2022 CAP Congress / Congrès de l'ACP 2022

Sunday, 5 June 2022 - Saturday, 11 June 2022

McMaster University

Programme

Table of contents

Sunday, 5 June 2022

Congress Registration | Inscription au congrès (12:00 - 15:00 and 18h30 - 21h00) - MDCL Lobby (14:35 - 15:00)

Graduate Student Workshop (TBD) | Atelier pour les étudiant(e)s diplômé(e)s - Building ABB 136, Physics & Astronomy Dept. (15:00 - 18:00)

-Conveners: Suen, Cissy (University of British Columbia (Quantum Matter Institute), Max Planck Institute for Solid State Research, Advanced Light Source (Lawrence Berkeley National Laboratory))

CAP Board, Council and Friends Social | Réunion du conseil d'administration, du conseil et des amis de l'ACP - The Phoenix Bar and Grill (16:00 - 18:00)

-Conveners: Paranjape, Manu (Université de Montréal)

CAP Past Presidents' Working Dinner Meeting | Réunion et souper des ancien(ne)s président(e)s de l'ACP - The Phoenix Bar and Grill, Alcove (18:00 - 20:00)

-Conveners: Manu Paranjape

Monday, 6 June 2022

Congress Registration and Information (07h30-17h30) | Inscription au congrès et information (07h30-17h30) - MDCL Lobby (07:05 - 07:30)

CNILC Breakfast Meeting | Réunion du comité de liaison national canadien de l'UIPPA - MDCL 2230 (07:30 - 08:30)

-Conveners: Rituparna Kanungo

Congress Welcoming Remarks | Ouverture du Congrès - MDCL 1305/07 (08:30 - 08:45)

High School / Cégep Teachers' Day Workshop (08h45-15h15) - MDCL Lobby then LRW Building (08:45 - 16:00)

-Conveners: Schmidt, Miranda (McMaster University); Reza Nejat; Meyer, Chris (Toronto District School Board, Canada)

M-PLEN1 - Plenary Session | Session plénière - Jane Heffernan - MDCL 1305/07 (08:45 - 09:30)

-Conveners: Cornelia Hoehr

[3025] Mathematical Modelling of COVID-19 (08:45, 45 minutes)

Presenter: HEFFERNAN, Jane (York University Department of Mathematics and Statistics)

COVID-19 has plagued the globe. Mathematical models have been used to inform public health decision makers various global regions. In Canada, non-pharmaceutical intervention and vaccination programming were informed by modelling forecasts. In this talk we will review COVID-19 in Canada. We will then introduce mathematical models that have been used during the pandemic. Mathematical models of immunity will be presented, which quantify immunity protection by Canadian region.

M-PLEN2 Plenary Session | Session plénière - Arthi Jayaraman - MDCL 1305/07 (09:30 - 10:15)

-Conveners: Robert Wickham

[3023] Combining modelling, theory, and simulations with experiments for design and structural characterization of soft materials (09:30, 45 minutes)

Presenter: JAYARAMAN, Arthi (University of Delaware)

My research group focuses on development and application of molecular models, liquid state theory, molecular simulation, and machine learning for studying soft macromolecular materials. In this lecture I will share examples of how we develop appropriate molecular models and use them with computational methods to better understand and predict effects of polymer design on the resulting macromolecular material structure and thermodynamics. I will also share experimental work from our collaborators that help us validate our model and computational methods as well as confirm our computational predictions.

Health Break (Travel time to technical sessions) | Pause santé (Transfert vers les sessions techniques) - MDCL Hallways (10:15 - 10:45)

M1-3 Imaging - MRI (DPMB) I Imagerie - IRM (DPMB) - MDCL 1102 (10:45 - 12:15)

-Conveners: Cornelia Hoehr

[3443] (I) On oxygen-enhanced MRI in the tumor microenvironment (10:45, 30 minutes)

Presenter: REINSBERG, Stefan Alexander (The University of British Columbia)

Low oxygen tension in tumour tissue has long been recognized as an indicator of poor outcomes and, independently, as an obstacle to effective treatment with radiation and chemotherapy drugs. Consequently, the search for non-invasive imaging techniques has been ongoing to guide diagnosis and monitor treatments. Dynamic contrast-enhanced MRI has seen the most widespread use but only visualizes a related, not overly direct measurement of blood supply. More recently attempts to measure oxygen saturation in tissue using MRI have been deployed with varying success. One vexing issue in TOLD (T1) and BOLD (T2*) experiments has been the many confounding influences on contrast. We present a method of imaging the presence of oxygen more directly in tissue of tumour models using a dynamic oxygen-enhanced MRI imaging technique in the presence of a repeated oxygen gas challenge. Since many factors influence the T1-weighted signal intensity over the course of minutes, we use independent component analysis to separate the response to increased oxygen in the tumour microenvironment. We have now tested our technique in a range of tumour models and compared to a ground truth of hypoxia status using pimonidazole staining on histology slices. A remaining question of interest is the underlying cause of oxygen-mediated T1 changes: To what degree are there oxygen-modulated perfusion changes or true variations in the amount of tissue-dissolved, available oxygen? To elucidate this we are now also embarking on a simultaneous, dynamic measurement of T2*.

[3278] (G*) Multicomponent T1 Magnetic Resonance Relaxometry with Neural Networks (11:15, 15 minutes)

Presenter: Mr PARASRAM, Tristhal (University of Windsor)

Magnetic resonance imaging (MRI) is widely used as a non-invasive diagnostic technique to visualize the internal structure of biological systems. Quantitative analysis of the T1 magnetic resonance (MR) relaxation time could reveal microscopic properties and has significance in the study of biological tissues such as the brain, heart, and tumors. A multicomponent model, with a continuous relaxation spectrum, requires exponential analysis which is an intrinsically ill-posed problem. Traditional methods to determine multicomponent T1 spectra require high quality data and are computationally intensive. With magnitude data, an additional phase correction pre-processing step is required which may lead to large errors with few input data points. A large number of data points and high signal-to-noise ratio (SNR) result in long acquisition times. Extending our previous work using neural networks for exponential analysis, artificial neural networks (ANNs) have been trained to generate the multicomponent T1 distribution spectra with as few as 8 input data points and reduced SNR. Deep learning with ANNs is a technique for solving complex nonlinear problems. The performance of the optimized ANNs was evaluated across a large parameter range and compared to traditional methods. In addition to superior computation speed, a higher accuracy was achieved. No phase correction or user-defined parameters were required. This improved performance, with a significantly reduced number of input data points, will enable faster multicomponent relaxation experiments. The proposed method for exponential analysis is not restricted to magnetic resonance. It is readily applicable in other areas with exponential analysis and can be extended to higher dimensional spectra. It can also be adapted to solve other ill-posed problems.

[3379] (G*) Novel Accelerated Imaging Method for 1H and 129Xe MRI with Deep Learning (11:30, 15 minutes)

Presenter: PERRON, Samuel (The University of Western Ontario)

Introduction: Recently, accelerated imaging, using Compressed-Sensing (CS) and fitting to the Stretched-Exponential Model (SEM), has been shown to significantly improve SNR of MRI images without increasing scan duration¹: k-space is undersampled according to high acceleration factors (AF) and averaged together using a specific averaging pattern. A density decay curve can then be fitted and reconstructed using the SEM combined with CS.² Reconstruction artefacts can be minimized or removed using a convolutional neural network.³ **Method:** ¹H MR was performed on a resolution-phantom at the low-field (0.074T) MRI scanner using a home-built RF coil. Using FGRE, 9 2D undersampled k-spaces were acquired for three AFs (7, 10, 14): these were averaged for every unique combination of images without overlap, resulting in 14 k-spaces total (2 combinations for 4 averages, etc.). Nine fully-sampled 2D human lung images were acquired at 3.0 T using inhaled hyperpolarized ¹²⁹Xe (35%); these were averaged using the previously-described pattern, and retroactively undersampled for 3 Cartesian sampling schemes (FGRE, x-Centric⁴, & 8-sector FE Sectoral⁵). The SNR attenuation is assumed to represent a decrease of the resonant isotope density in phantom after diluting it with the non-resonant isotope. For both phantom and lung images, the resulting signal decay (density) curve was fitted using the Abascal method.² A 3-stage U-Net was developed to generate artefact masks (segmentation), and applied to phantom data to remove artefacts. **Results:** The reconstructed human lung images saw 4-5x higher SNR (>21 for all sampling schemes) compared to the original non-averaged images (SNR=6). FE-Sectoral featured less artefacts than FGRE and x-Centric. **Conclusion:** In all cases, this technique resulted in 4-5x higher SNR without increasing scan duration; although only a third of a typical ¹²⁹Xe dose was used, the human lung images still saw large SNR gains. The artefact removal neural network was able to remove reconstruction artefacts from AF=7 phantom images, but suffered at higher AFs. These improvements in SNR permit the use of a smaller xenon dose, significantly reducing scan costs. **References:** **1** Perron et al. ISMRM (2021); **2** Abascal et al. IEEE Trans Med Imaging (2018); **3** Lee et al. MRM (2017); **4** Ouriadov et al. MRM (2017); **5** Khrapitchev et al. JMR (2006)

[3279] (G*) Optimized Phase Cycling for Coherence Pathway Cancelation in Magnetic Resonance Imaging (11:45, 15 minutes)

Presenter: ARMSTRONG, Mark (University of Windsor)

Magnetic Resonance Imaging (MRI) is a non-invasive imaging modality which provides excellent soft tissue contrast. An MR echo signal can be generated by an excitation and a refocusing radiofrequency (RF) pulse, where spatial encoding is achieved by applying magnetic field gradients that create signal phase evolution at different spatial locations. A train of echoes can be generated with multiple refocusing RF pulses to acquire images more rapidly. However, non-ideal refocusing RF pulses result in multiple coherence pathways in the echo signals, leading to image artifacts. The Rapid Acquisition with Relaxation Enhancement (RARE) method used crusher gradients to remove the unwanted coherence pathways. Balanced imaging gradients within each echo interval were employed for a net zero phase evolution due to spatial encoding gradients. The high amplitude gradient pulses limit the echo spacing which affects the MRI image contrast, resolution and signal-to-noise ratio. High levels of gradient switching can reduce image quality, create acoustic noise, and cause peripheral nerve stimulation. In this work, we propose to employ RF phase cycling to eliminate the coherence pathway artifacts and reduce the magnetic field gradient duty cycle. The phase cycling schemes were determined through an optimization procedure. The method was applied to both 2D and 3D imaging sequences and compared to conventional balanced RARE sequences.

M1-10 Fields, Particles, and Strings I (DTP) | Champs, particules et cordes I (DPT) - MDCL 1115 (10:45 - 12:15)

-Conveners: Walton, Mark (University of Lethbridge)

[3092] (G*) New BPS Gravitational Solitons in Anti-de Sitter Spacetimes (10:45, 15 minutes)

Presenter: DURGUT, Turkuler

Gravitational solitons are globally stationary, geodesically complete spacetimes with positive energy. These event-horizonless geometries do not exist in the electrovacuum by the classic Lichnerowicz Theorem. However, gravitational solitons exist when there are non-Abelian gauge fields in higher dimensions. In this talk, I will present a new class of supersymmetric asymptotically globally Anti-de Sitter gravitational solitons. I will then show that they contain evanescent ergosurfaces, a timelike hypersurface where the timelike Killing vector field becomes null. The presence of this hypersurface strongly suggests nonlinear instability due to the stable trapping phenomena. I will present an analytical argument for the derivation of this nonlinear instability. This is joint work with Dr. Hari K. Kunduri.

[3177] (G*) Schwinger pair production - from fall to infinity to fall to the centre (11:00, 15 minutes)

Presenter: SUNDARAM, Sriram (McMaster University)

The vacuum instability in the presence of a static electric field that creates charged pairs is termed as Schwinger pair creation. The classical field theory of Schwinger pair creation can be described using an effective Schr\"{o}dinger equation with an inverted harmonic oscillator (IHO) Hamiltonian which exhibits fall to infinity[1]. In this talk we demonstrate that the classical field theory of Schwinger pair creation has a hidden scale invariance described by the quantum mechanics of an attractive inverse square potential in the canonically rotated (Q,P) coordinates of the inverted harmonic oscillator. The quantum mechanics of the inverse square potential is well known for the problem of fall to the centre and the associated ambiguities in the boundary condition. The physics of inverse square potentials appears in various problems including, pair creation in the presence of an event horizon [3] and black hole decay, optics of Maxwell's fisheye lenses [4] and coherence of sunlight on the earth [5] etc. We use point particle effective field theory (PPEFT) to derive the boundary condition which describes pair creation. This leads to the addition of an inevitable Dirac delta function with a complex coupling to the inverse square potential, describing the physics of the source that runs in the.sense of renormalization group. The complex coupling gives rise to conservation loss or gain at the centre which is physically due to charged pairs being produced in Schwinger pair production. References : [1.] R. Brout, S. Massar, R. Parentani, and P. Spindel, Physics Reports 260, 329 (1995). [2.] N. Balazs and A. Voros, Annals of Physics 199, 123 (1990). [3.] K. Srinivasan and T. Padmanabhan, Physical Review D 60, 024007 (1999). [4.] U.Leonhardt, New J. Phys. 11 093040 (2009). [5.] S. Sundaram and P. K. Panigrahi, Optics Letters, 41(18) 4222 - 4224, (2016).

[3098] (I) String Theory, Antisymmetric Tensor Fields and Dark Matter (11:15, 30 minutes)

Presenter: Dr DICK, Rainer (University of Saskatchewan)

Antisymmetric tensor fields are an unavoidable prediction from string theory that adds to the theory's set of unique signatures. After a brief review of the emergence of antisymmetric tensor fields and of other possible string signatures, we will focus on the possible implications of antisymmetric tensor fields for particle physics and dark matter research.

[3346] A Little Excitement Across the Horizon (11:45, 15 minutes)

Presenter: Dr NG, Keith (Nanyang Technological University)

I report on the results of the first analysis of a time-and-space localised quantum system crossing the horizon of a (3+1)-dimensional black hole. We analyse numerically the transitions in an Unruh-DeWitt detector, coupled linearly to a massless scalar field, in radial infall toward a (3+1)-dimensional Schwarzschild black hole. In the Hartle-Hawking and Unruh states, the transition probability attains a small local extremum near the horizon-crossing and is then moderately enhanced on approaching the singularity. In the Boulware state, the transi- tion probability drops on approaching the horizon.

[3014] Non-standard Inflation and Quantum Gravity (12:00, 15 minutes)

Presenter: KAMALI, Vahid

There are some conjectures in the context of string theory related to the effective field theories (EFT) looking consistent with quantum gravity. Early time cosmology contains gravity as well as quantum field theory. It was speculated that some EFTs which seem to be consistent with quantum gravity are not in the landscape of string theory. An important model out of these conjectures will be discussed in my presentation.

M1-9 Exploring the Energy and Precision Frontier I (PPD) | Exploration de la frontière d'énergie et de précision I (PPD) - MDCL 1105 (10:45 - 12:30)

-Conveners: Pachal, Kate (TRIUMF)

[3037] (G*) Measurement of the W Boson Drell-Yan Angular Coefficients with the ATLAS detector (10:45, 15 minutes)

Presenter: BACHIU, Alexander (Carleton University (CA))

The Large Hadron Collider located at CERN outside of Geneva, Switzerland uses proton-proton collisions to produce a wide range of particles. W and Z bosons, the mediators of the fundamental weak force, are some of the particles that can be produced in proton-proton collisions and can be used to give a more complete understanding of the Standard Model. One of the ways they can decay is into detectable lepton particles, such as electrons, which can be measured with the ATLAS (A Toroidal LHC ApparatuS) detector. The Drell-Yan process is the production of W/Z bosons in proton-proton interactions with leptonic final states. Its differential cross-section expresses the probability for this process to occur depending on the W/Z bosons' and decay products' kinematic variables. It can be separated into eight spin-related ratios, known as the Drell-Yan angular coefficients. The coefficients are coupled to trigonometric polynomials which contain information about the detected leptons. Using the property that the polynomials are orthogonal to each other, it is possible to isolate each coefficient. All eight of the coefficients for the Z boson have been measured, while only two of these coefficients for the W boson have been measured with limited precision. One reason for this difference is that there is added difficulty for the W boson case as it requires reconstructing the neutrino which goes undetected. This talk will cover my research towards measuring these coefficients for the W boson with special low pileup data sets, which aid in reconstructing the neutrino. This measurement gives both a unique result for many of the coefficients as well as it helps reduce the uncertainty for other measurements like the mass of the W boson.

[3110] (G*) A study of hadronic tagged $B\rightarrow D^{(*)}\ell \nu$ at the Belle II experiment (11:00, 15 minutes)

Presenter: WAKELING, Hannah (McGill University)

With only 0.5% of the full projected $50\,\textrm{ab}^{-1}$ dataset, the Belle II detector is already a competitive high luminosity environment in which to study B decays with missing energy. At a centre of mass energy of the $\Upsilon(4S)$ resonance, Belle II is a B factory, producing approximately 1.1×10^9 $B\bar{B}$ pairs per $\textrm{ab}^{-1}$. Precise knowledge of one fully reconstructed B meson through the hadronic Full Event Interpretation (FEI) tagging algorithm provides strong constraints for any signal decay studied using the other B meson in the $B\bar{B}$ pair. In this talk, recent measurements of the signal decay $B\rightarrow D^{(*)}\ell \nu$ will be examined alongside the prospects of the $R(D)$ and $R(D^{*})$ measurements, in which Belle II anticipates a result of unprecedented precision with as little as $5\,\mbox{ab}^{-1}$ of data, and a sensitivity that could exhibit indirect New Physics effects.

[3163] (G*) Pion background measurement and correction in the MOLLER Experiment at Jefferson lab (11:15, 15 minutes)

Presenter: Ms GORGANNEJAD, Fatemeh (University of Manitoba)

The Measurement of a Lepton Lepton Electroweak Reaction (MOLLER) Experiment at Jefferson lab will search for new dynamics beyond the Standard Model at low (~100 MeV) and high energies (multi-TeV). MOLLER will measure the parity-violating asymmetry (APV) in the scattering of longitudinally polarized electrons from unpolarized target electrons to an accuracy of 2.4% using an 11 GeV beam in Hall A at Thomas Jefferson National Accelerator Facility. To achieve the expected precision, experimental corrections to the measured asymmetries are required to account for background processes characterized by fractional dilution factors and background asymmetries. Pion dilution factors and asymmetries have significant contributions to the experimental corrections and will be measured in a dedicated pion detector system. The University of Manitoba has been designing, developing, and constructing the pion detector system for MOLLER experiment. The Geant4 simulation toolkit is used to determine the optimal geometry and position of the pion detector system to maximize the signal from pions. To improve the understanding of uncertainties introduced by experimental corrections, a Bayesian analysis method is investigated to complement the commonly used frequentist methods for background corrections in parity-violating electron scattering experiments. We anticipate that this will allow for a better assessment of the uncertainties in the corrections. This talk will review the MOLLER experiment and the optimization process for the pion detector system. Also, the idea of using the Bayesian method for the experimental corrections will be introduced.

