reconstruction of GeV-scale neutrinos in IceCube-DeepCore by direct event simulation

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The IceCube Neutrino Observatory is a cubic-km Cherenkov detector of instrumented ice, designed with the primary goal of detecting very high energy neutrino events beyond the TeV scale from astrophysical sources. Detection of few-GeV atmospheric neutrinos is made possible by the DeepCore infill array. The relatively small amount of recorded event information at these energies introduces challenges for the reconstruction of particle properties, such as energy and incoming angle. Further, the naturally-occurring deep glacial Cherenkov medium requires detailed models, based on in-situ calibrations, to describe photon propagation in the ice. Current reconstruction methods rely on approximated tabulated template events. Replacing these templates with event simulation allows use of the full description of the natural ice medium for accurate resolution of event properties. This method of "direct reconstruction" can also be used for study of ice-related systematic errors. A full description of the algorithm, as well as an estimation of its effects on event reconstruction will be presented.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2333

Characterization of the structure and function of self-assembling hydrophobin proteins

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Hydrophobins are low molecular weight (5-20 kDa) self-assembling proteins secreted by fungi that accumulate at hydrophobic-hydrophilic interfaces and are extremely surface-active. Hydrophobins can also undergo a structural rearrangement and oligomerize to form rodlets, which are an insoluble functional amyloid that coats fungal spores to act as a water repellent, facilitate dispersal into the air, and prevent immune recognition. Rodlets are extremely durable and due to their biochemical properties they are a target for commercial application. To better understand what protein sequence characteristics determine hydrophobin properties, we are characterizing the structure and properties of diverse class IB hydrophobins from various fungal sources. We have expressed hydrophobins in E. coli and purified them to homogeneity using immobilized metal ion affinity and ion exchange chromatography. We then used nuclear magnetic resonance spectroscopy to characterize the high-resolution molecular structures of hydrophobins and are comparing their self-assembly properties with thioflavin-T fluorescence assays and atomic force microscopy. These experiments will form the basis of future mutagenesis experiments to develop new hydrophobins with desired properties.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2334

Organelles without borders: How phase transitions functionally organize living cells (I)

Author: Stephanie Weber[None]

Living cells are composed of a complex mixture of macromolecules. To regulate their activity, cells partition these molecules into specialized compartments called organelles. Typically, membranes form a selective barrier between organelles and the cytoplasm, allowing each compartment to maintain a distinct biochemical composition that is tailored to its function. However, cells also contain a variety of organelles that are not enclosed by membranes. For example, germ granules, stress granules and the nucleolus consist of local concentrations of protein and nucleic acid that rapidly exchange with the surrounding cytoplasm or nucleoplasm. Recent progress suggests that

these membraneless organelles assemble through phase separation, whereby soluble components condense from the cytoplasm to form dynamic droplets. Intracellular phase transitions appear to be widespread in eukaryotes and we hypothesize that they may contribute to spatiotemporal organization in bacteria as well. Nevertheless, the molecular forces that drive such phase transitions, and how they are regulated in response to environmental and/or developmental conditions, remain poorly understood. Here, I describe our efforts to answer these questions using quantitative live-cell imaging and physical modeling.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2335

Manufacturing Novel Biomaterials by Elongation of Fibers from Highly Viscous Polymer Solutions (I)

Author: John Frampton[1]

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Biomaterial fabrics have numerous biomedical applications ranging from drug delivery to tissue engineering. A variety of approaches are available for generating biomaterial fibers from various precursor polymer solutions. Approaches such as wet-spinning, electrospinning, and extrusion have been exploited in the past to generate extremely long fibers ranging in diameter from tens of nanometers to hundreds of microns. An alternative approach for manufacturing polymer fibers is to utilize a dry-spinning approach that generates fibers by balancing the cohesive forces within a highly-concentrated and highly-viscous polymer solution with the adhesive forces of this fluid with a solid substrate applicator. This approach can be used to generate a multitude of fibers that can be arranged on a collector to generate large scale fabrics from a variety of polymer precursor solutions. This presentation will describe the working principals underlying this approach to biomaterial fabric production, along with preliminary material characterization data. Applications in the release of drugs and the templating of protein networks for directing cell growth will also be described. The versatility and potential of these materials for wound reconstruction, as well as in non-biomedical industrial applications will also be highlighted.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2336