[3165] (G*) Search for multiquark states decaying to neutral strange particles: K_s^0 and Λ^0 (or $\bar{\Lambda^0}$ (11:30, 15 minutes)

Presenter: PAUL, Antara (McGill University, (CA))

Conventional matter consists of mesons, made of two quarks or baryons, made of three quarks. However, the Standard Model of Particle Physics does not forbid particles consisting of more than three quarks. This analysis focuses on the search for possible exotic hadronic states using strange particles, the kaon meson (K_s^0) and the lambda baryon (Λ^0 or $\bar{\Lambda^{0}}$) with the ATLAS Run 2 data. Bump searching techniques are to be performed on the invariant $K_s^0 K_s^0$, $K_s^0 \Lambda^0$ and $\Lambda^{0} \Lambda^0$ mass spectra to look for possible multiquark states. Summary of the ongoing analysis including the background studies will be presented in the talk.

[3193] (G*) Study of the combined performance of the Digital Hadronic Calorimeter and Si-W Electromagnetic Calorimeter for the CALICE R&D; Collaboration (11:45, 15 minutes)

Presenter: Ms ALMANZA SOTO, Melissa (McGill University)

The Digital Hadronic Calorimeter (DHCAL) and the Silicon-Tungsten Electromagnetic Calorimeter (Si-W ECAL) are both CALICE prototypes originally meant for the International Linear Collider (ILC) experiments. The analysis of the combined response to different particles will be presented. The data was obtained from test runs at Fermilab in 2011. The linearity, energy and spatial resolutions results will be shown, as well as the calibration and alignment of the detectors. Both DHCAL and Si-W ECAL are fine-layered high-granularity detectors with 1cm x 1cm pixel sizes, which allows for much-improved tracking and particle identification, thus for the application of modern particle flow algorithms.

[3519] (I) 2022 CAP Thesis Prize Winner -- Dominique Trischuk (12:00, 30 minutes)

M1-7 Quantum Materials I (DCMMP) | Matériaux quantiques I (DPMCM) - MDCL 1010 (10:45 - 12:15)

-Conveners: Mark Gallagher

[3425] (I) Quantum materials at the atomic scale (10:45, 30 minutes)

Presenter: LUICAN-MAYER, Adina (University of Ottawa)

Understanding and controlling the properties of 2D materials to our advantage can be contemplated with the development of experimental tools to probe and manipulate electrons and their interactions at the atomic scale. In this talk, I will present scanning tunnelling microscopy and spectroscopy experiments aimed at: elucidating the nature of atomic-scale defects in 2D materials [1], visualizing moiré patterns between crystals with different symmetries [2] and imaging surface and edge states in a magnetic topological system. Moreover, I will discuss how we leverage our expertise in probing and engineering electronic states at surfaces of 2D materials to further the development of graphene-based gas sensors [3] and gated quantum dot circuits based on 2D semiconductors [4]. [1] Plumadore et al., PRB, (2020) [2] Plumadore et al., Journal of Applied Physics, (2020) [3] Park et al., ACS Applied Materials & Interfaces (2021) [4] Boddison-Chouinard, Appl. Phys. Lett., (2021)

[3429] (I) Formation of 1D and 2D carbon-based nanomaterials on surfaces (11:15, 30 minutes)

Presenter: EBRAHIMI, Maryam (Lakehead University)

The growing interest in nanostructured materials stems from their remarkable properties, such as high conductivity, heat transfer, mechanical and chemical stability, and emerging quantum properties, arising from reduced dimensionality. These exceptional properties have made graphene, the only 2D material in nature, the focus of significant academic research over the past two decades.

However, the lack of an electronic bandgap limits its use in electronic applications. This limitation has motivated interdisciplinary research at the intersection of condensed-matter physics, physical chemistry, and materials science to identify ways to design and create candidate nanomaterials with engineered bandgap and electron-spin sites for quantum processors. Our research focuses on the surface-confined reactions to design molecular-based low-dimensional nanomaterials whose electronic properties can be tailored by their structural design, morphology, dimension, size, building blocks, and the chemical nature of the bonds which hold them together. We present various surface reactions for creating 1D and 2D polymers, metal-organic networks, and organometallic structures on noble metal single crystal surfaces. To identify their morphology and chemical nature, we employ scanning tunnelling microscopy and non-contact atomic force microscopy, and other surface characterization techniques, such as X-ray photoelectron spectroscopy, complemented with density functional theory calculations. Our research benefits from an interdisciplinary approach for the rational design of electronic structures, known as **band-structure engineering**. The electronic properties of 1D and 2D nanomaterials can be tailored for smaller and faster transistors, or for quantum processors in carbon-based nanoelectronics. **References** [1] M. Ebrahimi, F. Rosei, Nature 542 (2017) 423-424 (News & Views) [2] M. Ebrahimi, Nature Chemistry (2021) https://doi.org/10.1038/s41557-021-00868-y [3] D. P. Goronzy et al., ACS Nano 12 (2018) 7445-7481 [3] M. Ebrahimi et al., Journal of the American Chemical Society 133 (2011) 16560-16565 [4] G. Galeotti et al., Faraday Discussions 204 (2017) 453-469 [5] F. De Marchi et al., Nanoscale 10 (2018) 16721-16729 [6] G. Galeotti et al., Chemical Science 10 (2019) 5167-5175 [7] C. Jing et al., Angewandte Chemie International Edition 58 (2019) 18948-18956 [8] G. Galeotti et al., Nature Materials 19 (2020) 874-880 [9] P. Ji et al., Small 16 (2020) 2002393 [10]. N. Cao et al., Nanoscale 13 (2021) 19884-19889

[3426] (I) Charge Transfer Processes in Molecularly Doped Organic Semiconductors (11:45, 30 minutes)

Presenter: Prof. SALZMANN, Ingo (Concordia University)

The doping of conjugated polymers and molecules forming the material class of organic semiconductors (OSCs) is routinely performed to tune their electric properties and electronic structure to meet application specific demands. P-doping is done by adding molecular electron acceptors to initiate charge transfer with the OSC host. The efficiency of this process is found to depend subtly on the degree of charge transfer, the dopant strength and molecular shape, the OSC conjugation length, and the OSC structure upon doping. I will provide an overview of the current understanding of the various phenomena associated with the p-doping of OSCs and discuss parameters that govern the degree of charge transfer (fractional versus integer), focusing on oligothiophenes of chain lengths towards the polymer limit.

M1-1 Dark Matter Experiments I (PPD) | Expériences sur la matière sombre I (PPD) - MDCL 1309 (10:45 - 12:15)

-Conveners: Hartz, Mark Patrick (TRIUMF & Kavli IPMU, University of Tokyo)

[3064] (I) Detecting Dark Matter (10:45, 30 minutes)

Presenter: Prof. PIRO, Marie-Cécile (University of Alberta)

Astronomical and cosmological observations strongly suggest that most of the matter in our Universe is non-luminous and made of an unknown substance called Dark Matter. But, currently, it remains invisible and undetectable directly on Earth and makes it one of the greatest mysteries in particle physics. Even if its direct detection escapes to the scientific community in our time, dark matter remains a fundamental concept that would explain how our Universe was formed and offer a unique chance to discover physics beyond the Standard Model. Many worldwide experiments are actively searching for dark matter to understand its properties. After presenting how we can detect it directly, I will give an overview of cutting-edge technologies used by particle physicists focusing on the challenges we are currently facing and the need for innovative tools to improve the sensitivity of measurements at low energies.

[3027] (G*) CUTE: An Overview and Applications to SuperCDMS (11:15, 15 minutes)

Presenter: PRADEEP, Aditi

Cryogenic detectors offer excellent resolution and sensitivity for low mass dark matter searches but require testing in a well-shielded, low background environment for complete characterization. The Cryogenic Underground TEst (CUTE) facility is located 2 km underground in SNOLAB near Sudbury, ON. CUTE has served as a well-shielded, low background site for the testing, characterization and optimization of Super Cryogenic Dark Matter Search (SuperCDMS) detectors, since 2019. The low background at the facility combined with the low threshold of the new SuperCDMS detectors leaves the door open for competitive dark matter searches at CUTE. This talk will present an overview of the CUTE facility, a progress report of detector testing and measurements done to date and exciting plans for the upcoming testing of the first SuperCDMS detector tower at CUTE.

[3081] (G*) 39Ar decay analysis and annual modulation search with DEAP-3600 (11:30, 15 minutes)

Presenter: Ms KAUR, Gurpreet

DEAP-3600 is a single-phase dark matter experiment looking at direct detection elastic nuclear scatters of the dark matter candidate, Weakly Interacting Massive Particles (WIMPs), with 3279 kg of liquid argon. The DEAP detector has recorded more than 3 years of physics data, and in addition to the direct search of dark matter, the collaboration is also working to extend the sensitivity of the detector by looking for annual modulation of the signal. The absolute stability of the detector and the detailed understanding of the detector systematics over the time of data collection allows the analysis of event rates in the detector data, which also compliments many other interesting physics analyses, such as a precise measurement of the lifetime of the 39Ar isotope. In this talk, the stability of the DEAP-3600 detector with some preliminary measurements for the 39Ar lifetime analysis and modulation analysis will be presented.

[3167] SuperCDMS IMPACT: Measuring the sub-keV Ionization Yield in Cryogenic Solid-State Detectors (11:45, 15 minutes)

Presenter: REYNOLDS, Tyler (University of Toronto)

The SuperCDMS collaboration uses cryogenic silicon and germanium detectors to directly search for dark matter. Dark matter particles in the mass range of 1-10 GeV/c^2 interacting via nuclear recoils would deposit energies below 1 keV. Such interactions produce both phonons and electron-hole pairs. The number of electron-hole pairs produced per unit energy deposited in an electron recoil, called the ionization yield, is a critical quantity for reconstructing the recoil energy and properly modeling the dark matter signal. However, the ionization yield has not been well-characterized for sub-keV nuclear recoils. IMPACT is a neutron scattering measurement campaign that aims to measure the ionization yield in Si and Ge down to 100 eV recoil energies. This talk will describe the first data taking campaign at the Triangle Universities Nuclear Laboratory using a Si detector and present the results obtained from the data.

[3176] (G*) Projected Sensitivities for Future Upgrade Scenarios of SuperCDMS SNOLAB (12:00, 15 minutes)

Presenter: FASCIONE, Eleanor

The Super Cryogenic Dark Matter Search (SuperCDMS) Collaboration uses cryogenic semiconductor detectors to look for evidence of dark matter interactions with ordinary matter. The current generation is under construction at SNOLAB, and will use two target materials (silicon and germanium) and two detector types (HV and iZIP) to probe low mass dark matter. For potential future upgrades, SuperCDMS is exploring possibilities in both reducing known background contributions and improving detector performance. Multiple detector optimization scenarios have been modelled, with various detector sizes and sensor configurations, to enhance detector resolution and background discrimination ability. This talk will describe sensitivity projections for such future upgrades. Forecasts for nucleon-coupled dark matter (5 MeV/c^2 - 5 GeV/c^2), dark photon-coupled light dark matter (1 - 100 MeV/c^2), and dark photons and axion-like-particles (1 - 100 eV/c^2) will be shown.

M1-8 Statistical physics and biology (DCMMP) | Physique statistique et biologie (DPMCM) - MDCL 1116 (10:45 - 12:15)

-Conveners: James Polson

[3419] (I) Dynamical mean-field theory: from ecosystems to reaction networks (10:45, 30 minutes)

Presenter: DE GIULI, Eric (Ryerson)

Both natural ecosystems and biochemical reaction networks involve populations of heterogeneous agents whose cooperative and competitive interactions lead to a rich dynamics of species' abundances, albeit at vastly different scales. The maintenance of diversity in large ecosystems is a longstanding puzzle, towards which recent progress has been made by the derivation of dynamical mean-field theories of random models. In particular, it has recently been shown that these random models have a chaotic phase in which abundances display wild fluctuations. When modest spatial structure is included, these fluctuations are stabilized and diversity is maintained. If and how these phenomena have parallels in biochemical reaction networks is currently unknown, but is of obvious interest since life requires cooperation among a large number of molecular species, and the origin of life is hotly debated. To connect these phenomena, in this work we find a reaction network whose large-scale behavior precisely recovers the random Lotka-Volterra model considered recently. This clarifies the assumptions necessary to obtain a reduced large-scale description, and shows how the noise must be approximated to recover the previous mean-field theories. Then, we show how local detailed balance and the positivity of reaction rates, which are key physical requirements of chemical reaction networks, provide obstructions towards the construction of an associated dynamical mean-field theory of biochemical reaction networks. We outline prospects and challenges for the future, and argue for a synthetic approach to a physical theory of the origin of life.

[3090] (G*) Random Asymmetric Markov Models (11:15, 15 minutes)

Presenter: MOSAM, Faheem (Ryerson University)

Biological systems need to react to stimuli over a broad spectrum of timescales. If and how this ability can emerge without external fine-tuning is a puzzle. This problem has been considered in discrete Markovian systems where results from random matrix theory could be leveraged. Indeed, generic large transition matrices are governed by universal results, which predict the absence of long timescales unless fine-tuned. Previous work has considered an ensemble of transition matrices and motivated a temperature-like variable that controls the dynamic range of matrix elements. Findings were applied to fMRI data from 820 human subjects scanned at wakeful rest. The data was quantitatively understood in terms of the random model, and brain activity was shown to lie close to a phase transition when engaged in unconstrained, task-free cognition – supporting the brain criticality hypothesis in this context. In this work, the model is advanced in order to discuss the effect of matrix asymmetry, which controls entropy production, on the previous results. We introduce a new parameter that controls the asymmetry of these discrete Markovian systems and show that when varied over an appropriate scale this factor is able to collapse Shannon entropy measures. This collapse indicates that structure emerges over a dynamic range of both temperatures and asymmetry, and allows a phase diagram of temperature in discrete Markovian systems to be produced.

[3119] (G*) Entropy, Networks, and Design (11:30, 15 minutes)

Presenter: CHITNELAWONG, Pheerawich (Queen's University)

Some of the most intriguing thermodynamic phases in nature involve an interplay between multiple types of degrees of freedom. However, multiple types of degrees of freedom are also a common feature of design problems in distributed systems that can be cast in terms of complex networks. Here, we show that generic network models of design exhibit an intricate interplay between configurational and conformational entropy. This interplay produces behaviours in non-matter systems that have direct analogues in conventional condensed matter. We give concrete illustrations of these behaviours using a model drawn from naval architecture, but our results have implications for distributed systems more generally. Our framework provides new tools for describing how competing degrees of freedom shape the space of design choices in complex systems.

[2986] (G*) Dynamics of exciton polaron in microtubule (11:45, 15 minutes)

Presenter: Mr NGANFO YIFOUE, Willy Aniset (Université de Dschang)

In this paper, we study the dynamical properties of the exciton-polaron in the microtubule. The study was carried out using a unitary transformation and an approximate diagonalization technique. Analytically, the modeling of exciton-polaron dynamics in microtubules is presented. From this model, the ground state energy, mobility, and entropy of the exciton-polaron are derived as a function of microtubule’s parameters. Numerical results show that, depending on the three vibrational modes (protofilament, helix, antihelix) in MTs, exciton-polaron energy is anisotropic and is more present on the protofilament than the helix and absent on the antihelix. Taking into account the variation of the protofilament vibrations by fixing the helix vibrations, exciton-polaron moves between the 1st and 2nd protofilaments. It is seen that the variation of the two vibrations induces mobility of the quasiparticle between the 1st and 15th protofilament. This result points out the importance of helix vibrations on the dynamics of quasiparticles. It is observed that the mobility of the exciton polaron and the entropy of the system are strongly influenced by the vibrations through the protofilament and helix. The effects of the one through the antihelix is negligible. The entropy of the system is similar to that of mobility. Confirming that the quasiparticles move in the protofilament faster than in the helix.

[3431] Modelling finger-like pattern formation in a bacteria colony growing at an interface using dynamical self-consistent field theory (12:00, 15 minutes)

Presenter: Prof. WICKHAM, Robert (University of Guelph)

Fascinating finger-like patterns are observed at the edge of *Pseudomonas aeruginosa* bacteria colonies that grow at the effectively two-dimensional interface between agar and glass. We study this pattern formation phenomenon by simulating a dynamical self-consistent field theory. The twitching bacteria are modelled as self-propelled rods pushing against the agar-glass adhesion force, represented as a bath of passive particles. We show that a perturbation to a flat interface between uniform agar and bacteria, which are aligned perpendicular to the interface, is unstable. Fingers emerge from the interface as regular regions of dense, polar-aligned rods that move along the finger axis. By introducing a random spatial variation into our model for the strength of the agar adhesion with the glass, we are able to produce more realistic irregular finger patterns, similar to those observed in experiment. We discuss the impact of various model parameters on the finger properties and propose an interpretation for some of the trends seen in these properties as the agar concentration is varied in experiment.

M1-2 Gravity and Cosmology I (DTP) | Gravité et cosmologie I (DPT) - MDCL 1008 (10:45 - 12:15)

-Conveners: Sanjeev Seahra

[2993] (I) The Hubble tension and the magnetic universe (10:45, 30 minutes)

Presenter: POGOSIAN, Levon

Magnetic fields, if present in the primordial plasma prior to last scattering, would induce baryon inhomogeneities and speed up the recombination process. As a consequence, the sound horizon at last scattering would be smaller, which would help relieve the Hubble tension. Intriguingly, the strength of the magnetic field required to alleviate the Hubble tension happens to be of the right order of magnitude to also explain the observed magnetic fields in galaxies, clusters of galaxies and the intergalactic space. I will review this proposal and provide an update on its status in the context of the latest data.

[3272] (G*) The galactic white-dwarf population from the CLAUDS deep fields (11:15, 15 minutes)

Presenter: Mr RIPOCHE, Paul

The Canada-France-Hawaii Telescope (CFHT) Large Area U-band Deep Survey (CLAUDS) produces images to a median depth of $U=27.1$ AB. These U-band images are the deepest ever assembled over such a large area. The catalogue resulting from this survey contains a little more than 10,000,000 objects. Our goal is to identify white dwarfs from the CLAUDS deep fields and to study their physical properties and spatial distribution, in the Milky Way. Considering the size of the catalogue, we conduct our search via machine learning. We use the end-to-end open-source platform for machine learning, TensorFlow. Via TensorFlow, we perform a binary classification using deep learning methods. After filtering the white-dwarf candidates, to limit contamination by other objects such as main-sequence stars, we find over 600 white dwarfs. We then determine the physical properties of the white dwarfs, such as surface temperature, distance modulus and age, using cooling models. We then fit for the thin and thick disc scale heights of the white-dwarf space distribution, and we derive the white-dwarf luminosity function. Thanks to the properties of the CLAUDS fields, we provide one of the deepest catalogues of galactic white dwarfs.

[3276] (G*) On the validity of the quasi-static approximation in scalar-tensor theories of Gravity (11:30, 15 minutes)

Presenter: Mr MIRPOORIAN, Hamid (Department of Physics, Simon Fraser University)

The accelerating expansion of the universe has been widely studied beyond the standard $\mathrm{\Lambda}$-cold dark matter model ($\mathrm{\Lambda CDM}$) through modified gravity and dynamical dark energy models. Such modifications of laws of gravity at large scales usually require a new degree of freedom beyond the $\mathrm{\Lambda CDM}$ cosmology. In this work, we utilize the scalar-tensor theories of gravity to study models of scalar field dark energy non-minimally coupled to matter. We focus our study on a symmetron model, which is one of the modified gravity models with a screening mechanism, and provide a detailed analysis to investigate the evolution of the universe via an exact solution of field equations and within the quasi-static approximation (QSA). We consider two scenarios where in one case the scalar field is only coupled to dark matter and in the other it couples to all of the matter. We identify the range of the symmetron model parameters for which the QSA is valid.

[3301] (G*) Cosmology of scalar fields coupled to dark matter and to all matter (11:45, 15 minutes)

Presenter: WANG, Zhuangfei (Simon Fraser University)

Alternative gravity theories have been extensively explored beyond general relativity to study the modified growth of the cosmological perturbations, in which the scalar-tensor theory, with a single scalar field coupled to all of the matter is the most conventional one. MGCAMB, as the public code used to study modifications to the growth structure, has been used to study cosmological predictions of different types of such modified gravity theories. In this work, we extend MGCAMB to include models with a scalar field coupled only to dark mater. We then identify the characteristic observational signatures that could distinguish between the all-matter and the dark matter-only coupled scalar fields.

M1-5 DPE I - Joint with DGEP (DPE/DGEP) | DEP I - conjointement avec DEGP (DEP/DEGP) - MDCL 1009 (10:45 - 12:15)

-Conveners: Daria Ahrensmeier

[3480] (I) Diversifying Talent in Quantum Computing (10:45, 30 minutes)

Presenter: MEYER, Ella (University of British Columbia)

Given the potential impact of quantum computing on many neighboring disciplines of science and engineering, it is key that a diverse talent pool is developed for the future. We have opted to start education and exposure at the K-12 level, with particular focus on underserved demographics, in order to support student's confidence and passion for STEM. In this talk, I will share how we adapted to fully online education, our most successful methods of teaching technical topics to diverse youth, and how we intend to expand our reach to students, teachers and the general public.

[3126] Physical Science in Contemporary Society (11:15, 15 minutes)

Presenter: Dr SEALFON, Carolyn

How do we prepare physics students to grapple with vital questions regarding complex relationships between physics and society? This winter semester, I facilitated for my first time the ethics requirement for physics specialists at the University of Toronto. I will share my course design considerations, lessons learned, useful resources, and invite discussion of the educational implications and responsibilities to place physics in its societal context.

[3087] The IDEAS Initiative (11:30, 15 minutes)

Presenter: TAM, Benjamin (Queen's University)

The Innovation, Diversity, Exploration, and Advancement in STEM (IDEAS) Initiative has recently been launched at Queen's University. The IDEAS Initiative utilizes a multi-generational approach to diversity and outreach, aiming to coordinate historically under-represented individuals within STEM to foster an interest towards the natural sciences in Canadian youths. The IDEAS Initiative is a major EDII and outreach arm of both the Arthur B. McDonald Canadian Astroparticle Physics Research Institute and the Queen's University Department of Physics, Engineering Physics & Astronomy. The IDEAS Initiative has run an extensive suite of outreach programmes following this methodology since 2019.Volunteer scientists lead experiments, projects, and confidence building activities both in-person and online to encourage development of self-identity and a sense of belonging to STEM in the participants. In parallel, the IDEAS Initiative provide opportunities for volunteers to participate in teaching and outreach training workshops as a cornerstone of a network-building objective, which is then utilized to maximize impact. Pedagogy, performance, and future prospects of the IDEAS Initiative will be discussed.

[3371] (G*) STEM for Everyone - Results From a Pilot Intervention to Address the Gender Gap in High School Physics (11:45, 15 minutes)

Presenter: CORRIGAN, Eamonn

During the Winter 2022 semester we have begun the first pilot of STEM for Everyone, a research-based intervention designed to promote the Physics Identity of women and other gender minorities in high school physics classes. For the past 15 years, the median proportion of female physics students across Ontario has remained constant at <35%. This imposes a hard cap on any potential progress to reduce gender inequities for undergraduate programs and beyond. This is why STEM for Everyone has been designed to target high school students, looking to address the long-standing gender gap in high school physics. We will present preliminary results from our pilot project partnering with the Toronto District School Board and select independent schools across Ontario. This includes attitudinal surveys to measure change in Physics Identity, focus groups, and an analysis of enrollment statistics. We will also discuss planned improvements to the program based on student and teacher feedback as we look towards expanding during the 2022-2023 academic year.

[3488] Round Table (12:00, 15 minutes)

TBD

M1-6 Accelerator Developments in Canada (DAPI) | Progrès dans les accélérateurs au Canada (DPAI) - MDCL 1016 (10:45 - 12:15)

-Conveners: Gottberg, Alexander (TRIUMF (CA))

[3368] New CLS e-linac (10:45, 15 minutes)

Presenter: BOLAND, Mark James (University of Saskatchewan (CA))

The Canadian Light Source has been running the 250 MeV electron linac from the 1960s for injecting into the booster synchrotron since 2002. As part of a renewal program, the CLS will be installing a new linac with an RF frequency synchronised to the booster ring. The project is expected to take 3 years to 2025 and lead to improved performance, especially for the recently achieved constant brightness top-up mode. An overview of the requirements and plans for the new linac will be provided.

[3304] Superconducting RF research in Canada (11:00, 15 minutes)

Presenter: LAXDAL, Robert Edward

Superconducting Radio-frequency (SRF) technology using niobium accelerating cavities enables high performance and efficient acceleration for modern accelerator projects. These projects deliver accelerators that serve different fields of science, dominated by sub-atomic physics, photon science and applications. Global R&D in SRF science and technology focusses on: 1) Reducing rf losses, 2) Increasing accelerating gradients 3) Developing new materials beyond Niobium. In Canada, TRIUMF and CLS both utilize SRF technology in their on-site accelerators. TRIUMF has had an active SRF R&D program since 2000 to support the development of in-house accelerators, to support global collaborations and to support student focused fundamental studies. Recent developments together with the U. of Victoria key on the study of coaxial cavities for hadron acceleration as well as the characterization of SRF materials using a variety of material science techniques. In particular, a new beamline has just been commissioned at the beta-NMR facility at TRIUMF for depth resolved studies of the Meissner state at high parallel fields. The talk will give an overview of SRF science and technology in Canada.

[3315] A Prototype Compact Accelerator-based Neutron Source for Canada for Medical and Scientific Applications (11:15, 15 minutes)

Presenter: D. MAHARAJ , Dalini (TRIUMF, Department of Chemistry and Biochemistry, University of Windsor)

Compact Accelerator-based Neutron Sources (CANS) offer the possibility of an intense source of pulsed neutrons with a capital cost significantly lower than spallation sources. In an effort to close the neutron gap in Canada a prototype, Canadian compact accelerator-based neutron source (PC-CANS) is proposed for installation at the University of Windsor. The PC-CANS is envisaged to serve two neutron science instruments, a boron neutron capture therapy (BNCT) station and a beamline for fluorine-18 radioisotope production for positive emission tomography (PET). To serve these diverse applications, a linear accelerator (or, linac) solution is selected, that will provide 10 MeV protons with a peak current of 10 mA within a 5% duty cycle. The accelerator is based on an RFQ and DTL with a post-DTL pulsed kicker system to simultaneously deliver macro-pulses to each end-station. The neutron production targets for both neutron science and BNCT will be of Beryllium and engineered to handle the high beam power density. Conceptual studies of the accelerator and benchmarking studies of neutron production and moderation in FLUKA and MCNP in support of the target-moderator-reflector (TMR) design will be presented.

[3366] The New Electron Source Lab at CLS (11:30, 15 minutes)

Presenter: Dr STRAGIER, Xavier (CLS)

The Canadian Light Source (CLS) has recently created a new Electron Source Laboratory (ESL) . This lab is a cut off section of the linac hall/tunnel that was constructed late 1950's to host the Saskatchewan Accelerator Laboratory experimental nuclear physics. The rebuilt has new shielding and a separate entrance that can accommodate an independent use of the area from the existing linac and can operate an accelerator of up to 100 MeV and . The laboratory will be used to prepare an operational spare electron gun for the existing 250 MeV linac. In addition, there are plans to develop RF electron sources for a future branch line to inject into the linac and for possible short pulse production. This paper will give an overview of the ESL space and the first electron guns which plan to be installed and characterized.

[3374] TRIUMF e-linac as driver for FLASH, DarkLight and ARIEL (11:45, 30 minutes)

Presenter: RÄDEL, Stephanie Diana (TRIUMF)

The linear accelerator for electrons at TRIUMF is one of the main drivers for its Advanced Rare Isotope Laboratory (ARIEL) project. The electron linac was designed and built for this purpose and is in its final commissioning stage with the capability of 10mA 30MeV CW superconducting machine. ARIEL will expand TRIUMF’s ability to produce rare isotope beams. But the potential for the linac is far more than this one purpose. Taking advantage of its design, the e-linac is in a stage to serve the first experiments. These experiments will happen at different energies and different time scales. The FLASH experiment, running at the first acceleration stage, will investigate the influence of short but high intense radiation pulses for cancer therapy. The DarkLight experiment, running at the second acceleration stage, will investigate the possible existence of a dark fifth-force carrier, which could explain the Atomki anomaly.

M1-4 Nuclear Structure and Astrophysics (DNP) | Structure nucléaire et astrophysique (DPN) - MDCL 1110 (10:45 - 12:30)

-Conveners: Liliana Caballero Suarez

[3477] (I) Parity violation measurements of the neutron skin in ^{208}Pb and ^{48}Ca (10:45, 30 minutes)

Presenters: KING, Paul (Ohio University), THE PREX/CREX COLLABORATION

The PREX-II and CREX experiments at Jefferson Lab have completed measurements of the parity violating elastic electron scattering asymmetry from ^{208}Pb and ^{48}Ca targets. These asymmetries are sensitive to the weak charge radius of the nuclei, and thus to the RMS radius of the neutron distribution. In neutron-rich nuclei such as ^{208}Pb and ^{48}Ca, the neutrons extend to larger radii than the protons, forming the neutron skin. Evaluation of the neutron skin in ^{48}Ca provides an important benchmark for nuclear theory, while that of ^{208}Pb provides meaningful constraints to the density dependence of the symmetry energy in neutron rich nuclear matter, a parameter of the nuclear equation of state. A brief discussion of the experimental techniques, analysis, and results of the experiments will be presented, as well as our understanding of the impact regarding nuclear matter systems, from nuclear structure to neutron stars. *We acknowledge the support of the U.S. Department of Energy Office of Science, Office of Nuclear Physics, the National Science Foundation, and NSERC (Canada).

[3143] (G*) Investigating the Nuclear Shell Evolution in Neutron-Rich Calcium (11:15, 15 minutes)

Presenter: COLEMAN, Robin

Nuclei away from the line of stability have been found to demonstrate behavior that is inconsistent with the traditional magic numbers of the spherical shell model. This has led to the concept of the evolution of nuclear shell structure in exotic nuclei, and the neutron-rich Ca isotopes are a key testing ground of these theories; there have been conflicting results from various experiments as to the true nature of a sub-shell closure for neutron-rich nuclei around ^{52}Ca. In November of 2019, an experiment was performed at the ISAC facility of TRIUMF; ^{52}K, ^{53}K, and ^{54}K were delivered to the GRIFFIN gamma-ray spectrometer paired with the SCEPTAR and the ZDS ancillary detectors for beta-tagging, as well as DESCANT for neutron-tagging. Using this powerful combination of detectors, we combine the results to construct level schemes for the isotopes populated in the beta-decay. Preliminary results from the analysis will be presented and discussed in the context of an N=32 shell closure in neutron-rich nuclei.

[3201] (G*) Model constraints for degenerate neutron capture rates in neutron star crusts (11:30, 15 minutes)

Presenter: KNIGHT, Bryn

Heavy element synthesis within stellar bodies typically manifests in explosive environments such as neutron star mergers. However, at the low temperature and high density conditions of a neutron star crust, degenerate neutrons provide alternate synthesis pathways compared to conventional systems. In this work, we study the effect of this degeneracy on neutron capture rates by several rp-process ashes and neutron-rich nuclei within accreting neutron stars. We consider strongly interacting asymmetric nuclear matter and its effect on the neutron chemical potential and therefore on the capture rates. We then investigate variations in the nuclear physics input which constructs the absorption cross section, and their effects on the reaction rate in the context of degenerate neutron capture. Finally, we propose an analytic approximation for highly degenerate neutron capture rates. Our results may help interpret the abundance evolution of rp-process ashes.

[3206] (G*) Constraining the Neutron Capture Rate for the Short-Lived 91Sr Nucleus (11:45, 15 minutes)

Presenter: GREAVES, Beau (University of Guelph)

In recent years, attention has been brought to intermediate neutron capture processes, working between the rates and environmental neutron densities of the r-process and s-process, while their full contribution to abundances is not yet fully characterized. Operating in neutron densities of 10^{13} - 10^{20} neutrons/cm^{3}, the i-process and n-process have been shown in sensitivity studies to take reaction pathways through experimentally accessible neutron-rich nuclei, providing an opportunity to better characterize the neutron capture rates that define these processes and their resultant abundances. In this contribution we will review the β-Oslo analysis of the notable n-process isotope, ^{91}Sr, taken with the SuN total absorption spectrometer at the NSCL in 2018. By simultaneously measuring both γ-ray energies and excitation energies in this experimental setting, a coincidence matrix was produced to perform the Oslo analysis, providing experimental information on the nuclear level density and gamma ray strength functions, two critical components to finding the neutron capture cross section. Since the neutron capture rates are historically unconstrained by experimental work, this provides an opportunity to further reduce these uncertainties, better characterizing the contribution of such nuclei to these exotic captures processes.

[3138] (G*) β-decay of 68Mn: Probing the N=40 Island of Inversion (12:00, 15 minutes)

Presenter: Ms UMASHANKAR, Rashmi (TRIUMF/UBC)

Although the shell model forms the backbone of our understanding of nuclear structure, the breakdown of traditional magic numbers far from stability gives insight into the nature of the underlying nuclear interactions and acts as a tool to test existing models. Islands of inversion (IoI) in the nuclear landscape are characterized by the presence of deformed multi-particle multi-hole (*npnh*) ground states instead of the 0$\it{p}$0$\it{h}$ configurations predicted by spherical mean-field calculations. In the *N*=40 region, the relatively large energy gap separating the *pf* shell from the neutron *g*$_{9/2}$ orbital points towards a strong sub-shell closure at *N*=40, which has been supported by the observation of a high-lying 2^{+} state and low $\it{B}$($\it{E}$2) value in ^{68}Ni (*Z*=28) [1]. However, systematics of *E*(2^{+}) and $\it{B}$($\it{E}$2) values have indicated a sudden increase in collectivity below *Z*=28 when approaching *N*=40, evidenced in the rapid drop of *E*(2^{+}) in Fe (*Z*=26) and Cr (*Z*=24) isotopes [2,3]. This increase in collectivity around *N*=40 and *Z*<28 is thought to be due to the neutron occupation of intruder states from a higher shell, similar to the island of inversion around *N*=20 [4,5]. Recent studies also suggest the occurrence of a new IoI at *N*=50 and a proposed merging of the *N*=40 and *N*=50 IoIs, equivalent to the one observed between *N*=20 and *N*=28 [6,7]. Detailed spectroscopic information of the Fe, Co, and Ni isotopes will be crucial to understand the structure of nuclei near and inside the *N*=40 IoI and map the bridge between *N*=40 and *N*=50. To this end, an experiment was performed at TRIUMF-ISAC using the GRIFFIN spectrometer that utilized the β and βn decay of ^{68}Mn to populate excited states in ^{67,68}Fe, ^{67,68}Co and ^{67,68}Ni. Preliminary results from the analysis which includes an expanded ^{68}Fe level scheme will be presented and discussed. [1] O. Sorlin et al. PRL (2002) [2] S. Naimi et al. PRC (2012) [3] M. Hannawald et al. PRL (1999) [4] S. M. Lenzi et al. PRC (2010) [5] Y. Tsunoda et al. PRC (2014) [6] C. Santamaria et al. PRL (2015) [7] E. Caurier, F. Nowacki, and A. Poves. PRC (2014)

[3308] (G*) High-precision half-life measurements of 26Na with GRIFFIN (12:15, 15 minutes)

Presenter: Mr FUAKYE, Eric Gyabeng (University of Regina)

A high precision half-life measurement was performed for the radioactive isotope, 26Na at the Isotope Separator and Accelerator (ISAC) rare-isotope beam facility at TRIUMF in Vancouver. This is the first experimental test of the high-efficiency Gamma-Ray Infrastructure for Fundamental Investigations of Nuclei (GRIFFIN) spectrometer for performing high precision (± 0.05% or better) half-life measurements [1]. Following the implantation of the samples at the centre of the GRIFFIN spectrometer, a γ-ray counting measurement was performed by detecting 1809-keV γ-rays in the 26Mg daughter. In this talk, I will discuss new results of the half-life obtained from gating on 1809-keV γ-ray photopeaks that include corrections for pile-up and deadtime losses. The results obtained from these techniques will be compared to a previous high-precision measurement of the 26Na half-life that employed direct β counting [2]. KEYWORDS: radioactive isotope, half-life, deadtime, pile-up References 1. Garnsworthy, A. B., Svensson, C. E., Bowry, M., Dunlop, R., MacLean, A. D., Olaizola, B., ... & Zidar, T. (2019). The GRIFFIN facility for Decay-Spectroscopy studies at TRIUMF-ISAC. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 918, 9-29. 2. Grinyer, G. F., Svensson, C. E., Andreoiu, C., Andreyev, A. N., Austin, R. A. E., Ball, G. C., ... & Zganjar, E. F. (2005). High precision measurements of Na 26 β− decay. Physical Review C, 71(4), 044309.