High-Throughput 3D Neural Cell Culture Analysis Facilitated by Aqueous Two-Phase Systems (G)

Author: Kristin Robin Ko[1]

Co-authors: Rishima Agarwal [1]; John Frampton [1]

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Introduction: The three-dimensional (3D) culture of neural cells in extracellular matrix (ECM) gels holds promise for modeling neurodegenerative diseases. However, air-liquid interfacial tension and evaporation can result in inconsistent 3D cultures at low volumes. Thick-layer hydrogels can counter these factors, but large diffusion distances, high cost, and incompatibility with standard imaging tools, plate readers and assays limit their use. To address these limitations, we have developed a thin-layer, 3D culture technique using a commonly used self-assembling ECM hydrogel (Matrigel) combined with an aqueous two-phase system (ATPS).

Methods: A dextran T10 (D10) and hydroxypropyl methylcellulose 4000 cPs (HPMC) ATPS was used to confine small volumes of Matrigel containing the model neural cell line, SH-SY5Y, into thin

layers in a 96-well plate format. SH-SY5Y cells were differentiated and cell viability and morphology were observed under epifluorescence microscopy. The ATPS-Matrigel 3D culture method was characterized by monitoring the distribution of 3.0 μm microbeads within gel constructs without cells.

Results: Matrigel evaporation was eliminated in the ATPS-Matrigel 3D culture method, and small volumes (20 μl and lower) formed evenly thin gels. SH-SY5Y cells were observed to extend neurite-like processes in three-dimensions when differentiated, and cell viability remained high, suggesting minimal negative impact of the protocol on cell growth.

Conclusion: We demonstrate a low cost, simple, high-throughput, 3D neuronal cell culture system that is compatible with well-established equipment and commercially available materials.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2337

Multisequence algorithm for coarse-grained biomolecular simulations: Exploring the sequence-structure relationship of proteins (G)

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Many biologically motivated problems naturally call for the investigation and comparison of molecular variants, such as determining the mechanisms of specificity in biomolecular interactions or the mechanisms of molecular evolution. We consider a generalized ensemble algorithm for coarse-grained simulations of biomolecules which allows the thermodynamic behavior of two or more sequences to be determined in a single multisequence run. By carrying out a random walk in sequence space, the method also enhances conformational sampling. Escape from local energy minima is accelerated by visiting sequences for which the minima are shallower or absent. We test the method on an intermediate-resolution coarse-grained model for protein folding with 3 amino acid types and explore the potential for large-scale coverage of sequence space by applying it to sets of more than 1,000 sequences each. The resulting thermodynamic data is used to analyze the structures and stability properties of sequences covering the space between folds with different secondary structures. Besides demonstrating that the method can be applied to a large number of sequences, the results allow us to carry out a more systematic analysis of the biophysical properties of sequences along mutational pathways connecting pairs of different folds than has been previously possible.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2338

Folding landscapes of shape-shifting proteins: insights from a 3-letter coarse-grained model

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Natural and engineered proteins have recently been discovered with a unique ability to reversibly switch between entirely different 3-dimensional structures, with accompanying major changes in their secondary structure contents, hydrophobic sidechain packing and overall shape. The major

conformational changes in these shape-shifting proteins are triggered by, for example, ligand binding, changes in pH, or —as in evolutionary processes —mutations. Using a coarse-grained model for protein folding with 7 atoms per amino acid and 3 amino acid types (polar, hydrophobic and turn-type), we investigate the character of fold switching transitions. We determine the folding thermodynamics of several "single-ground state"sequences that fold spontaneously into a unique structure, including all-alpha, mixed alpha-beta, and beta barrel folds. We then apply a generalized-ensemble Monte Carlo algorithm to explore sequences that lie in the space between folds. We find that proteins in our model can be driven to switch folds through a series of mutations without needing to pass through unstable "non-folding"sequences, in line with recent protein design experiments. At the border between folds, some sequences exhibit an ability to populate more than one fold. Such sequences are relatively rare, however, and fold changes are therefore typically accomplished in just a few mutational steps. We comment on potential evolutionary implications.

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2339

POS-56 Contrôle des propriétés d'émission des lasers à l'aide de couches minces nanostructurées.