Science Policy Workshop | Atelier de science politique - MDCL 1305/07 (12:15 - 13:15)

-Conveners: Donovan, Eric (University of Calgary)

Break for Lunch (12h15-13h15) | Pause pour dîner (12h15-13h15) (12:15 - 13:15)

M2-6 Soft condensed matter I (DCMMP) | Matière condensée molle I (DPMCM) - MDCL 1116 (13:15 - 14:45)

-Conveners: Robert Wickham

[3054] Formation of Complex Spherical Packing Phases in Hard Spheres with SALR Interactions (13:15, 15 minutes)

Presenter: Mr BURNS, Cameron (McMaster University)

Complex spherical packing phases, namely the Frank-Kasper (FK) phases, have been discovered in various soft matter systems such as block copolymers and surfactant solutions. A generic and simple model for the formation of spherical packing phases in these systems comprises hard spheres with short-range attraction and long-range repulsion (SALR). In the SALR systems, the attractive head promotes the colloids to form clusters, while the repulsive tail prevents the clusters from growing infinitely. The resultant finite-sized clusters could pack onto a crystal lattice forming a cluster crystal. It is anticipated that the ability of the clusters to change their volume and shape could enable the formation of stable complex spherical packing phases. In the current work, the formation of the FK σ and A15 phases in a system of hard spheres with SALR interactions is studied using density functional theory. A set of phase diagrams with different SALR potentials are constructed showing that the stability of σ and A15 phases is highly sensitive to the potential. The key factor stabilizing the FK phases is also discussed. Our results provide a first step in understanding the universality of the existence of the complex spherical packing phases in a broader range of soft matter systems.

[3199] Flatness and Intrinsic Curvature of Linked-Ring Membranes (13:30, 15 minutes)

Presenter: POLSON, James

Recent experiments have elucidated the physical properties of kinetoplasts, which are chain-mail-like structures found in the mitochondria of trypanosome parasites formed from catenated DNA rings. Inspired by these studies, we use Monte Carlo simulations to examine the behavior of two-dimensional networks (``membranes'') of linked rings. For simplicity, we consider only identical rings that are circular and rigid and that form networks with a regular linking structure. We find that the scaling of the eigenvalues of the shape tensor with membrane size are consistent with the behavior of the flat phase observed in self-avoiding covalent membranes. Increasing ring thickness tends to swell the membrane. Remarkably, unlike covalent membranes, the linked-ring membranes tend to form concave structures with an intrinsic curvature of entropic origin associated with local excluded-volume interactions. The degree of concavity increases with increasing ring thickness and is also affected by the type of linking network. The relevance of the properties of linked-ring model membranes to those observed in kinetoplasts is discussed.

[3310] (G*) Surface Relaxation of Vapor Deposited Polystyrene Glasses (13:45, 15 minutes)

Presenter: YIN, Junjie (University of Waterloo)

Our laboratory has recently reported the technique of preparing stable glass films of polymers through PVD and the exceptional properties of these materials. This technique is in principle applicable to a wide range of polymers, and it has been demonstrated for polystyrene and poly(methyl methacrylate). Stable glasses are known to have higher density and enhanced kinetic stability compared to ordinary glasses, but less is known about their surface dynamics. We use AFM to probe the surface response of vapor deposited polystyrene stable glasses to the perturbation provided by gold nanoparticles placed on the free surface. The surface response of stable glasses and ordinary glasses (prepared by rejuvenating vapor deposited glass) shows that they have quantitatively similar surface dynamics. By varying the temperature of relaxation, we quantify the dependence of surface dynamics on temperature.

[3407] Osmotic Pressure and Swelling of Permeable Ionic Microgels (14:00, 15 minutes)

Presenter: DENTON, Alan (North Dakota State University)

Ionic microgels are soft, permeable, colloidal particles, made of crosslinked polymer networks, that ionize and swell in a good solvent. Their sensitive response to changes in environmental conditions, e.g., temperature and pH, and their capacity to encapsulate drug or dye molecules, have spawned applications of microgels to drug delivery, biosensing, and filtration. Swelling of these soft colloids involves a balance of electrostatic and gel contributions to the single-particle osmotic pressure. The electrostatic contribution depends on distributions of mobile microions and fixed charge. Working within the cell model and Poisson-Boltzmann theory, we derive the electrostatic contribution to the osmotic pressure from the free energy functional and the gel contribution from the pressure tensor. By varying the free energy with respect to microgel size, we also derive exact statistical mechanical relations for the electrostatic osmotic pressure for models of planar, cylindrical, and spherical microgels with fixed charge uniformly spread over their surface or volume. To validate these relations, we solve the Poisson-Boltzmann equation and compute microion densities and osmotic pressures [1, 2]. We show that microgel swelling depends on the nonuniform electrostatic pressure profile inside the particles and on the distribution of fixed charge. Finally, we discuss implications for interpreting experiments. [1] A. R. Denton and M. O. Alziyadi, *J. Chem. Phys.* **151**, 074903 (2019). [2] M. O. Alziyadi and A. R. Denton, *J. Chem. Phys.* **155**, 214904 (2021). ARD was supported by the National Science Foundation (Grant No. DMR-1928073). MOA acknowledges support of Shaqra University.

[3350] Transition in the glassy dynamics of melts of acid hydrolyzed phytoglycogen nanoparticles (14:15, 15 minutes)

Presenter: SHAMANA, Hurmiz

Phytoglycogen (PG) is a natural polysaccharide produced in the form of compact, 44 nm diameter nanoparticles in the kernels of sweet corn. Its highly branched, dendritic structure and soft, compressible nature leads to interesting and useful properties that make the particles ideal as unique additives in personal care, nutrition, and biomedical formulations. These applications are particularly dependent on the softness of PG, which can be controlled through chemical modifications. We consider the effect of acid hydrolysis on the softness of PG by characterizing the fragility of acid hydrolyzed PG glasses: as acid hydrolyzed PG particles are dispersed in water at packing densities approaching their soft colloidal glass transition, the dependence of the zero-shear viscosity on effective volume fraction abruptly changes from behaviour well-described by the Vogel-Fulcher-Tammann equation to more Arrhenius-like behaviour. This result is consistent with stronger glass behaviour for acid hydrolyzed PG relative to that for native PG, suggesting that acid hydrolysis of PG makes the particles softer.

[3215] (G*) Changes to the Stiffness and Compressibility of Soft Phytoglycogen Nanoparticles Through Acid Hydrolysis (14:30, 15 minutes)

Presenter: EL-RAYYES, Yasmeen (University of Guelph)

Phytoglycogen (PG) is a glucose-based polymer that is naturally produced by sweet corn in the form of compact nanoparticles with an underlying dendritic architecture. Their deformability and porous structure combined with their non-toxicity and digestibility make them ideal for applications in personal care, nutrition and biomedicine. PG nanoparticles can be modified using chemical procedures such as acid hydrolysis, which reduces both the size and density of the particles. We used atomic force microscopy (AFM) force spectroscopy to collect high resolution maps of the Young's modulus E of acid hydrolyzed PG nanoparticles in water, and we compare these results to those obtained on native PG nanoparticles. [1] Acid hydrolysis produced distinctive changes to the particle morphology and significant decreases in E. These measurements highlight the tunability of the physical properties of PG nanoparticles using simple chemical modifications. 1. B. Baylis et al., Biomacromolecules 2021, 22, 2985.

<u>M2-1 Exploring the Energy and Precision Frontier II (PPD) | Exploration de la frontière d'énergie et de précision II (PPD)</u> - MDCL 1105 (13:15 - 14:45)

-Conveners: Trischuk, Dominique Anderson (Brandeis University (US))

[3016] (I) ATLAS Highlights (13:15, 30 minutes)

Presenter: KAY, Ellis (University of Victoria (CA))

The ATLAS collaboration has been preparing for the imminent Run-3 data-taking period during the long shutdown of the LHC. In this presentation, the upgrades to the detector which have been installed and commissioned during this time will be presented. Aside from these hardware and software improvements, the collaboration has been exploiting the wealth of Run-2 data in order to perform a wide range of measurement and searches. Highlights from these physics analyses will also be presented.

[3180] (G*) Relative luminosity measurement and long-term stability studies with ATLAS-TPX network during LHC Run-2. (13:45, 15 minutes)

Presenter: USMAN, Muhammad (Universite de Montreal (CA))

ATLAS-TPX network is a network of 15 pixelated detectors based on Timepix ASICs which was installed in ATLAS cavern to measure the Radiation Field composition and Luminosity during Run 2 in the framework of a collaboration between Montreal University and IEAP Czech Technical University in Prague. The Timepix silicon detectors are two-layered and equipped with neutron converters (Lithium Floride and Polyethylene). Thanks to the two operation modes available in Timepix ASICs i-e Time over Threshold (ToT) and Time of Arrival (ToA), each detector in the network is capable of measuring Luminosity with 5 different algorithms namely Cluster Counting Algorithm, Hit Counting Algorithm, Total Deposited Energy Algorithm, Thermal Neutron Counting Algorithm and MIPs (Minimum Ionizing Particles) Counting Algorithm. In addition to measuring the number of proton-proton collisions at the Interaction Point, finely segmented detectors (55um Pitch) allow a high-quality track reconstruction which helps to identify the particle types. Timepix Detectors network provide about 150 relative Luminosity measurements for each ATLAS Run. These measurements are then further analyzed to select the measurements with highest precision. Different algorithms that were developed for Luminosity measurement were tested by comparing the Integrated Luminosity measurements with other ATLAS Luminosity detectors. Most algorithms show good agreement with other ATLAS Luminometers, while some algorithms showed slight disagreements which opened the door for crucial studies like track overlapping correction and Activation measurement in ATLAS cavern. Each algorithm comes with its statistical and systematic uncertainties. We have conducted Long Term stability studies with the ATLAS-Timepix network for the complete Run-2. We propose to present results from the different Luminosity measurement algorithms and Long-Term Stability studies for the year 2016, 2017 and 2018 with ATLAS-Timepix network.

[3192] (G*) Most precise measurement of the top-quark pair production cross-section in the single-lepton channel (14:00, 15 minutes)

Presenter: SINGH, Sahibjeet (University of Toronto (CA))

The inclusive top-quark pair ($t\bar{t}$) production cross-section was measured in proton-proton collisions at a center of mass energy of 5 TeV with 257 pb^{-1} of data collected by the ATLAS detector. The $t\bar{t}$ cross-section measurement at a lower center of mass helps to further constrain the gluon Parton Distribution Function (PDF) at high Bjorken x. The cross-section is first measured individually in both the dilepton and single-lepton channels of the $t\bar{t}$ decay before being combined. The measurement in the dilepton channel is measured using a "cut-and-count" approach whereas the single-lepton measurement utilizes a Boosted Decision Tree (BDT) trained on Monte Carlo to separate signal from background. The output distribution of the BDT is the fit to data in a profile-likelihood fit leading to the single-lepton measurement being the most precise single measurement of the $t\bar{t}$ cross-section. The combined cross-section improves this measurement by an additional 10%. The results are used to further constrain PDFs at 5 TeV center-of-mass energy.

[3213] Search for single production of a vector-like T quark decaying into a Higgs boson and top quark with fully hadronic final states using the ATLAS detector (14:15, 15 minutes)

Presenter: FOO, Joel Hengwei (University of Toronto (CA))

A search is made for a vector-like T quark decaying into a Higgs boson and a top quark in 13 TeV proton-proton collisions using the ATLAS detector at the Large Hadron Collider with a data sample corresponding to an integrated luminosity of 139 fb^{-1}. The all-hadronic decay modes $H \rightarrow b\bar{b}$ and $t \rightarrow bW \rightarrow bq\bar{q}'$ are reconstructed as large-radius jets and identified using tagging algorithms. Improvements in background estimation, signal discrimination, and a larger data sample, contribute to an improvement in sensitivity over previous all-hadronic searches. No significant excess is observed above the background, so limits are set on the production cross-section of a singlet T quark at 95% confidence level, depending on the mass, m_{T}, and coupling, κ_{T}, of the vector-like T quark to Standard Model particles. This search targets a mass range between 1.0 to 2.3 TeV, and a coupling value between 0.1 to 1.6, expanding the phase space of previous searches. In the considered mass range, the upper limit on the allowed coupling values increases with m_{T} from a minimum value of 0.35 for 1.07 $ < m_{T} < $ 1.4 TeV up to 1.6 for $m_{T} = 2.3$ TeV.

[3333] (G*) Measurements of the production cross section for the collinear emission of a Z boson from a jet in pp collisions at 13 TeV with the ATLAS detector (14:30, 15 minutes)

Presenter: LAURIER, Alexandre (Carleton University (CA))

Measurements of the production cross section of a Z boson decaying to muons and electrons in association with at least one energetic jet (Z+jet) are presented. Then, the Z+jets events are further separated into a topology corresponding to the collinear emission of an on-shell Z boson from a high-energetic jet, corresponding to the radiation of a Z boson from a quark such that their angular separation is small. The measurements are performed in proton–proton collisions at center-of-mass energy of 13 TeV, using data corresponding to an integrated luminosity of 139 inverse femtobarns collected by the ATLAS experiment at the CERN Large Hadron Collider. The fiducial cross sections are compared to state-of-the-art Monte-Carlo predictions, which allows for a detailed study of the mechanism of Z boson production at next-to-next leading order within the framework described by the Standard Model of particle physics.

M2-4 Precision Techniques in Nuclear and Particle Physics (DNP) | Techniques de précision en physique des particules et des noyaux (DPN) - MDCL 1110 (13:15 - 14:45)

-Conveners: Korkmaz, Elie (UNBC)

[3353] (G*) Higher-Order Leptonic Corrections in Covariant Approach (13:15, 15 minutes)

Presenter: GHAFFAR, Mahumm (Memorial University of Newfoundland)

In order to search for the physics beyond the Standard Model at the precision frontier, it is sometime essential to account for the Next-to-Next-Leading Order (NNLO) corrections theoretical calculations. Using the covariant approach, we calculated the full electroweak leptonic tensor up to quadratic (one loop squared) NNLO (α3) order, which can be used for the processes like e−p and μ−p scattering relevant to MOLLER (background studies) and MUSE experiments, respectively. In the covariant approach, we apply unitary cut of Feynman diagrams and separate them into leptonic and hadronic currents and hence, after the squaring matrix element, we can obtain the differential cross section up to NNLO level. In this presentation, I will quickly review covariant approach and provide our latest results for quadratic QED and electroweak corrections to e−p and μ−p scattering processes.

[3202] (G*) Applications of ab initio nuclear theory to tests of fundamental symmetries (13:30, 15 minutes)

Presenter: GENNARI, Michael

Recent global analysis of Fermi decays, and the corresponding V_{ud} determination, reveal a statistical discrepancy with the well-established SM expectation for Cabibbo-Kobayashi-Maskawa (CKM) matrix unitarity. Theoretical confirmation of the discrepancy would point to a deficiency within the SM weak sector. Necessary for extracting V_{ud} from experiment is calculation of several theoretical corrections to the Fermi transition values. In fact, the development of the novel dispersion relation framework (DRF) for evaluating the nucleon γW-box contribution to the electro-weak radiative corrections (EWRC) is at the centre of the recent tension with unitarity. Thus, what remains is to calculate the two nuclear structure dependent corrections: (i) δ_C, the isospin symmetry breaking correction (ii) δ_{NS}, the EWRC representing evaluation of the γW--box on a nucleus. These corrections are calculable within the ab initio no-core shell model (NCSM), which describes nuclei as systems of nucleons experiencing inter-nucleonic forces derived from the underlying symmetries of Quantum Chromo-Dynamics (QCD). As we have explored calculations of δ_C in the past, it is a natural next step to calculate δ_{NS} in the same approach, providing a consistent evaluation of both nuclear structure dependent corrections to Fermi transitions. Preliminary evaluations of δ_{NS} have already been made using the DRF, however, while one can capture various contributions to δ_{NS} in the DRF, the approach cannot include effects from low-lying nuclear states. These contributions require a true many-body treatment and can be directly computed in the NCSM using the Lanczos continued fractions method. Hence, by studying Fermi transitions in light-nuclei, e.g. the $^{10}\text{C} \rightarrow {}^{10}\text{B}$ and $^{14}\text{O} \rightarrow {}^{14}\text{N}$ beta transitions, we may perform a hybrid calculation of δ_{NS} utilizing the ab initio NCSM and the novel DRF. We aim to present a preliminary calculation of δ_{NS} for the $^{10}\text{C} \rightarrow {}^{10}\text{B}$ transition.

[3375] (G) Novel Conditional Generative Approach and Applications in Nuclear and Particle Physics (13:45, 15 minutes)

Presenter: GIROUX, James (University Of Regina, University Of Ottawa)

A novel Machine Learning architecture has been recently developed combining cutting-edge conditional generative models with clustering algorithms. This model relies on information from one reference class and can be deployed for different applications in nuclear and particle physics, e.g., one-class classification, data quality control, and anomaly detection. The flexibility of the architecture allows also an extension to multiple categories. We explore its utilization for neutron identification in the Barrel Calorimeter at GlueX, along with an anomaly detection method for Beyond Standard Model physics at the Large Hadron Collider.

[3151] (G*) Developing the Integrating Detector Electronics Chain for the MOLLER Experiment (14:00, 15 minutes)

Presenter: BLAIKIE, Brynne

The MOLLER experiment, in preparation at Jefferson Laboratory, in the United States, aims to constrain physics beyond the Standard Model using parity-violating Moller scattering at 11 GeV. The parity-violating asymmetry between the cross-sections for right- and left-handed helicity beam electrons scattered from the atomic electrons in a liquid hydrogen target is expected to be 35.6 ppb and MOLLER aims for 0.73 ppb precision. The measured asymmetry will be used to determine the weak charge of the electron to a fractional accuracy of 2.3%. Among the most challenging aspects of the experiment will be the detection of the small asymmetry in the detector signal. Consequently, it is very important to decrease the noise of the detector electronics as much as possible, which requires many iterations of simulation, prototyping, and testing of detector systems. This lengthy process is also necessary to fully understand and characterize the electronics for the data analysis at the end of the experiment. This talk will focus on recent developments of the integrating detector electronics chain for the MOLLER main detector system. Specifically of interest are the results of recent beam tests and plans for future design modifications.

[3170] (G*) First principles calculations of 7Li+p radiative capture (14:15, 15 minutes)

Presenter: Mr GYSBERS, Peter

We examine the nuclear reactions 7Li(p,y)8Be and 7Li(p,e+e-)8Be from an ab initio perspective. Using chiral nucleon-nucleon and three-nucleon forces as input, the no-core shell model with continuum technique allows us to obtain an accurate description of both 8Be bound states and p+7Li scattering states. We investigate scattering, transfer and capture reactions with 8Be as the composite state and compare the cross-sections to data. The energy freed up by capture is enough to produce electron-positron pairs. The angular distribution of these pairs will be different if the intermediate particle is beyond the standard model rather than the photon, for example, the axion or an axial vector boson. Computing the standard model background and comparing experimental data with new decay modes is necessary to support or rule out new physics in the ATOMKI anomaly (which posits the existence of a new boson with a mass of 17 MeV). Supported by the NSERC grants No. SAPIN-2016-00033 and No. PGSD3-535536-2019. TRIUMF receives federal funding via a contribution agreement with the National Research Council of Canada.

[2998] Mirror Symmetry in the f7/2 Shell Below 56Ni, Excited States and Electromagnetic Transition Rates in 55Ni and 55Co (14:30, 15 minutes)

Presenter: STAROSTA, Krzysztof (SFU)

Experiment S1758 aims to explore the charge dependence of the strong nuclear interaction by probing ^{55}Ni and ^{55}Co near the doubly magic ^{56}Ni. This will be achieved by impinging beams of radioactive ^{20}Na and stable ^{20}Ne upon ^{40}Ca targets to produce ^{55}Ni and ^{55}Co, respectively. Charged particles and γ-rays will be detected by combining the TRIUMF-ISAC Gamma-Ray Escape Suppressed Spectrometer (TIGRESS), the TIGRESS Integrated Plunger (TIP) and the CsI Ball. This trio allows for a higher degree of sensitivity when in unison. Data analysis will involve: transition rate reconstruction using the Doppler-Shift Attenuation Method (DSAM), Doppler-shift lineshape profile extraction from Monte Carlo simulations via the GEANT4 framework, and lifetime extraction from minimizing a χ^2 goodness-of-fit between the measured and simulated lineshapes. The results will paint a clearer picture of the charge dependence of the strong nuclear interaction.

M2-9 DPE II (DPE) | DEP II (DEP) - MDCL 1009 (13:15 - 14:45)

-Conveners: Daria Ahrensmeier

[3485] (I) Data Science and Modern Astronomy, a match made in the heavens (13:15, 30 minutes)

Presenter: HYDE, Elaina (York University)

This talk will discuss my research in data science and astrophysics. We will investigate our Milky Way Galaxy and have a short discussion of how data science can be used to detect faint and sparse objects such as the dwarf satellites and streams that helped form the galaxy we live in. When trying to make detections of these mysterious stars, the advent of greater cloud computing capability means the sky really is no longer the limit (for programming or Astronomy)! We will also cover data science applications for smaller telescopes like the 1m at York University and how small telescopes can support some of these 'big data' science endeavours.

[3284] Self-Evaluation Tools in Canadian STEM Outreach Programs (13:45, 15 minutes)

Presenter: Dr BARKANOVA, Svetlana (Grenfell Campus, Memorial University of Newfoundland)

We report the results on the self-evaluation tools used in Canadian STEM outreach activities reported by representatives for English-language NSERC PromoScience programs. The approaches to evaluation are categorized such as output vs. outcome, quantitative vs. qualitative, metrics vs. surveys, and general vs. specific. While qualitative answers are useful for informing changes to the event/program in the short term, quantitative answers may be useful for analysis as data is collected over time. In general, programs tend to favour low-cost methods (i.e. simple metrics recording, brief post-event surveys) and few programs make an effort to measure their long-term impacts (i.e. track actual outcomes, not just potential outcomes). Thus, this study is more able to demonstrate which tools are common, as a potential proxy for what is effective, than demonstrate which tools are effective directly. The directions for future work are discussed.

[3036] Integrating Group Discussion and Inquiry-Guided Learning into Physics TA Training (14:00, 15 minutes)

Presenter: DRINGOLI, Benjamin

Graduate student teaching assistants (GTAs) fill many roles in undergraduate education: grading exams and assignments, facilitating laboratory sessions, and leading tutorials, among others. Since GTAs have a high degree of interaction with students in each of these roles, their understanding of educational practices is critical to improving student understanding of course material. Improving GTAs' teaching strategies can also be important for their research projects, future collaborations, and professions outside of academic research, but is often overlooked in training programs. As part of a department-wide community of practice focused on applying inquiry-guided learning (IGL) strategies in undergraduate physics courses, a new GTA training program was created and deployed in Fall 2021. In contrast to the previous training which focused on presenting the mechanics of properly executing GTA duties, the new training emphasizes applying IGL teaching strategies such as leading questions and scaffolding instruction through group discussions and examples tailored for physics courses. This format has been shown to improve GTA effectiveness from both the student and GTA perspective and was informed by a pilot IGL learning community of eight physics GTAs in the previous semester. After completing the new training program, feedback collected from graduate students showed they appreciated a focus on IGL and found that the group discussion format allowed them to learn strategies specific to physics courses from senior GTAs. The inspiration, format, and outcomes of this new GTA training program will be discussed, with a focus on how GTAs can be introduced to new pedagogical frameworks for their benefit, as well as the benefit of undergraduate students and professors.

[3392] (U*) Student Preparedness and Motivations in Introductory Physics Courses (14:15, 15 minutes)

Presenter: FERNANDO, Nitara

Introductory physics courses are required at McMaster for students in three different streams: physical sciences, engineering, and life sciences. While students in the engineering stream are required to take the physics course for their stream, most students in the Faculty of Science can choose between taking physics for life sciences or for the physical sciences, where both options meet all upper-year physics requirements. Examining students' self-evaluations of their preparedness and motivations provide insight into their experiences, preferences, and reasons for choosing their stream of physics. In this study, online surveys were distributed to students in all three streams of introductory physics. End-of-term surveys were collected in Dec. 2021 (N=182) and April 2022, and an entry survey was collected in Sept. 2021 (N=239). From these results, we examined students' study habits to see if there are trends across different streams, genders, or other demographic groups that may influence course performance. These results show that most students emphasize retrieval practices such as practice problems and practice tests in their studying, while there are some differences between different demographics and streams. Additionally, students were asked to rate their preparedness and change of preparedness throughout the semester. Interestingly, preparedness in the life sciences stream follows a unique trend because the cohort contains students with varying high school physics backgrounds. Preparedness is also compared to students' predictions of their final grades and their comfort with the mathematics taught in the course to look at any trends between these factors. Additionally, the motivation of students in the life sciences and physical sciences streams are examined to see what influences them when choosing their stream of physics. For these students, external recommendations and previous high school physics experiences are prominent factors in their decision. These results provide insight into the background of students and factors that influence their performance and enjoyment of introductory physics courses at McMaster. We can utilize these results as a tool for improving the performance and experience of students taking these courses.

[3487] Round Table (14:30, 15 minutes)

TBD

M2-7 Low Dimensional Materials and Heterostructures (DCMMP) | Matériaux à basse dimension et hétérostructures (DPMCM) - MDCL 1010 (13:15 - 14:45)

-Conveners: Luican-Mayer, Adina (University of Ottawa)

[3053] (G*) Gated quantum structures in 2D semiconductors (13:15, 15 minutes)

Presenter: BODDISON-CHOUINARD, Justin

Quantum confinement in two-dimensional (2D) transition metal dichalcogenides (TMDs) offers the opportunity to create unique quantum states that can be practical for quantum technologies. The interplay between charge carrier spin and valley, as well as the possibility to address their quantum states electrically and optically, makes 2D TMDs an emerging platform for the development of quantum devices. In this talk, we present the fabrication of a fully encapsulated monolayer tungsten diselenide (WSe2) based device in which we realize gate-controlled hole quantum dots. We demonstrate how our device architecture allows us to identify and control the quantum dots formed in the local minima of electrostatic potential fluctuations in the WSe2 using gates. Coulomb blockade peaks and diamonds are observed which allow us to extract information about the dot diameter and its charging energy. Furthermore, we demonstrate how the transport passing through the channel formed by two gates is sensitive to the occupation of a nearby quantum dot. Additionally, we show how this channel can be tuned to be in the charge detection or the Coulomb blockade regime. Finally, we present a new device architecture which exhibits quantized conductance plateaus over a channel length of 600 nm at a temperature of 4 K. Quantized conductance over such a long channel provides an opportunity to incorporate gate defined quantum dot circuits without the nuisance of inhomogeneity within the channel.

[3061] (G*) Method for exfoliating large area monolayer transition metal dichalcogenides (13:30, 15 minutes)

Presenter: LABBÉ, Antoine (University of Ottawa)

Atomically thin materials - or two-dimensional (2D) materials – confine electrons at the ultimate thickness, giving rise to electrical and optical properties that can enable new quantum devices. Developing these devices requires large-area and high-quality monolayers. A limitation thus far has been that samples made by mechanical exfoliation techniques, thinning down crystals made of weakly bonded layers, are restricted in size to only a few microns. Bottom-up growth methods yielding large area monolayers, such as chemical vapour deposition (CVD), however, have lower sample quality. Therefore, it is desirable to develop methods that result in large area monolayers, while preserving the high quality of the crystal. In this presentation, an exfoliating method based on 150nm Au film successfully used to disassemble bulk van der Waals crystals is presented. Specifically, this presentation demonstrates micron-size crystals of transition metal dichalcogenides such as MoS2, WSe2, and WS2 deposited on the surface of Si/SiO2 wavers. This presentation discusses how different parameters of the process influence the flatness and size of the exfoliated films and how this process can be implemented to create millimeter-size monolayers. To determine the quality of the atomically thin layers obtained with this method, optical and electrical characterization were performed and compared to the results obtained with measurements of mechanically exfoliated flakes and CVD grown films. This method opens the possibilities of producing high-quality macroscopic monolayers that can be used for high quality devices. Acknowledgment: This work was performed with support from funding from the National Sciences and Engineering Research Council (NSERC) Discovery Grant (No. RGPIN-2016-06717)

[3147] (G*) Stacking order domains in twisted transition metal dichalcogenides (13:45, 15 minutes)

Presenter: MOLINO, Laurent

Vertically stacking two-dimensional (2D) materials allows for the fabrication of heterostructures with properties not present in their constituent layers, presenting an opportunity to study new quantum phenomena. In twisted bilayers of hexagonal 2D materials, the formation of a moiré pattern can lead to electron confinement and flat bands. In bilayers of hexagonal transition metal dichalcogenides, moiré patterns have been observed at twist angles within approximately three degrees of parallel alignment. At smaller twist angles, in-plane relaxation of the moiré pattern produces a network of stacking order domains bound by domain walls consisting of shear solitons. In these systems, this deformation has been observed to result in ferroelectricity. Additionally, topological edge states have been predicted to exist at the domain walls. In this work, we use scanning tunneling microscopy (STM) and spectroscopy (STS) to study domain networks in mechanically assembled WS$_2$ homobilayers. We report a technique for fabricating rotationally controlled homobilayers with sufficiently clean interfaces for STM measurement. Using STM, we observe triangular stacking order domains. In spectroscopic measurements, the domains show variation in the local density of states. These results are discussed in light of the anti-symmetric ferroelectricity predicted in these materials.

[3015] (G) Fine Structure of Excitons in TMD Type-II Heterostructures (14:00, 15 minutes)

Presenter: SADECKA, Katarzyna (Wrocław University of Science and Technology)

We describe the electronic and optical properties of MoSe2/WSe2 type-II heterostructure using *ab initio* based tight-binding (TB) approximation and Bethe-Salpeter equation (BSE) [1]. We start with determining the electronic structure of MoSe2/WSe2 from first principles. We obtain type-II band alignment and conduction band minima at Q points. Then we perform analysis of Kohn-Sham wavefunctions allowing to detect leading layer and spin contributions. Next, we construct minimal TB model for MoSe2/WSe2 heterostructure, which allow us to understand orbital contributions to Bloch states and study wavefunctions effect on excitonic spectrum. We accurately solve BSE and determine the exciton fine structure due to type-II spin-split band arrangement [2] and topological moments, considering both A/B, spin bright/dark and intra-/interlayer exciton series using simplified Rytova-Keldysh non-local screening theory. In next step we analyse effect of moiré potential and compare it with fully tight-binding approach to excitons in twisted heterostructures. [1] M. Bieniek, L. Szulakowska, and P. Hawrylak, Band nesting and exciton spectrum in monolayer MoS2, Physical Review B 101, 125423 (2020) [2] K. Sadecka, Inter- and Intralayer Excitonic Spectrum of MoSe2/WSe2 Heterostructure, Acta Physica Polonica, to be published (2022)

[3396] (G*) The charge characterization of atomic wires on hydrogen passivated silicon (14:15, 15 minutes)

Presenter: YUAN, Max

With current CMOS technologies approaching their performance limits, nanoscale atomic electronics are poised to provide the next-generation of devices and a continuation of Moore's law. Several promising beyond-CMOS platforms, such as dangling bond (DB) circuitry on hydrogen-passivated silicon require precise knowledge of the location of charges within fabricated atomic structures. To achieve this in the past, atomic force microscopy (AFM) measurements have been used to determine the charge population of dangling bonds structures, though these measurements are often cumbersome. Here, we employ a quicker, minimally-perturbative scanning tunneling microscope charge sensing scheme to measure the charge of atomic dangling bond wires and compare the results with AFM data. Two DB wires were sequentially lengthened to form a continuous wire near a sensor DB. IV spectroscopy over the sensor reveals spectral shifts which correspond to the addition of nearby charge with single electron sensitivity. The results show a reduction of charge when the wires are joined and agree with standard AFM based techniques which predict dangling bond wires to be ionic chains.

[3097] Scanning Tunneling Microscopy and Spectroscopy of a Graphene-rhenium Disulfide Heterostructure at Low Temperature (14:30, 15 minutes)

Presenter: PLUMADORE, Ryan (University of Ottawa)

Vertical stacking of atomically thin materials offers a large platform for realizing novel properties enabled by proximity effects and moiré patterns. Here, a van der Waals heterostructure consisting of monolayer graphene on in-plane anisotropic layered semiconductor ReS$_2$ is prepared using dry-transfer technique. Locally resolved topographic images reveal a striped superpattern originating in the interlayer interactions between graphene's hexagonal structure and the triclinic, low in-plane symmetry of ReS$_2$. Scanning tunneling spectroscopy at low temperature is used to characterize the modulation of the local density of states by this moiré pattern. These results shed light on the complex interface phenomena between van der Waals materials with different lattice symmetries.

M2-5 Degenerate Quantum Gases and Cold Atoms and Molecules (DAMOPC/DCMMP) | Gaz quantiques dégénérés, molécules et atomes froids (DPAMPC/DPMCM) - MDCL 1309 (13:15 - 14:45)

ALPHA - anti-hydrogen spectroscopy, Tim Friesen, Assistant Professor of Univ. of Calgary

-Conveners: Jens Lassen

[3497] (I) anti-hydrogen spectroscpy ALPHA @ CERN (13:15, 30 minutes)

Presenter: Prof. FRIESEN, Tim (U Calgary)

[3363] Caustics in quantum many-body dynamics (13:45, 15 minutes)

Presenter: O'DELL, Duncan

Caustics are singularities arising from natural focusing and are well known in optics but also occur in any system that has waves including water and quantum waves. Caustics take on universal shapes that are described by catastrophe theory and dominate wave patterns. My group has been extending these ideas to quantum fields, such as those found in the sine-Gordon and Bose-Hubbard models. Our physical motivation is to describe the dynamics of Bose-Einstein condensates (BECs) following a sudden quench, including the cases of two and three independent BECs that are suddenly coupled together. Our theoretical simulations [1] of the dynamics of these low-dimensional many-body systems following the quench shows that caustics form in Fock space over time and this seems to be a generic phenomenon. Furthermore, the caustics are singular in the mean-field theory but are regulated and adopt universal interference patterns in the full many-body theory. These caustics represent a form of universal quantum many-body dynamics associated with singularities in the underlying classical dynamics. [1] Caustics in quantum many-body dynamics, W. Kirkby, Y. Yee, K. Shi and D.H.J. O'Dell, Phys. Rev. Research 4, 013105 (2022).

[3361] Caustics, Chaos, and Branched flow in a Kicked Bose-Einstein Condensate (14:00, 15 minutes)

Presenter: HAINGE, Joshua

We numerically study the quantum dynamics of a bosonic Josephson junction (a Bose-Einstein condensate in a double-well potential) in the context of periodic driving of the tunnel coupling. In particular we examine how caustics, which can dominate the Fock space wavefunction following a sudden quench of the undriven system, are affected as the kicking strength is increased. In the limit of weak tunnelling and low number imbalance, the system maps onto the kicked rotor (an archetype of chaotic dynamics). By varying the strength of the kick quasi-randomly, we are able to realize a regime of "branched flow", a paradigm of wave behaviour in random media relevant to electron flow in conducting materials, radiowave propagation through the interstellar medium, and tsunamis in the ocean.

[3046] (G*) Indistinguishable Photon Generation on Hybrid Photonic Integrated Circuits (14:15, 15 minutes)

Presenter: Ms YEUNG, Edith (University of Ottawa)

Quantum dots embedded within photonic nanowires can act as highly efficient single-photon generators. Integrating such sources on-chip offers enhanced stability and miniaturization; both of which are important in many applications involving quantum information processing. We employ a "pick and place" technique to transfer nanowires to on-chip waveguides where each nanowire contains a single quantum dot emitter. This approach provides for efficient coupling of the quantum light generated in an InP photonic nanowire to a SiN-based photonic integrated circuit. We have previously demonstrated that such devices can efficiently generate single photons on chip. Here we study the potential for generating indistinguishable photons from such sources. We demonstrate post-selected two-photon interference visibilities of up to 70% between sequential photons emitted from the same quantum dot. These findings show that the proposed approach offers a viable route for the integration of a stable source of indistinguishable photons on chip.