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Il s'agit de concevoir et de fabriquer un laser à l'état solide aux dimensions réduites pouvant émettre dans un seul mode aux hautes puissances. Nous fabriquons nos miroirs lasers polarisants en déposant sur un miroir laser commercial une couche anisotrope servant de lame quart d'onde par la méthode de déposition par incidence oblique. Le matériau utilisé est le dioxyde de titane. Une caractérisation par microscopie à force atomique est faite de même que des mesures ellipsométriques afin de déterminer l'épaisseur et les propriétés optiques de nos revêtements. Ces miroirs sont utilisés pour construire un laser de sorte que les polarisations des deux ondes contra-propagatives soient orthogonales pour éliminer le brûlage spatial de trous. Le milieu actif utilisé est le YAG dopé avec de l'ytterbium trivalent pompé avec une diode laser. Les tests lasers sont faits en régime continu puis pulsé.

In this project, we design and manufacture a solid-state microchip laser with single transverse and longitudinal mode emission at high power. We manufacture our polarizing laser mirrors by depositing an anisotropic quarter-wave plate on a commercial laser mirror using the Glancing Angle Deposition. The material used is titanium dioxide. Characterization by atomic force microscopy is done as well as ellipsometric measurements to determine the thickness and optical properties of our deposited coatings. These mirrors are used to construct a laser so that the polarizations of the two counter-propagating waves are orthogonal to eliminate the spatial hole burning. The active medium is YAG doped with trivalent ytterbium pumped with a fiber-coupler laser diode. Laser experiments are performed in both continuous and pulsed modes.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2340

POS-37 Effect of Addition of Lanthanum on the Hydrogen Storage Properties of TiFe Alloy

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TiFe is one of the good candidates for the solid-state hydrogen storage. Despite having fast kinetics and fairly good capacity, it's first hydrogenation is difficult. In this study, we investigated the effect of addition of lanthanum on the hydrogen storage properties of TiFe alloy. As the melting point of lanthanum is much lower than the ones of the other two elements, synthesis by casting was impossible. Instead ball milling was used to synthesize the compound. It was found that the TiFe alloy is formed after 5 hours of milling. The hydrogen storage properties were measured at room temperature and at a pressure of 20 bars on a home-made Sievert's apparatus. For the first hydrogenation, the alloy absorbed 1 wt.% of hydrogen in less than 5 minutes. But, the first de-hydrogenation showed a reduced capacity from 1 wt% to 0.65 wt% i.e., a reduction of 0.35 wt%. Further hydrogenation and dehydrogenation shows no further loss in capacity. To understand the loss in capacity, the X-ray diffraction of fully hydrogenated and fully dehydrogenated samples were performed. But from these diffraction patterns a secondary phase was observed. The presence of this secondary phase may explain the loss of capacity. Possible crystal structure of this phase will be discussed.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2341

A new perspective on the wetting of a solid surface by the drops of an emulsion (I)

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Traditionally, the wetting of a solid surface by the drop of an emulsion has been thought to be mediated by the formation of a liquid bridge that connects the drop and the surface. In the current work, we experimentally show the spreading of a drop on a surface follows a different, new mechanism. Experiments were conducted for liquid-liquid systems, wherein drops of higher density (glycerol) were allowed to settle under gravity in a lighter polymeric liquid phase (silicone oil) under conditions of small Bond numbers. The approach of the drop towards the substrate was visualized using Reflection Interference Contrast Microscopy (RICM), and the details of the film drainage dynamics and the spreading process of the drop on the surface were recorded. The film shapes obtained were compared with predictions from scaling analysis. The temporal variation of the minimum film heights matched theoretical expectations, until the height reached few tens of nanometers, at which point a stable film was formed. Following this, deformable islands were observed to grow on the substrate, one of which eventually merged with the parent drop to complete spreading. The reasons for the arrest of film drainage and the appearance of the islands will be discussed. The fundamental mechanism discovered here will ultimately guide the tailoring of emulsion-based coatings or paints to have predefined spreading times.