M2-2 Mathematical and Theoretical Physics (DTP) | Physique mathématique et physique théorique (DPT) - MDCL 1115 (13:15 - 14:30)

-Conveners: Di Matteo, Olivia (The University of British Columbia)

[3349] Applying the Conjugate Gradient Method in an Infinite Dimensional Hilbert Space (13:15, 15 minutes)

Presenter: PETRY, Robert

The ground state wave function and energy of a quantum system with a given Hamiltonian may be approximated using perturbation theory or the variational method. Both methods have limitations, the former requiring the Hamiltonian perturbation be small enough for the series to converge while the latter being only as good as the choice of functions used in the expansion, ultimately providing only an approximate ground state whose mean energy is an upper bound to the ground state energy. The iterative method of Gradient Descent (GD) applied to the energy expectation functional of the wave function can overcome the limitations of the aforementioned methods. Applying GD in an infinite-dimensional space is achievable by careful bookkeeping of only the non-zero components of the state vector in the chosen basis of expansion and those matrix elements of the Hamiltonian in that basis required to calculate the next iteration. For a Hamiltonian with a sufficiently sparse matrix representation in the chosen basis, the calculation is numerically tractable. Unsurprisingly, however, the GD method applied in infinite dimensions suffers from the same convergence problems that it suffers from in finite-dimensional space. In finite dimensional problems the Conjugate Gradient (CG) method overcomes the GD convergence limitations using improved search directions. CG will be formulated in infinite dimensions for a quantum system with a time-independent Hamiltonian. Polak-Ribière and Fletcher-Reeves versions of CG will be implemented. The method will be used to find energy eigenstates and eigenvalues using three functionals of the wave function, one based on energy expectation, one on its variance, and a third utilizing a Lagrange multiplier. Several simple quantum systems will illustrate the method.

[3045] (I) Quantum Resource Theories and Beyond (13:30, 30 minutes)

Presenter: SCANDOLO, Carlo Maria (University of Calgary)

Quantum resource theories are a powerful framework for the quantification of resourcefulness in the quantum world. They arise naturally whenever one has a restriction on what one can do on a quantum system. However, the idea behind them is very general, and can be successfully exported to non-quantum scenarios. After introducing quantum resource theories and their mathematical framework, I will present some situations in which we can learn something new from their application to a non-quantum setting, e.g. to statistical mechanics in arbitrary physical theories and to discrete dynamical systems.

[3033] (I) Markovian master equation for correlated initial states (14:00, 30 minutes)

Presenter: MERKLI, Marco (Memorial University)

The dynamics of a quantum system in contact with some external surroundings (a `reservoir') is complex. The total system-reservoir evolution is governed by the (global) Schrödinger equation, but the reduced system dynamical equations are not of that form. If the reservoir is vast and has a short correlation time (little memory), then a markovian approximation is known to be valid. The approximate system dynamics is the solution of the famous markovian master equation. The derivation of the master equation is based on initial states in which the system and the reservoir are uncorrelated (of product form). In many situations, however, such initial conditions are not reasonable. In this talk, we address the case of (classically or quantum) correlated initial states and ask: Is the markovian approximation still valid? In this talk, we show that the answer is YES for a standard class of open system models, where a small system is coupled to a reservoir (quantum field) of thermal oscillators. The talk is based on the work https://arxiv.org/abs/2107.02515

M2-10 Black Holes (DTP) | Trous noirs (DPT) - MDCL 1008 (13:15 - 14:45)

-Conveners: Siegel, Daniel (Univ. of Guelph)

[3108] (I) Black hole mergers and internal geometry (13:15, 30 minutes)

Presenter: BOOTH, Ivan

How event horizons evolve and ultimately combine during a black hole merger has been understood for five decades. The theory appears in Hawking and Ellis (1972) and modern numerical simulations have confirmed those early insights. That text also included some speculation about how apparent horizons merge but left the end stages unresolved: it was known that, once they get close enough, a common horizon forms outside the two initial black holes and that those horizons persist for some time inside. However, their ultimate fate was not predicted by theory and also not resolved by numerical simulations, which always lost track of the initial horizons during the final approach. In just the last few years, things have changed as new techniques have been introduced to locate and track marginally outer trapped surfaces (MOTS), a generalization of apparent horizons. These have revealed an intricate picture in which, as the merger progresses, a froth of MOTSs pair create, evolve and annihilate deep inside the known horizons. Most of these MOTSs are self-intersecting and, though the picture is complex, strict rules are imposed on possible behaviours by a MOTS stability operator. In particular, it is now known that the initial horizons are annihilated in encounters with members of this previously unsuspected family of objects. As attention has focused on these exotic MOTS, it has become clear that they are present not only during mergers but also lurk inside most stationary solutions (including an infinite number in Schwarzschild). In this talk I will review recent studies of exotic MOTS and consider what they tell us about mergers as well as the geometry of spacetime inside all black holes.

[3091] (G*) Marginally Outer-trapped Surfaces Act Up with Inner Horizons in Black Holes (13:45, 15 minutes)

Presenter: CHAN, Kam To Billy

The advent of gravitational wave detectors had facilitated a constant stream of black hole merger observations. Despite this, black hole mergers are not fully understood. The details of the two apparent horizons becoming one is unclear due to the non-linear nature of the merger process. Recent numerical work had shown that there is an appearance of self-intersecting marginally outer-trapped surfaces (MOTS) during the black hole merger [Pook-Kolb et. al. arXiv:1903.05626]. Following papers have found similarly behaving MOTS in a simpler and static scenario, that of a Schwarzschild black hole, where a seemingly infinite number of self-intersecting MOTS were found [Booth et. al., arXiv:2005.05350]. This talk introduces new phenomena that occur in presence of an inner horizon. For Reissner-Nordstrom and Gauss-Bonnet black holes, we find that the maximum number of self-intersections becomes finite with the MOTS parameter space deeply dependent on the interior structure of the black hole and in particular the stability of the inner horizon [Hennigar et. al., arXiv:2111.09373].

[3152] (G*) Evolution of exotic marginally outer trapped surfaces in an accreting black hole (14:00, 15 minutes)

Presenter: TAVAYEF, Matin (Memorial University of Newfoundland)

Marginally outer trapped surfaces (MOTS), (closed surfaces of vanishing outward null expansion) provide a useful tool to study the local and global dynamics of black holes. They can be used both to locate black hole boundaries as well as study their internal geometry. Understanding the evolution of these objects can play an important role in understanding realistic black dynamics: in particular their complex dynamics has recently been studied in black mergers. In this talk, I summarize a method that can be used to identify axisymmetric MOTSs with arbitrarily complicated geometries in arbitrary axisymmetric spacetimes. Using this method, I find new MOTSs in dynamical Lemaitre-Tolman-Bondi spacetimes, focusing on the case of a large dust shell falling into an existing black hole. I will present the evolution of the many MOTS (both standard and exotic) that can be observed during this process.

[3145] (G*) Negative Mass de Sitter Black Holes (14:15, 15 minutes)

Presenter: HULL, Brayden

Higher curvature gravity theories have long been known to have a variety of black hole solutions that differ from the standard cases in general relativity. A common feature amongst these solutions is that their horizons have constant curvature. We have recently obtained a class of black hole solutions in Lovelock gravity that do not not have constant curvature horizons. We find that negative mass solutions are possible even in spacetimes with positive cosmological constant. We reveal simple formulas that provide a lower bound on the black hole mass and discuss the implications of these solutions.

[3158] (G*) Probing BTZ Black Hole via Fisher Information (14:30, 15 minutes)

Presenter: PATTERSON, Everett (University of Waterloo)

Relativistic quantum metrology is a framework that not only accounts for both relativistic and quantum effects when performing measurements and estimations, but further improves upon classical estimation protocols by exploiting quantum relativistic properties of a given system. Here I present results of the first investigation of the Fisher information associated with a black hole. I review recent work in relativistic quantum metrology that examined Fisher information for estimating thermal parameters in (3+1)-dimensional de Sitter and Anti-de Sitter (AdS) spacetimes. Treating Unruh-DeWitt detectors coupled to a massless scalar field as probes in an open quantum systems framework, I extend these recent results to (2+1)-dimensional AdS and black hole spacetimes. While the results for AdS are analogous to those in one higher dimension, we observe new non-linear results arising from the BTZ mass.

M2-3 Functional Biophysics (DPMB) | Biophysique fonctionnelle (DPMB) - MDCL 1102 (13:15 - 14:45)

-Conveners: Ozzy Mermut

[3472] (I) Single-molecule perspectives of GPCRs (13:15, 30 minutes)

Presenter: Prof. GRADINARU, Claudiu (University of Toronto)

G protein coupled receptors (GPCRs) form a large family of more than 800 transmembrane proteins that serve as signal transducers between extracellular ligands, such as hormones or medicinal drugs, and intracellular mediators, such as G proteins and arrestins. Recent evidence suggests that, as opposed to the classical two-state model of a single unit switching from an inactive to an active state upon ligand binding, GPCRs exist in a dynamic equilibrium between monomers, dimers and higher oligomers, and monomeric receptors exhibit a high degree of intrinsic structural flexibility. Applying a slew of single-molecule fluorescence (SMF) methods, we identified and characterized oligomers of the muscarinic M2 receptor and of the attendant Gi protein in vitro, demonstrated their presence in live cells and examined their dynamic, ligand-dependent nature as well as their involvement in cell signalling. Single particle tracking data of receptors and G proteins in live cells shows a broad range of diffusion behaviours, pointing to significant contributions from non-random regimes, in particular for the M2 receptors. Using nanodisc-reconstituted samples of a different GPCR from the same family, the adenosine A2A receptor, we have recently measured nanosecond-to-microsecond conformational dynamics in the receptor. The dynamics was recorded at an intracellular site near the interaction region with the G protein, and it appears to be fine-tuned allosterically by the ligand binding at an extracellular site. Our results point to a new paradigm for GPCRs functioning as an ensemble of multiple, interchanging active and inactive states, in which different ligands shift not only their populations (conformational selection), but also their intrinsic flexibility (dynamics selection).

[2992] The Effects of Dietary Ingestion of Nickel Recovery Slag as a Grit Source on Avian Bone (13:45, 15 minutes)

Presenter: GALIANO, Eduardo

The ubiquity of the nickel recovery slag deposited in the environment of the Sudbury, Ontario basin gives merit to the study of the impact this foreign material could potentially have on wildlife in the area. In this work, the effects of ingestion of this largely metallic grit source on the bone health of Columbia Livia Domestica pigeons was measured. This was accomplished by controlling the diets of two groups of birds, one given an exclusively limestone grit source, the second given exclusively slag as grit source. After one year of this controlled diet, the subjects were euthanized, their tibiotarsi were subsequently harvested for testing. Tests performed include breaking strength, Young's modulus, cortical thickness, density, bone mineral density, and mass spectrometry with focus on iron and calcium concentrations. Additionally, conventional micrographs and scanning electron micrographs with accompanying energy dispersive spectrometry were collected. Our analysis of the results are consistent with degraded bone physiology in the slag-fed group.

[3372] (U*) Whispers from the active inner ear (14:00, 15 minutes)

Presenter: KHADOUR , Zena

The vertebrate inner ear achieves high sensitivity and selectivity via active sensors known as hair cells. Hair cells use metabolic energy to generate force to improve their functionality, resulting in self-induced vibrations that can manifest as faint sounds akin to whispers – otoacoustic emissions (OAEs). OAEs are detectable in the ear canal using a sensitive microphone and can arise spontaneously (SOAEs) or be evoked by external tones (eOAEs). Even though OAEs are used extensively for clinical purposes, the underlying mechanics and active dynamics that govern their production, particularly the collective interactions of hair cells, are not well understood. Here we focus on the green anole lizard (Anolis carolinensis) to study the biophysical processes associated with active hearing. Despite simpler morphology relative to the mammalian cochlea, anole lizards show sensitivity and selectivity comparable to many mammals. We present two sets of preliminary OAE results from anole lizards. First, we characterize how changing the level of an external tone at a fixed frequency affects SOAE activity. We observe a broadening frequency range of suppression of the SOAE with increasing tone level, suggesting an entrainment effect where activity effectively synchronizes to the stimulus. Based upon the assumptions of a simple model for tonotopy (i.e., how frequency maps to different spatial locations along the sensory epithelium of the inner ear), we attempt to characterize the spatial extent of the entrainment region. Such could have important constraints for hair cell coupling in theoretical models of the inner ear. Second, we examine intermodulation distortions arising from the presentation of two tones at nearby frequencies. Characterizing such reveals features of the underlying nonlinearities, a key facet in helping constrain mathematical models of the inner ear. Ultimately, these data combined with modeling will help elucidate how the collective behaviour emerges more generally from active spatially-distributed biomechanical systems.

[3354] (G*) Title: To Emit or Not to Emit: Collective Dynamics of the Inner Ear (14:15, 15 minutes)

Presenter: FEDORYK, Olha

The healthy ear not only detects incident sound, but also generates and emits it as well. These sounds, known as otoacoustic emissions (OAEs), can arise spontaneously (SOAEs) and thus provide salient evidence that there is an active (metabolic-based) process taking place at the level of the inner ear. Such a process appears to enhance the sensitivity and frequency selectivity of hearing. However, a detailed understanding of the underlying mechanisms of OAE generation still remains unclear. Our work here focuses on the inner ear of a lizard, developing a theoretical model to characterize their OAE generation. Broadly, the model consists an array of active oscillators, each of which describes an individual hair cell with its own unique characteristic frequency. They are coupled together in varying fashions (e.g., nearest-neighbor via visco-elastic elements; globally via a rigid/resonant substrate). Broadly, we aim to use the model to elucidate how collective dynamics emerge from the system as a whole, as well as constrain the model (e.g., is the coupling required to get some effect actually physiologically reasonable?). Several general features have thus far emerged. First, coupling allows elements to synchronize into groups, where they share a common (self-sustained) oscillation frequency. Such an effect can explain some qualitative aspects of SOAE features (e.g., presence of spectral peaks), but fails to explain others (e.g., width of said peaks). Second, we explore how variations in coupling might lead to "amplitude death", where the active oscillators collectively become quiescent. This phenomenon could lead to improved sensitivity and selectivity, as well as explain the observation that not all ears emit SOAEs.

[3265] FUNCTIONAL AND FUNCTIONALIZED RED BLOOD CELL MEMBRANES (14:30, 15 minutes)

Presenter: Dr HIMBERT, Sebastian (McMaster University)

Membranes are an essential building block in cells, and their biophysical properties impact cellular metabolism and functions. Synthetic lipid membranes are widely used as model systems to understand properties of their much more complex biological counterparts. However, the accuracy of this approximation remains an open question. Advancements in sample preparation and instrumentation now allow the study of the structure of native biological membranes with an unprecedented resolution [1]. We isolated the cytoplasmic membrane from human red blood cells (RBCs) and measured its bending modulus κ using Neutron Spin Echo (NSE) Spectrometry and X-ray diffuse scattering (XDS). Despite their high cholesterol content of 50 mol%, we find surprisingly small bending rigidities between 2-6 k_BT [2], much smaller than literature values of most single component lipid bilayers. We speculate that this extreme softness results from the presence of highly unsaturated lipids in biological membranes. We also show that this bending rigidity significantly increases during blood storage due to an increased fraction of liquid ordered membrane domains as function of storage time. This effect potentially explains the observed organ dysfunction and the increased mortality in patients who received older blood bags [3]. RBCs are ideal for pharmaceutical applications as they provide access to numerous targets in the human body and superior biocompatibility over synthetic particles. We developed protocols to functionalize RBC membranes to form hybrid membranes [4] that can contain different types of synthetic lipids and proteins. Erythro-VLPs (virus like particles) were designed by embedding the SARS-CoV 2 spike protein into RBC hybrid liposomes that work as COVID vaccine [5]. [1] S. Himbert, et.al. Scientific Reports 7 (39661), (2017) [2] S. Himbert, et.al. The Bending Rigidity of Red Blood Cell Membranes, submitted [3] S. Himbert, et.al. Plos one 16 (11), e0259267 [4] S. Himbert, et.al Advanced Biosystems, 1900185. [5] S. Himbert, et.al. ErythroVLPs: Erythro-VLPs: anchoring SARS-CoV-2 spike proteins in erythrocyte liposomes, accepted for publication in Plos One

M2-8 Quantum and Strongly Interacting Electron Systems (DCMMP) | Systèmes quantiques d'électrons interagissant fortement (DPMCM) - MDCL 1016 (13:45 - 15:15)

-Conveners: Bill Atkinson

[3065] Effect of Metallicity on Ferroelectric Thin Films (14:15, 15 minutes)

Presenter: ATKINSON, Bill

In the past few years, several experiments have demonstrated that cation-substituted SrTiO3 can simultaneously sustain both metallicity and ferroelectricity; however, little is known about how the metallicity influences the ferroelectric state. In thin films, for example, nonmetallic ferroelectrics tend to break up into nanoscale Kittel domains of opposite polarization to alleviate large internal electric fields. In this talk, I will show through a mix of numerical simulations and heuristic arguments that the selective screening of these fields by a free electron gas fundamentally alters the structure of the ferroelectric. In particular, I will show that, as the two-dimensional electron density n2D increases, there is a smooth crossover from Kittel domains to a head-to-head domain wall configuration, and that the head-to-head domain wall is energetically preferable when en2D >□ P0, where e is the electron charge and P0 the polarization amplitude within the domains.

[3232] (G) Intermediate Valence state in $\mathrm{YbB_4}$ revealed by RXES (14:30, 15 minutes)

Presenter: FRONTINI, Felix

In crystal systems with competing, incongruous, anti-ferromagnetic exchange interactions, geometric frustration is found and often leads to the suppression of long-range magnetic order. On the other hand, in Yb-based systems where the Kondo interaction between local $4f$ and conduction electrons is dominant, hybridization between these also results in the suppression of long-range magnetic order. When the Kondo interaction is strong enough physical hybridization between the $4f$ and conduction electrons occurs, resulting in a quantum mechanically degenerate electronic ground-state, a so-called intermediate valence (IV) state. $\mathrm{YbB_4}$ is a rare system where both mechanisms are plausible explanations for the lack of magnetic order down to at least 0.34 K [1]. $\mathrm{YbB_4}$ crystallizes into a tetragonal crystal structure (space group $P4/mbm$) that can be mapped to the well known geometrically frustrated Shastry-Sutherland Lattice within the ab plane [2]. $\mathrm{YbB_4}$ has also been proposed as a Kondo-dominated system residing in the IV regime but has to date lacked direct confirmation of such via spectroscopic means [3,4]. We study the existence of an IV state in $\mathrm{YbB_4}$ using resonant X-ray emission spectroscopy at the Yb $L_(α_1)$ transition and study the temperature dependence of the Yb valence from 12 to 300 K. We confirm that $\mathrm{YbB_4}$ exists in an IV state at all temperatures and observe that the Yb valence increases gradually from $ v = 2.61 \pm 0.01$ at 12 K to $v = 2.67\pm0.01$ at 300 K. We compare the temperature scaling of the valence with other Yb-based Kondo lattices and find that $\mathrm{YbB_4}$ and other systems within the IV regime do not obey the universal temperature scale of valence change, T_v, observed in weakly mixed-valent Kondo lattices [5]. We find that in the case of IV systems, T_v also does not appear to be linked to the Kondo temperature T_K of the system. [1] J. Etourneau et al., Journal of the Less-Common Metals 67, 531 (1979). [2] D. Okuyama et al., Journal of the Physical Society of Japan 74, 2434 (2005). [3] J. Y. Kim et al., Journal of Applied Physics 101, 09D501 (2007). [4] A. S. Panfilov et al., Low Temperature Physics 41, 193 (2015). [5] K. Kummer et al., Nature Communications 9, 2011 (2018).

[3222] (G) Broken Sublattice Symmetry Effects and Phase Transitions in Triangular Artificial Graphene Quantum Dots (14:45, 15 minutes)

Presenter: SALEEM, Yasser (University of Ottawa)

We describe here the effects of broken sublattice symmetry, and the emergence of a phase transition in triangular artificial graphene quantum dots with zigzag edges. The system consists of a structured lateral gate confining two dimensional electrons in a quantum well into artificial minima arranged in a hexagonal lattice. The sublattice symmetry breaking is generated by forming an artificial triangular graphene quantum dot with zigzag edges. The resulting Hamiltonian of this system generates a tunable ratio of tunneling to strength of electron-electron interactions and a degree of sublattice symmetry with control over shape. Using a combination of tight binding, Hartree-Fock and configurations interaction we show that the ground state transitions from a metallic to an antiferromagnetic phase by changing the distance between sites or depth of the confining potential. At the single particle level these triangular dots contain a macroscopically degenerate shell at the Fermi level. The shell persists at the mean-field level (Hartree Fock) for weak interactions (metallic phase) but disappears for strong interactions (antiferromagnetic phase). We determine the effects of electron-electron interactions on the ground state, the total spin, and the excitation spectrum as a function of filling of the system away from half-filling. We find that the half-filled charge neutral system leads to a fully spin polarized state in both metallic and antiferromagnetic regimes in accordance with Lieb’s theorem. In both regimes a relatively large gap separates the spin polarized ground state to the first excited many-body state at half-filling of the degenerate shell, but by adding or removing an electron, this gap drops dramatically, and alternate total spin states emerges with energies nearly degenerate to a spin polarized ground state.

[3204] (G*) Pushing the length and time scales of AIMD (15:00, 15 minutes)

Presenter: ABARBANEL, Daniel

Molecular Dynamics (MD) is a commonly used technique to simulate the evolution of atomic structures and complex materials. MD based on classical force fields can solve large systems with relatively long time scales. Since the accuracy of MD depends on the quality of the underlying force fields, and there are many situations where complex chemical reactions occur due to electronic interactions, an important research direction is to advance the method of Ab Initio Molecular Dynamics (AIMD) based on the self-consistent Kohn-Sham density functional theory (KS-DFT), to larger length and time scales. In this work, we present an accelerated AIMD which harnesses its power by two approaches. First, the AIMD is based on our real space KS-DFT method RESCU [1] which can efficiently solve supercells containing many thousands of atoms. Second, we leverage Gaussian Process Regression (GPR) to efficiently extrapolate forces by interpolating between KS-DFT calculations from previous timesteps in the AIMD simulation. By extrapolating forces via GPR when possible, and only calculating forces via KS-DFT when necessary, novel reactive dynamics on increasingly large timescales can be studied using modest computational resources. The accelerated AIMD is applied to simulate the Solid Electrolyte Interphase (SEI) formation in a 2590-atom system consisting of an interface between a lithium slab and liquid organic electrolyte, to time scales of a picosecond or more, where important chemical reactions at the solid/liquid interface are identified.

Break for Teachers' Workshop | Pause pour l'atelier des enseignants - Wilson Hallway (14:30 - 15:00)

Health Break | Pause santé - MDCL Hallway (14:45 - 15:15)

M-PLEN3 Plenary Session | Session plénière - Krishna Rajagopal - MDCL 1305/07 (15:15 - 16:00)

-Conveners: Daria Ahrensmeier

[3024] From MOOCs to Magic: Using Digital Tools to Enhance the On-Campus Learning Experience (15:15, 45 minutes)

Presenter: RAJAGOPAL, Krishna (Massachusetts Inst. of Technology (US))

As a university proud of the education we offer on our campus, we often speak about the “Magic of MIT”. Each of you has an analogous phrase. But, what do we mean? So much of the magic of the (MIT) on-campus university experience lies in the unscripted in-person engagement that happens among our community members, whether it be students working together on problems or projects or students and instructors engaging in seminars, discussions, solving problems, lab classes, research, …. Why, then, have MIT faculty put so much energy into building MOOCs? Standard answers include reach — bringing MIT to the world — and reputation and impact, within a field or more broadly. But among the physics faculty who have developed MOOCs these motivations come second to using MOOCs to enhance the learning experience of our on-campus students. I'll describe some of the ways in which physics instructors at MIT are using MOOCs — or elements thereof — to deliver some of the more scripted parts of our teaching so as to create more time and space for the active, engaging, interactive, components from which the magic originates.

M3-1 Advances in Nuclear and Particle Theory (DTP/DNP/PPD) | Progrès en théorie des particules et des noyaux (DPT/DPN/PPD) - MDCL 1105 (16:00 - 17:30)

-Conveners: Merkli, Marco (Memorial University); Gericke, Michael (University of Manitoba); Danninger, Matthias (Simon Fraser University (CA))

[3334] (G*) The S-wave pairing gap in neutron matter (16:00, 15 minutes)

Presenter: PALKANOGLOU, Georgios

The existence of S-wave neutron superfluidity in the inner crust of neutron stars is well established and it affects the thermal properties and the cooling of the stars. In this talk, I will present a detailed ab initio study of the S-wave pairing gap and the equation of state of superfluid neutron matter. These calculations were carried out using the auxiliary field diffusion Monte Carlo method for finite systems and the results were extrapolated to the thermodynamic limit. I will also discuss how we quantify the error of this extrapolation using phenomenology, such as the symmetry-restored BCS theory of superconductivity. These results can be used in calculations of thermal properties of neutron stars and they can be probed in cold atom experiments utilizing the universality of the unitary Fermi gas.

[3340] (G*) FeynArtsHelper- a Mathematica package for phenomenological calculations (16:15, 15 minutes)

Presenter: REEFAT

The incompleteness of the Standard Model demands new physical models, and one of the most tested approaches is perturbative Quantum Field Theory (QFT), where we can calculate observables from a given Lagrangian. It is well known that at a given order of perturbation theory, matrix elements can be calculated using Feynman calculus. Existing Mathematica packages such as FeynArts and FormCalc help us create those diagrams from a pre-programmed model file in the package, which can perform a wide variety of calculations for the Standard Model. This presentation will present a short overview of a new Wolfram Mathematica package, FeynArtsHelper, intended to help create those model files for FeynArts using arbitrary given Lagrangian. As a result, the package can be employed for the models Beyond Standard Model and produce results up to one-loop order.

[3154] (I) Neutrinos from the past, present and future: passage through compact objects (16:30, 30 minutes)

Presenter: Dr CABALLERO, Liliana

Elusive neutrinos are a window to the interior of compact objects, potentially unveiling the behavior of phenomena such as neutron star mergers, core-collapse Supernovae, and the synthesis of elements. As standalone detections or in the context of multi-messengers signals, neutrinos offer opportunities to understand our Universe in unprecedented ways. Interpreting neutrino observations relies on models of neutrino emission and their interaction with highly dense matter. In this talk, I shall discuss neutrino emission from collapsars and neutron-star mergers, and the possibility of overcoming challenges in nuclear models through their detection.

[3189] Plane-wave and wave-packet neutrino oscillations in GR, f(R) and in conformal coupling models (17:00, 15 minutes)

Presenter: HAMMAD, Fayçal (Bishop's University)

Investigating neutrino flavor oscillations under the influence of curved spacetime is more involved when the mass eigenstates of the superposition—out of which each neutrino flavor is made—are taken to be wave packets. The subtleties behind applying the wave packet formalism to neutrino flavor oscillations in curved spacetimes, as opposed to the plane wave formalism, will be discussed. Applications to various spacetime metrics from GR and from modified gravity models are included. I will then expose, separately, the problem of neutrino flavor oscillations within conformal coupling models, both within the plane wave formalism and within the wave packet formalism.

[3291] Meson spectroscopy using holographic QCD plus 't Hooft equation (17:15, 15 minutes)

Presenter: AHMADY, Mohammad

The light-front wavefunction of mesons is the product of the transverse and longitudinal modes. Holographic QCD leads to a Schr\"{o}dinger-like equation for the transverse mode. We show that, when the longitudinal mode is obtained from the 't Hooft equation, the resulting wavefunction predicts remarkably well the meson spectroscopic data.

M3-9 Atomic and Molecular Physics - Laser Spectroscopy (DAMOPC) | Physique atomique et moléculaire - spectroscope laser (DPAMPC) - MDCL 1008 (16:00 - 17:30)

-Conveners: Jens Lassen

[3233] Parametric Amplification of Few-cycle Laser Pulses (16:00, 15 minutes)

Presenter: HAMMOND, TJ (University of Windsor)

The amplification of intense, ultrashort laser pulses nearly four decades ago revolutionized ultrafast and strong field physics, creating many active fields of research such as femtosecond and attosecond science, and laser-based surgeries. More recently, optical parametric amplifiers (OPAs) are driving the next generation of ultrafast and intense light sources because of their phase stability, wavelength tuneability, and high pulse contrast. However, the bandwidth of OPAs is limited by the phase matching of the crystal, increasing the pulse duration. In this talk, we theoretically and experimentally investigate the amplification of few-cycle pulses by exploiting the nonlinear index of refraction, which we refer to as Kerr instability amplification (KIA). We find that there is a modification to the phase matching condition in KIA, which leads to the possibility of single-cycle pulse amplification. As in all nonlinear effects phase matching plays a vital role in the efficiency of the process. In KIA, the frequency dependent index of refraction, the nonlinear index of refraction, the pump intensity, and the transverse momentum of the signal all determine the phase matching. For example, in our simulations in magnesium oxide (MgO), when pumped at intensities $> 10^{13}$ W/cm^2 in the near-infrared (IR), the phase matching is optimized at 4° over an octave of spectrum, allowing for the amplification of 5 fs pulses. When pumped in the short-wave IR, we calculate multi-octave amplification from $1 - 6$ μm, well-suited for ultrafast strong-field physics experiments in condensed matter. We verify our simulations experimentally. We find compression through amplification in the case of 100 fs pulses. Using a 100 fs Ti:Sapphire laser as the pump, we amplify pulses by nearly four orders of magnitude from the visible to the infrared in a 0.5 mm MgO crystal. The amplification of these longer pulses leads to spectral broadening, and when measured with a frequency resolved optical gating setup (FROG), we find that the pulses are nearly transform limited. The experimental findings, such as resulting dispersion, amplification, tuneability, and angle dependence agree with our simulations.

[3320] Rapid Ultrashort Pulse Characterization using Neural Networks (16:15, 15 minutes)

Presenter: PARASRAM, Tristhal

Ultrashort femtosecond to attosecond laser pulses of electromagnetic radiation are an essential tool for measuring ultrafast phenomena. Such pulses due to their short duration, can have high intensity and minimal heat transfer. When working with ultrashort pulses it is crucial to characterize them by determining their amplitude and phase. There are numerous methods to characterize these pulses. Frequency resolved optical gating (FROG) is one method which is widely used to characterize ultrashort pulses. The FROG trace obtained through measurement of an ultrashort pulse is processed to obtain the phase and intensity of the pulse. Conventional processing methods generally require a full spectrogram and are iterative, taking several seconds to execute. A computationally efficient signal analysis method, based on convolutional neural networks, has been developed to provide fast ultrashort pulse characterization with low signal-to-noise ratio and without a full spectrogram. Deep learning with neural networks is a technique for solving complex nonlinear problems. Convolutional neural networks were optimized to invert the FROG trace to obtain the pulse amplitude and phase. Simulations were used to train the network based on pulses of different widths passing through a dispersive medium with up to fourth order dispersion. Additional noise was added to the phase, to increase the diversity of sample pulse shapes, and to the FROG trace to improve robustness. The performance of this algorithm was evaluated on simulated FROG traces and compared to a conventional singular value decomposition method. The neural network was able to characterize pulses times three orders of magnitudes faster compared to the traditional method and does not requiring a full spectrogram to be sampled.

[3270] (G*) Focal Cone High Harmonic Generation in a Gas Sheet (16:30, 15 minutes)

Presenter: Mr GJEVRE, John Matthew (University of Alberta)

A new geometry of Focal Cone High Harmonic Generation (FCHHG) for generation of High Harmonic radiation is presented by focusing the incoming cone of light through a gas sheet leading to a focusing beam of harmonic radiation. Using 100 TW to 1 PW laser pulses, high energy, microjoule to millijoule, high harmonic pulses should be achievable. Such a focusing geometry generates a converging cone of high harmonic radiation producing a high intensity high harmonic hot spot (HHHS) at focus. An experimental investigation of this scheme was carried out at the Centro de Láseres Pulsados (CLPU) in Salamanca Spain. We will present the initial findings of this study using a rectangular gas sheet target of argon gas generated by a puffed gas jet. The rectangular gas sheet is chosen to provide a region of uniform areal density over which the laser can interact. The interaction area is scaled to maintain the interaction intensity in the optimum range of 1-2 x 1014 W cm-2 for efficient harmonic generation, so as not to exceed the saturation intensity for argon. A number of diagnostics were employed to characterize the emission including spatial imaging with an XUV CCD camera, quantitative XUV diode measurements, x-ray transmission grating measurements of the spectra, divergence measurements using patterned aperture plates and spatial coherence measurements using knife edge diffraction. The effect of a non-uniform gas region was also explored by scanning the laser beam away from the gas jet exit to regions where the gas jet expands and becomes more non-uniform. In all cases, the primary laser light was blocked using multiple layers of 800nm thick aluminum foil, which led to significant attenuation of the high harmonic signal in the current experiments. The initial results will be presented and scaling to efficient high energy, high harmonic pulse sources will be discussed.

M3-5 DPE III (DPE) | DEP III (DEP) - MDCL 1009 (16:00 - 17:30)

-Conveners: Daria Ahrensmeier

[3047] (I) Physics Education Commission of the International Union of Pure and Applied Physics (16:00, 30 minutes)

Presenter: Dr ANTIMIROVA, Tetyana

The goal of this presentation is to create an awareness about the C14 – Physics Education Commission of the International Union of Pure and Applied Physics (IUPAP) activities. The IUPAP is a unique international physics organization, the only one that is founded and run solely by the physics community. Its members are nominated by physics communities in countries representing different regions around the world. The broad mandate of the International Commission on Physics Education (ICPE) is to: “promote the exchange of information and views among the members of the international scientific community in the general fields of Physics Education”. The complete mission statement can be found at https://iupap.org/who-we-are/internal-organization/commissions/c14-physics-education/#mission-mandate. One of the core activities of the Commission is the organization of the International Conference on Physics Education (ICPE), often in partnerships with other international or regional physics/science education societies. The Commission awards Physics Education Medal every year and produces the ICPE Newsletter. IUPAP celebrates its centennial anniversary in 2022-2023 with Canada being one of the founding members of IUPAP. The Commissions of IUPAP (including C14) will promote the educational and scientific activities of IUPAP around the world.

[3513] Growing Your Undergraduate Physics Program – Insights from the Effective Practices for Physics Programs Initiative (16:30, 15 minutes)

Presenter: CRAIG, David (Oregon State University)

Physicists study subjects such as quantum mechanics and relativity that capture the popular imagination, yet physics departments often struggle to recruit and retain enough students to satisfy cost-conscious administrations. The Effective Practices for Physics Programs (EP3) Initiative of the American Physical Society and the American Association of Physics Teachers has tapped the expertise and experience of over 250 members of the physics community to create a Guide to help physics programs face challenges and enact change. In this workshop we’ll review some of the lessons Canadian physics departments can take from the EP3 Guide in order to help themselves build vibrant and growing undergraduate physics programs.

[3514] (G*) Creating Positive Learning Experiences with Constructive and Active Learning Approaches in Quantum Mechanics for Adolescents (16:45, 15 minutes)

Presenter: Mrs KHODAEIFAAL, Solmaz (Simon Fraser University)

We, teachers, curriculum designers and educators, should encourage students’ intellectual engagement and motivation and consider progressive and effective factors in their learning (Wentzel & Watkinz, 2016; Anderman & Dawson, 2011; Csikszentmihalyi, 1990, 1996; 1997; Shernoff et al., 2003). According to Dewey’s theory of learning (1916), learners need to become active participants in their own learning processes; and the individuals’ direct personal experiences in activities have a significant role in learning outcomes (Dewey, 1916). Thus, students must be provided with moments and opportunities through the teacher’s teaching (both curriculum and pedagogy) that would respond to and fulfill all those constructive and progressive experiences in learning. Here, I raise a question: How can we support and provide learners with constructive and active learning opportunities and approaches to learning quantum mechanics? It is emphasized that for teaching and learning the most complicated and abstract concept in physics like quantum mechanics, not only students but also teachers, particularly science teachers without a physics background knowledge, require simplified and visualized educational instructional resources such as guided activities accompanied with simulations (McKagan et al., 2008; Zollman et al., 2002; Baily & Finkelstein, 2009; Yulianti et al., 2021; Faletič & Kranjc, 2021). Today, the effectiveness of the basic and classical simulations, visualized instructional resources, and simulation-based inquiry learning (de Jong, 2011; Mayer & Alexander, 2016; Day & Goldstone, 2009) in quantum mechanics is significant (McKagan et al., 2008; Zollman et al., 2002; Faletič & Kranjc, 2021; Baily & Finkelstein, 2009; Yulianti et al., 2021). For instance, wave-particle behaviour of light and quantum objects is not something that can be easily imagined and conceived by students from the actual experiment itself (Olsen, 2002; Duit et al., 2014; Müller & Wiesner, 2002). The results of my studies, practices, and observations from a science program for adolescents (designed and developed by myself in British Columbia, Canada) acknowledge the discussions and arguments. One of the reasons that adolescents could successfully progress their learning from waves principles to quantum mechanics is the significant effectiveness of the PhET simulations on both curricular resources as well as the pedagogical approaches utilized for students' physics learning (Yulianti et al., 2021; Faletič & Kranjc, 2021; Baily & Finkelstein, 2009; McKagan et al., 2008; Zollman et al., 2002). In brief, these approaches are strongly recommended and developed in teaching the fundamentals of quantum physics, guiding, engaging, and encouraging adolescents in learning quantum mechanics.