W3-8 Nuclear Structure II (DNP) | Structure nucléaire II (DPN) / 2342

User Support and Engagement at TRIUMF

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As a facility for users from around the world, TRIUMF takes very seriously its commitment to providing researchers' the best possible experience at the lab. Recently a new 'Visitor Liaison' group has been established that enhances user support and engagement, and a new User Newsletter is being launched to provide users with up to date information about laboratory experimental services. This talk with introduce these other aspects of the upgraded user engagement initiative to TRIUMF's user community and those thinking of joining it.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2343

Bioprinting of Three-Dimensional Multicellular Skin Constructs (G)

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The production of functional skin equivalents derived from human cells holds promise for reconstruction of severe wounds and for modeling various skin pathologies. Although epidermal cells have the capacity to self-organize and form stratified structures in culture, it is often difficult to integrate these structures with dermal components. In recent years, cellular bioprinting has emerged as an efficient strategy for fabricating functional skin equivalents comprising both dermal and epidermal cells. Examples of bioprinting methods used for fabrication of functional skin equivalents include extrusion-based bioprinting, laser-assisted bioprinting, and inkjet printing. Here, we investigated the use of a layer-by-layer lab-on-a-printer technology for generating multi-cellular three-dimensional skin constructs. To efficiently print sheets of cells using this approach, we first examined the performance of several cross-linkable bio-ink formulations (e.g., alginate and chitosan) containing key extracellular matrix proteins hypothesized to improve cell attachment and growth (e.g., collagen I, collagen IV, fibronectin and laminin). Using these bio-inks, we demonstrate bioprinting of cell-laden sheets in various geometries such as squares and disks containing multiple layers of cells. We also demonstrate that it is possible to print cell-laden sheets using various fill patterns including rectilinear, concentric, and a combination of rectilinear and concentric. Furthermore, we demonstrate that it is possible to produce co-culture sheets consisting of dermal and epidermal cells using the lab-on-a-printer approach. Preliminary analysis of cell viability and organization within these bioprinted skin constructs is presented. Future work will optimize this approach to rapidly generate constructs that closely resembled the natural structure of skin.

Soft Matter Canada 2018 | Matière molle Canada 2018 / 2345

Polymorphism of stable collagen fibrils (G)

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We explore a variety of thermodynamically stable molecular configurations of collagen fibrils. Using a liquid crystal model of radial fibril structure with a double-twist director field, we show that two dimensionless parameters, the ratio of saddle-splay to twist elastic constants k_{24}/K_{22} and the ratio of surface tension to chiral strength $\tilde{\gamma} \equiv \gamma/(K_{22}q)$, largely specify both the scaled fibril radius and the associated surface twist of equilibrium fibrils. We find that collagen fibrils are the stable phase with respect to the cholesteric phase only when the reduced surface tension is small. Within this stable regime, collagen fibrils can access a wide range of radii and associated surface twists. Remarkably, we find a maximal equilibrium surface twist which is compatible with corneal collagen fibrils, and we show how the large surface twist is needed to explain the narrow distribution of corneal fibril radii. Conversely, we show how small surface twist is required for the thermodynamic stability of tendon fibrils in the face of considerable polydispersity of radius.

R3-1 Nuclear physics, special topics (DNP) | Sujets spéciaux en physique nucléaire (DPN) / 2346

The BRIKEN experimental campaign: Beta-delayed neutron measurements at RIKEN for nuclear structure, astrophysics, and applications (I)

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The study of the beta-decay properties in the very neutron-rich region is required for a better understanding of the elemental abundances of heavy elements in the Universe. An important decay mechanism in this region includes beta-delayed neutron emissions when the Q-beta value is larger than the neutron separation energy. Thus, by improving the knowledge about these decays we can better understand the freeze-out path to stability of astrophysical nucleosynthesis processes such as the r-process and the particularities of the nuclear structure of the involved species.

Since 2009 several experiments started to enhance this field and provided new neutron branching ratios in different regions. Recently an international cooperation of more than 20 institutions allowed the design and commissioning of the most efficient 3He-based neutron detector within the BRIKEN campaign at RIKEN (Japan). The Radioactive Beam Factory of RIKEN allows to reach unexplored regions of isotopes which were not accessible so far and separate and identify the species of interest by the BigRIPS spectrometer. BigRIPS together with a state-of-the-art implantation detector and two HPGe clover detectors complete the experimental setup. Promising results are being expected from the first measurements performed in 2017, which covered more than 230 beta-delayed neutron emitters between 64Cr up to 151Cs. Many of them were implanted for the first time with enough statistics to determine their half life and neutron branching ratios.

This talk will give an introduction of the type of RIB facilities able to produce neutron rich isotopes of interest for these measurements, as well as a detailed explanation of the BRIKEN setup 1, performed measurements, and the challenges of this experimental campaign, in which almost all of the previously measured beta-delayed neutron emitters will be remeasured, and approximately 150 new isotopes will be added to the current list of 298 known neutron emitters. Also multiple neutron emitters will be measured.

1 A. Tarifeño-Saldivia et al., Journal of Instrumentation 12 (2017) P04006.

DCMMP Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (28) / Employers | Session d'affiches DPMCM et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (28) / 2347

POS-38 Investigating the Removal of Layered Double Hydroxides in [Ni0.80Co0.15]0.95-xAl0.05+x(OH)2 (x = 0, 0.05) Prepared by Coprecipitation

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As lithium ion battery technology expands into more demanding applications such as electric vehicles, attention has shifted away from the conventional LiCoO2 positive electrode material. Instead, nickel-rich materials such as LiNi1-x-yMnxCoyO2 (NMC) and LiNi1-x-yCoxAlyO2 (NCA) have become attractive due to their lower cost, increased lifetime and increased safety.

Coprecipitation is a common method to synthesize mixed metal hydroxides (M(OH)2: M = divalent transition metals) as the precursor materials to the lithiated metal oxides. While the syntheses of divalent NMC precursor materials are well understood, the introduction of a trivalent cation, such as Al+3, complicates the synthesis and affects the products significantly.1 In order to balance the charge, an extra anion needs to be incorporated into the layered structure, and resulting in the formation of a new layered double hydroxide (LDH) phase.

LDH phases have been widely reported in supercapacitor research, even NiCoAl(OH)2.2 However, there has been little to no work reported on the conversion of LDH phases with trivalent cations to phases with no intercalated molecules.3 NCA literature often omits precursor characterization. Even when a group reported precursors with no LDH4 and with LDH5 using the same synthesis method, there was only a brief mention on LDH presence.

In this work, [Ni0.80Co0.15]0.95-xAl0.05+x(OH)2 (x = 0, 0.05) precursor materials were prepared by the coprecipitation method. The precursor materials were then washed in a solution of NaOH, filtered and dried. NaOH concentration, initial solution temperature, stirring temperature and stirring time were varied to study their impact on LDH removal. Unwashed and washed samples were characterized by XRD, ICP-OES, TGA-MS, SEM and photographs. Recommended recipes for the production of competitive NCA hydroxide precursors are reported.

M1-7 New Perspectives on the Status of Women in Physics - Jill Marshall (DPE/HS) / 2348

New Perspectives on the Status of Women in Physics

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Many hypotheses have been posed about the reasons why there are fewer women than men identified as physicists, although most have not been rigorously tested (and some could not be in an ethical way.) Over time these hypotheses have shifted in nature. I will use the Halpern, Wai and Saw (2005) psycho-bio-social framework for analyzing gender differences to review recent findings that shed light on reasons why we might find fewer women in our physics classrooms and laboratories. I will present suggestions from this body of research about measures we might take to address the gender gap in physics, should we choose to. Finally, I will highlight resources available from AAPT, APS, and AIP- and hope to learn more about the efforts of the CAP.

DPE Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (2) | Session d'affiches DPE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (1) / 2349

POS-63 Online lab sections with the IOLab and remotely operated experiments in first year physics

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We report on our implementation of online lab sections of PHYS 1100, a one-semester, algebra based course with separate classroom and lab components at Kwantlen Polytechnic University. Since January 2017, we have offered online as well as on-campus lab sections, which students take in conjunction with a class, which itself is available on-campus, online, or partially online. The online lab activities consist of seven experiments using kits based on the IOLab and two experiments that are remotely operated through the internet. The lab kits are loaned out from the university library and the remote experiments use the RWSL facility at North Island College. Topics parallel those in the on-campus labs. Each lab is preceded by a pre-lab assignment designed to equip students with theory, orientation and analysis tools required for the experiment. Student lab reports are heavily guided early in the semester but become progressively freer in format, with a corresponding progression in student expectations. Student outcomes and lessons learned for continued implementation will be discussed.

M-PLEN2 Plenary Session - Towards a More Inclusive Physics | Session plénière - Vers une physique plus inclusive / 2350

Towards a More Inclusive Physics

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Creative, collaborative effort to advance a respectful and caring community can make a big difference to students, staff and faculty in physics departments, improving their ability to thrive. Data on demography and the climate for inclusion at MIT show the effects of inclusive leadership based on community, culture and values. This short talk will provide both data and tips on how you can strengthen your department for everyone.

T-Plen-1 - Plenary Session - (J.Dutcher, Guelph U.) | Session pléniaire (J. Dutcher, Guelph U.) / 2351

Soft Colloids, Hard Science and the Path from Discovery to Commercialization

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Colloids are small particles with diameters that lie within the nanoscopic and microscopic domains. Recently, research has focused on deformable or soft colloidal particles, such as microgels and star polymers, which show fascinating behaviour such as jamming and glass formation in dense dispersions. I will describe a new type of soft colloidal particle, phytoglycogen, which is produced in the

form of highly branched, monodisperse nanoparticles in sweet corn 1. The particles are chemically simple, but it is their dendrimeric or tree-like physical structure that produces interesting and unusual properties such as extraordinary water retention, and low viscosity and exceptional stability in water. These properties point to a wide variety of promising applications from cosmetics to drug delivery, yet these applications need to be enabled by a deeper understanding of the unique structure of the particles and their unusually strong interaction with water 2. I will describe our journey from our initial serendipitous discovery of the particles to our detailed analysis of their structure, hydration and soft mechanical properties to the commercialization of this natural, sustainable nanotechnology in our Guelph-based spinoff company Mirexus.

1 J.D. Nickels, J. Atkinson, E. Papp-Szabo, C. Stanley, S.O. Diallo, S. Perticaroli, B. Baylis, P. Mahon, G. Ehlers, J. Katsaras and J.R. Dutcher. Structure and Hydration of Highly-Branched, Monodisperse Phytoglycogen Nanoparticles, Biomacromolecules **17**, 735-743 (2016).

2 M. Grossutti and J.R. Dutcher. Correlation Between Chain Architecture and Hydration Water Structure in Polysaccharides, Biomacromolecules **17**, 1198-1204 (2016).

DAMOPC Poster Session & Finals: Poster Competition and Mingle Session with Industry Partners (8) / Employers | Session d'affiches DPAMPC et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (8) / 2352

POS-62 Waveguide QED toolboxes for synthetic quantum matter with neutral atoms

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An exciting frontier in quantum information science is the realization of complex many-body systems whose interactions are designed quanta by quanta. Hybrid nanophotonic system with cold atoms has emerged as the paradigmatic platform for engineering long-range spin models from the bottom up with unprecedented complexities. Here, we develop a toolbox for realizing fully programmable complex spin-network with neutral atoms in the vicinity of 1D photonic crystal waveguides. The enabling platform synthesizes strongly interacting quantum materials mediated by Bogoliubov phonons from the underlying collective motion of the atoms. In a complementary fashion, phononic quantum magnets can be designed through the coupling to the magnonic excitation of the atomic medium. We generalize our approach to long-range lattice models for interacting SU(n)-magnons mediated by local gauge constraints. Universal open q-body dynamics with q > 2 can be built from floquet driven-dissipation, and the dynamics of arbitrary quantum materials can be constructed with minimal overheads.

R3-2 Light-Matter Interactions II (DAMOPC/DCMMP) | Interactions lumière-matière II (DPAMPC/DPMCM) / 2353

Real-time arrangement of atoms into a low-entropy state using high-resolution optical tweezers

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Designing and assembling highly complex quantum systems from their individual constituents provide an important milestone in quantum information science and quantum many-body physics. Cavity QED provides a means for efficient light-matter quantum interfaces, where the internal states of individual atoms can encode the information of the material system, whereas the cavity vacuum can act as the bosonic channel that mediates effective spin-spin interaction. Here, we investigate a new regime of cavity QED, which we call many-body QED. In this regime, the optical strong coupling of the light-matter interaction competes with the internal atom-atom interaction in the form of Rydberg excitations.
In our research group, we are pursuing an approach of introducing Rydberg excitations into a spatially regularized array of neutral atoms in an ultra-high-finesse optical cavity. A critical element required for this vision is the capability to resolve and identify Rydberg excitations, as well as to perform the real-time arrangement of atoms into a low-entropy state. We discuss how to do the trapping and manipulation of single neutral atoms in reconfigurable arrays of optical traps with micrometer resolution. This method is based on employing a Texas Instruments Digital Micro-Mirror Device (DMD) as a dynamical holographic phase-amplitude modulator with about 20 kHz update rate. The desired arrangement of traps (the Fourier transform of the mask) is produced in the focal plane of a microscope objective with NA of about 0.5, with a new phase-amplitude algorithm based upon superpixel techniques. We are trying to show how to perform high-precision modulations on laser beam profiles to create arbitrary potential landscapes or prepare the initial atomic states at the individual quanta level. In addition, we are trying to demonstrate a robust scheme to measure and compensate wavefront distortions of laser systems in-situ using a DMD as a holographic spatial light modulator. Our technique can be employed for resolving and trapping ultracold atoms in optical lattices, trapped ions, NV centers or other small, localized and fluorescent objects. We discuss the limitations of the technique and the scope for technical improvements.

M1-4 Quantum Theory (DTP) | Théorie quantique (DPT) / 2355

Modification of Landau levels and degeneracy due to a parallel linear electric field

Authors: Yann Audin[1]; Ariel Edery[None]

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When a charged particle moves in a plane perpendicular to a constant magnetic field (z-direction) the discrete energy levels are called Landau levels. The energies resemble those of the harmonic oscillator with ω the cyclotron frequency ω_c. The energies are highly degenerate, with the degeneracy being independent of the energy. We now add a linear electric field parallel to the magnetic field above the plane and anti-parallel below the plane. This introduces a second frequency ω_z associated with oscillations along the z-direction. We show how the Landau levels get modified, but more crucially show that the degeneracy increases with energy, with critical jumps when ω_z/ω_c is a rational number.

DPE Poster Session & Finals: Poster competition and Mingle session with Industrial partners/employers (2) | Session d'affiches DPE et finales: Concours d'affiches et rencontres avec partenaires industriels et employeurs (1) / 2356

POS-100 Physics for Modern Technology - a 4 Year Degree

Authors: Fergal Callaghan[1]; Takashi Sato[1]

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Physics for Modern Technology is a newly established, very applied bachelor's degree in physics and instrumentation at Kwantlen Polytechnic University, a teaching-led university in Greater Vancouver.

Modelled after similar programs running successfully in Europe, this program is aimed at students who wish to work in high tech industry after graduation. Although progression to graduate school is still possible, it is not our primary goal. The initial stages of program development involved visits to institutions in Ireland, which informed the program's content and shape. Back in Vancouver, local high tech companies were consulted on the need for graduates of such a program and on suitable program content. An industry advisory committee provides ongoing and invaluable input.

Students can declare the major after a typical first year science. Years 2, 3 and 4 include recognizable physics content such as E & M, relativity, classical mechanics, quantum mechanics and solid state physics. In addition, we place a significant focus on laboratory and hands-on components, with many courses taught in the laboratory. These include applied optics, control systems, and signal & image processing. There is a one-semester project in third year and a two-semester project in fourth year. To aid preparation for the workplace, students also complete two business courses and a work term of at least 14 weeks'duration.

Summer 2017 saw the first group of students successfully complete their work terms in the following areas: robotics, remote sensing, scientific camera development, laser optics, manufacturing engineering, and biomedical engineering. Several students continued to work for their employers after completion of the work term on a part-time or temporary full-time basis. The program sees its first graduates this year.

W3-7 Applied Physics Instrumentation (DAPI) | Instrumentation de physique appliquée (DPAI) / 2357

Developing ITk Front-End Silicon-Strips Readout ASIC Testing Capability

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Carleton University has a long history of involvement in detector design, testing, and construction for experiments at CERN including the original ATLAS detector at the LHC (Forward Calorimeter) and the New Small Wheel to be installed during LS1 (sTGC). In the past four years, we have developed the necessary capabilities and infrastructure to participate in the inner tracker upgrade needed for the High Luminosity LHC (ITk). While the Department of Physics at Carleton had expertise with numerous detector and readout technologies, the capability to characterize and test unpackaged Application Specific Integrated Circuits (ASICs) did not exist. Since then, with the support of professionals at DESY, RAL, and CERN; the Department of Electronics at Carleton; and partnering with two local companies in Ottawa, Canada, we can now characterize and dice a wafer of the ITk custom front-end silicon-strips readout ASICs, and are being asked to take ever larger roles in testing and characterizing the components to be used in the ITk detector. Through the expertise developed, Carleton can now participate in this and future silicon-based detector development and testing, including any custom chips required for readout and communication, which opens up exciting new opportunities for students and faculty, and builds the foundations needed to do research and development with these leading-edge technologies. This presentation will provide an overview of our work

with the custom front-end silicon-strips readout chip (ABC130), describe the partnerships we have formed in developing these capabilities, and will show preliminary results of our characterization and dicing of these ITk ASICs.

IPP AGM | AGA de l'IPP / 2358

IPP Director's Report & Council Election Results

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IPP AGM | AGA de l'IPP / 2359

IPP MRS Grant submission - discussion

IPP AGM | AGA de l'IPP / 2360

T2K

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IPP AGM | AGA de l'IPP / 2362

BREAK

IPP AGM | AGA de l'IPP / 2363

Belle II

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IPP AGM | AGA de l'IPP / 2364

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IPP AGM | AGA de l'IPP / 2365

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IPP AGM | AGA de l'IPP / 2366

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CPARC

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IPP AGM | AGA de l'IPP / 2368

Closeout

R-PLEN2 CAP Best Student Presentations Final Competition / Compétition finale de l'ACP pour les meilleures communications étudiantes / 2369

Competitor 8

M3-3 General Relativity I (DTP) I Relativité générale I (DPT) / 2370

Black Hole Chemistry in de Sitter: A New Approach

Authors: Saoussen MBAREK[1]; Robert Mann[1]

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In the context of black hole chemistry, we study the thermodynamics of asymptotically de Sitter black holes with conformal scalar hair in Einstein gravity. The hair parameter allows us to reach thermodynamic equilibrium between the event horizon and the cosmological horizon. We find

that the system of the black hole and the de Sitter space surrounding it undergo a phase transition that resembles the Hawking-Page phase transition provided we consider the micro-canonical ensemble.

R-PLEN1 Plenary Session | Session Plénière - Jeff Dahn, Dalhousie University / 2371

Why do lithium-ion batteries eventually die and what to do about the situation.

Author: Jeff Dahn[1]

[1] *Dalhousie University*

Corresponding Author: jeff.dahn@dal.ca

Lithium-ion batteries used in smart phones last several years. However, they must last at least a decade in electric vehicles and many decades in electrical energy storage systems. In this lecture I will explain why Li-ion batteries eventually fail and introduce simple methods we have invented to rank lithium-ion cell lifetime in experiments that only take a few weeks. These simple methods are crucial for researchers, battery manufacturers and users who cannot test new battery chemistries for years and years to identify better batteries.

Joint CINP-IPP Meeting / Réunion conjointe de l'ICPN et de l'IPP (DPN-PPD) / 2372

NSERC SAPES Chair Report

Corresponding Author: j.martin@uwinnipeg.ca

30 min presentation + 5 min questions

Joint CINP-IPP Meeting / Réunion conjointe de l'ICPN et de l'IPP (DPN-PPD) / 2373

CFI Report

Corresponding Author: olivier.gagnon@innovation.ca

20 min presentation + 5 min questions

Joint CINP-IPP Meeting / Réunion conjointe de l'ICPN et de l'IPP (DPN-PPD) / 2374

TRIUMF Director Report

Corresponding Author: bagger@triumf.ca

30 min presentation + 5 min questions

Joint CINP-IPP Meeting / Réunion conjointe de l'ICPN et de l'IPP (DPN-PPD) / 2375

SNOLab Director Report

Corresponding Author: nigel.smith@snolab.ca

R2-3 Laser Physics and Spectroscopy (DAMOPC) | Physique des lasers et spectroscopie (DPAMPC) / 2376**

high precision calculations for tune-out wavelengths in helium as a test of QED

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W1-1 Pattern Formation and Statistical Mechanics of Non-Equilibrium Systems (DCMMP) | Formation de motif et mécanique statistique des systèmes hors d'équilibre (DPMCM) / 2377

Shinning light on surface reactions: Real Time Imaging and Control of Catalytic Reactions

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W-MEDAL2 CAP Lifetime Achievement Medal | Médaille pour contributions exceptionnelles de carrière - Jean-Michel Poutissou, TRIUMF / 2378

Studying the weak interaction with a strong team at TRIUMF

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After briefly tracing the history of my involvement in weak interactions studies at TRIUMF, I will present the prospect for future major advances and opportunities which are available to the younger generation of Canadian physicists. Throughout this talk, neutrinos will take a special role as a unique but elusive tool which has and will continue to shed critical information of the working of our Universe.

I will point out the reward for working in strong partnership and with dedicated colleagues worldwide as a way to advance fundamental knowledge and to contribute to a better society.

IPP AGM | AGA de l'IPP / 2379

Technical Resources

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