[3489] Panel Discussion (17:00, 30 minutes)

TBD

M3-2 Unconventional superconductivity and topology (DCMMP) | Supraconductivité non conventionnelle et topologie (DPMCM) - MDCL 1010 (16:00 - 17:30)

-Conveners: Robert Wickham

[3423] (I) Topological physics with light and matter: new horizons (16:00, 30 minutes)

Presenter: Prof. ST-JEAN, Philippe (Universite de Montreal)

The discovery of topological phases of matter has revolutionized our understanding of condensed matter. Recently, the idea of emulating these phases in synthetic materials, e.g. cold atoms in optical lattices or photons in dielectric nanostructures, has proven to be an extremely powerful approach for exploring topological physics beyond what is physically reachable in the solid-state. This includes the development of new functionalities like topological lasers, but also more fundamental aspects including the discovery of exotic phases involving drive, dissipation, disorder or synthetic dimensions. In this talk, I will present recent works we have realized on a new type of synthetic topological matter involving polaritons, a hybrid light-matter quasiparticle with unique properties inherited from its dual nature.

[3019] Surface Bogoliubov-Dirac cones and helical Majorana hinge modes in superconducting Dirac semimetals (16:30, 15 minutes)

Presenter: Dr KHEIRKHAH, Majid (University of Alberta)

In the presence of certain symmetries, three-dimensional Dirac semimetals can harbor not only surface Fermi arcs, but also surface Dirac cones. Motivated by the experimental observation of rotation-symmetry-protected Dirac semimetal states in iron-based superconductors, we investigate the potential intrinsic topological phases in a C_{4z}-rotational invariant superconducting Dirac semimetal with $s_{\pm}$-wave pairing. When the normal state harbors only surface Fermi arcs on the side surfaces, we find that an interesting gapped superconducting state with a quartet of Bogoliubov-Dirac cones on each side surface can be realized, even though the first-order topology of its bulk is trivial. When the normal state simultaneously harbors surface Fermi arcs and surface Dirac cones, we find that a second-order time-reversal invariant topological superconductor with helical Majorana hinge states can be realized. The criteria for these two distinct topological phases have a simple geometric interpretation in terms of three characteristic surfaces in momentum space. By reducing the bulk material to a thin film normal to the axis of rotation symmetry, we further find that a two-dimensional first-order time-reversal invariant topological superconductor can be realized if the inversion symmetry is broken by applying a gate voltage. Our work reveals that diverse topological superconducting phases and types of Majorana modes can be realized in superconducting Dirac semimetals.

[3173] (G*) Transport of Majorana Zero Modes in 1D Topological Superconductors (16:45, 15 minutes)

Presenter: Mr TRUONG, Bill

We consider the transport of Majorana zero modes across a 1D topological superconductor by applying local gate voltages across sections of the superconductor. This "piano key" method allows for sections of the superconductor to switch between the trivial and topological phases, thereby facilitating the motion of a Majorana zero mode. As a single section, or piano key, undergoes a phase transition, it is possible for the ground state to experience excitations, especially near criticality. The excitation probability has been studied for a large piano key in Ref. [1] which casts the problem in terms of a simple Landau-Zener transition. In our work, we consider the excitation probability when a Majorana zero mode is transported using a series of smaller piano keys. We calculate the excitation probability numerically by simulating a sequence of piano keys. Furthermore, we demonstrate an analytical calculation of the excitation probability and compare this to the numerical results. [1] B. Bauer et al., SciPost Phys. 5, 004 (2018)

[3230] Charge Density Wave Order and Fluctuations above T_CDW and below Superconducting T_c in the Kagome Metal CsV3Sb5 (17:00, 15 minutes)

Presenter: Dr CHEN, Qiang (Department of Physics and Astronomy, McMaster University)

The phase diagram of the kagome metal family AV$_3$Sb$_5$ (A = Cs, Rb, K) features both superconductivity and charge density wave (CDW) instabilities, which have generated tremendous recent attention. Nonetheless, significant questions regarding the nature of the CDW states remain. In particular, the temperature evolution and demise of the CDW state has not been extensively studied, and little is known about the co-existence of the CDW with superconductivity at low temperatures. We report an x-ray scattering study of CsV$_3$Sb$_5$ over a broad range of temperatures from 300 K to $\sim$ 2 K, below the onset of its superconductivity at $\textit{T}_\text{c}\sim$ 2.9 K. Order parameter measurements of the $2\times2\times2$ CDW structure show an unusual and extended linear temperature dependence onsetting at T^* $\sim$ 160 K, much higher than the susceptibility anomaly associated with CDW order at $\textit{T}_\text{CDW}=94$ K. This implies strong CDW fluctuations exist to $\sim2\times\textit{T}_\text{CDW}$. The CDW order parameter is observed to be constant from $T=16$ K to 2 K, implying that the CDW and superconducting order co-exist below $\textit{T}_\text{c}$, and, at ambient pressure, any possible competition between the two order parameters is manifested at temperatures well below $\textit{T}_\text{c}$, if at all. Anomalies in the temperature dependence in the lattice parameters coincide with $\textit{T}_\text{CDW}$ for $\textit{c}(T)$ and with T^* for $a(T)$.

[3321] Muon Spin Rotation Study of Superconducting CsV3Sb5 (17:15, 15 minutes)

Presenter: GAUTREAU, Jonah

CsV3Sb5 a member of the recently discovered class of Kagome superconductors AV3Sb5 (A=K, Rb, Cs), which provide a rich environment to study topological band structure and charge density wave (CDW) order in an ideal vanadium Kagome lattice. In this work we performed muon spin rotation/relaxation (uSR) measurements on high-quality single crystal samples in the normal and superconducting states. In our measurement of we find no evidence of broken time reversal symmetry behavior associated with the superconducting state. Our measurements of the magnetic field penetration are well described by a two-gap model. Measurements of the normal state reveal changes to the internal field distribution at the muon site below approximately 60K and 30K, indicating the presence of several changes in the electrodynamics of CsV3Sb5 in addition to its charge density wave and superconducting order.

M3-3 Molecular and Soft Matter Biophysics (DPMB/DCMMP) | Biophysique moléculaire et de la matière molle (DPMB/DPMCM) - MDCL 1102 (16:00 - 17:00)

-Conveners: Cornelia Hoehr

[3430] (I) Learning from Life: Understanding and Design of Complex Biophysical Systems through Multiscale Modeling and Machine Learning (16:00, 30 minutes)

Presenter: Prof. MANSBACH, Re (Concordia University)

In recent years, the drug discovery industry has seen a steady decline in productivity due partially to the difficulty in rationally designing and exploring novel search spaces. At the same time, cutting-edge deep learning techniques offer the possibility of rapidly enhancing design of novel biomolecules, but suffer from a lack of interpretability. By employing physics-based techniques, including multi-scale molecular dynamics and manifold theory, my lab group hopes to engage with these problems to perform physics-based design of novel search spaces for therapeutics. In this talk, I will discuss our initial attempts to design an interpretable search space for (i) small molecule antibiotics, and (ii) short peptides. We focus on assessing search space quality and on the characterization through molecular dynamics of potential initial design points. I will also discuss our future work in creating an integrated and transferable platform for search space design.

[3135] The electrostatic gating of carbon nanotube field-effect biosensors characterized at the molecular scale using simulations (16:30, 15 minutes)

Presenter: COTE, Sebastien

Carbon nanotube field-effect biosensors (CNT-bioFETs) are ultraminiaturized devices that can be used to measure single-molecule kinetics of biomolecules. They monitor time scales going from a few microseconds to several minutes, as demonstrated for nucleic acid folding and enzyme function. The sensitivity of CNT-bioFETs originates from the interplay between the nanotube's conductance, which is monitored by the device, and the electrostatic potential generated by the biomolecule under investigation, which is localized on the nanotube. Yet, the origin of this electrostatic gating of the carbon nanotube by a single biomolecule is not well understood at the molecular scale. To bridge this gap, we employ molecular dynamics (MD) and Hamiltonian replica exchange (HREX) simulations to unveil: (1) the interactions between the biomolecule and the nanotube to which it is attached to the device and (2) the electrostatic potential on the nanotube as the state of the biomolecule changes. We address these questions by considering three prototypical cases: the function of the Lysozyme protein, the hybridization of 10-nt DNA sequence and the folding of a DNA G-quadruplex, which were previously characterized using CNT-bioFETs. Our simulations show that this protein and these DNAs interact differently with the nanotube to which they are attached. Consequently, the electrostatic potential (ESP) on the nanotube is very sensitive to the type and state of the biomolecule. When compared to experiment, the ESP distribution for the with-ligand and without-ligand states of the Lysozyme protein are in line with the two-level conductance measured by CNT-bioFETs. For the DNAs, however, the ESP distribution for its folded and unfolded states does not agree with the two-level conductance measured. To agree, the DNA strand should not interact with the nanotube, which is not what our simulations suggest. The reason for this apparent conflict could arise from the impact of the external electric field impose by the gate electrode in CNT-bioFETs on highly charged systems such as DNAs, as supported by our recent simulations.

[3297] Bringing a Compact Accelerator-based Neutron Source (CANS) to Canada (16:45, 15 minutes)

Presenter: MARQUARDT, Drew

In response to the retirement of the NRU Reactor at Chalk River Laboratories, a group of Canadian neutron scatterers, cancer clinicians and researchers, and accelerator physicists are carrying out an initial design of a prototype Canadian compact accelerator-based neutron source (PC-CANS) in Canada. The PC-CANS will help mitigate the challenges to maintain and expand the scientific resources needed for research using neutron beams by Canadian researchers and companies. Here, we will provide an update on the high-level design and strategies to secure resources to realize the PC-CANS in Canada. Our approach is staged with the first stage offering a medium neutron-flux, linac-based source for neutron scattering on the next generation of materials. The first stage will serve as a prototype for a second stage: a higher brightness, higher cost facility that could be viewed as a national centre for neutron applications.

M3-8 Dark Matter Experiment II (PPD) | Experiences de matière sombre II (PPD) - MDCL 1309 (16:00 - 17:30)

-Conveners: Piro, Marie-Cécile (University of Alberta)

[3068] (G*) The NEWS-G light Dark Matter search experiment: Current status and preparation for experiment at SNOLAB (16:00, 15 minutes)

Presenter: Mr DURNFORD, Daniel (University of Alberta)

The NEWS-G direct dark matter search experiment uses spherical proportional counters (SPC) with light noble gases to explore low WIMP masses. The first results obtained with an SPC prototype operated with neon gas at the Laboratoire Souterrain de Modane (LSM) have already set competitive results for low-mass WIMPs. The next phase of the experiment consists of a large 140 cm diameter SPC installed at SNOLAB with a new sensor design, lots of improvements in detector performance and data quality. Before its installation at SNOLAB, the detector was commissioned with pure methane gas at the LSM, with a temporary water shield, offering a hydrogen-rich target and reduced backgrounds. After giving an overview of the several improvements of the detector, preliminary results of this campaign will be presented, including UV laser and Ar-37 calibrations that allowed for precision characterization of the detector's energy response at the single-ionization regime.

[3394] (G*) First direct detection constraints on Planck-scale mass dark matter using DEAP-3600 detector (16:15, 15 minutes)

Presenter: GARG, Shivam

The DEAP-3600 experiment (Dark matter Experiment using Argon Pulseshape discrimination) at SNOLAB in Sudbury, Ontario is searching for dark matter via the elastic scattering of argon nuclei by dark matter particles as they traverse through the detector. The detector uses 255 photomultiplier tubes (PMTs) looking at ~3300kg of liquid argon in a spherical acrylic vessel. In addition to being sensitive to weakly interacting massive particles (WIMPs), DEAP-3600 is also sensitive to super-heavy dark matter candidates with masses up to the Planck scale. Sensitivity at such high masses is limited by the number density of dark matter rather than the cross-section. DEAP-3600 has the largest cross-sectional area amongst all the dark matter detectors which enables it to reach the Planck masses. In this talk, we present the search for these superheavy candidate particles in three years of data (using a blind analysis), looking for multiple-scatter signals. A dedicated search is carried out since this multi-scatter signal is entirely different from the standard WIMP signal (usually a single scatter). Regions of interests are defined and background estimates are presented. No signal events were observed leading to direct detection constraints for dark matter masses between 8.3e6 and 1.2e19 GeV and dark matter-nucleon cross section between 1e-23 and 2.4e-18 cm^2

[3288] (G*) Measuring alpha quenching factors in liquid argon using Argon-1 (16:30, 15 minutes)

Presenter: PERRY, Michael

The DEAP-3600 experiment located at SNOLAB is a single phase liquid argon detector looking to confirm the existence of dark matter via direct detection. The energy signature of the dark matter may be examined with 255 photomultiplier tubes (PMTs) measuring the scintillation signal produced via nuclear recoils of argon nuclei by a dark matter particle. As a result, modelling background channels that produce nuclear recoils in the detector is critical in ensuring a well understood dark matter search region. In particular, understanding the scintillation signature of alpha particles in liquid argon will aid immensely in the development of a proper background model. Alpha particles produce a reduced scintillation signal compared to electrons of the same energy, an effect known as “quenching”, which is in general energy dependent. In this talk, we will discuss progress on measurement of alpha particle quenching using Argon-1, a modular single phase liquid argon cryostat located at Carleton University, in Ottawa, Ontario.

[3185] (G*) Toward understanding the nuclear efficiency threshold of bubble chamber detectors (16:45, 15 minutes)

Presenter: LI, Xiang (University of Alberta)

A bubble chamber using fluorocarbons or liquid noble gases is a competitive technology to detect a low-energy nuclear recoil due to elastic scattering of weakly interacting massive particle (WIMP) dark matter. It consists of pressure and a temperature-controlled vessel filled with a liquid in the superheated state. Bubble nucleation from liquid to vapor phase can only occur if the energy deposition is above a certain energy threshold, described by the “heat-spike” Seitz Model. The nucleation efficiency of low-energy nuclear recoils in superheated liquids plays a crucial role in interpreting results from direct searches for WIMPs-dark matter. In this research, we used molecular dynamics simulation to study the bubble nucleation threshold, and we performed a Monte Carlo simulation using SRIM to obtain the nuclear recoil efficiency curve. The goal is to construct a physics model to explain the discrepancy observed between the experimental results and the current Seitz model. The preliminary results will be presented and compared with existing experimental data of bubble chamber detectors.

[3168] (G*) detector response simulation for NEWS-G experiment (17:00, 15 minutes)

Presenter: NOT SUPPLIED, Yuqi

The Spherical Proportional Counter (SPC) is used in NEWS-G to search for low-mass Weakly Interacting Massive Particles (WIMPs). UV laser and Ar37 data calibrations were previously taken at the Laboratoire Souterrain de Modane (LSM) with a 1.35m diameter SPC filled with pure CH4 gas. To verify our understanding of the detector behaviour and the physics model we are using, a simulation of the SPC response to these two sets of calibration data is needed. The primary electrons originating from the same event will drift toward the high voltage sensor and a current will be induced by the motion of secondary ions drifting away from the sensor. How much diffusion a swarm of electrons undergoes is parametrized by the “rise time” of the integrated charge pulse. Both rise times and drift times of electrons can be affected by the “space charges” which are secondary ions created near the sensor distorting the overall electric field within the detector. The simulation results will be compared with the calibration data and the effect due to space charges will be discussed. Finally, I will talk about the implication of the simulation results in cut efficiencies and WIMP signal acceptance to further extract the dark matter cross-section exclusion limits.

[3136] (G*) Laser Absorption Spectroscopy for Methane Sensing in SPCs for the NEWS-G Experiment (17:15, 15 minutes)

Presenter: Mr GARRAH, Carter (University of Alberta)

NEWS-G is a direct detection dark matter experiment specializing in low mass (sub ~1 GeV) WIMP (Weakly Interacting Massive Particles) searches. NEWS-G uses spherical proportional counters (SPCs), a type of gas-ionization detector capable of observing the signal from single-electrons via a small (~1 mm radius) high-voltage anode sensor. While SPCs primarily use noble gases as their target medium, methane (CH4) is also a suitable gas due to its high concentration of hydrogen atoms – optimal for observing low mass WIMP interactions. 300 mbar of pure CH4 was even used as the target medium during the 2019 measurement campaign at the Laboratoire Souterrain de Modane with “SNOGLOBE” – NEWS-G’s 140 cm SPC. However, a disadvantage of NEWS-G’s detectors is that there is currently no reliable way of monitoring the absolute concentrations of gases inside, crucial for accurately determining the target mass. At the University of Alberta, we have been working on improving our gas sensing capabilities by developing a laser absorption spectroscopy (LAS) system designed for measuring concentrations of CH4 in circulation with a 30 cm SPC. In this talk, I will outline the development and testing of this new LAS system for live CH4 monitoring and use alongside NEWS-G’s radon trapping setup.

M3-4 Strong Gravity and Black Holes (DTP) | Gravité forte et trous noirs (DPT) - MDCL 1116 (16:00 - 17:30)

-Conveners: Ivan Booth

[3406] (I) Strong Gravity and the Synthesis of Heavy Elements in the Universe (16:00, 30 minutes)

Presenter: SIEGEL, Daniel

Gravitational-wave and multi-messenger astronomy shed light on the astrophysics of black-holes and neutron-stars and also allow for unique probes of fundamental physics. I will discuss recent results on how the mergers of neutron stars and the death of massive, rotating stars give rise to the formation of heavy elements in the universe. In particular, I will discuss recent results at the interface of numerical relativity, neutrino physics, and nuclear astrophysics, and highlight how multi-messenger astronomy may lead to the answer of a 70-year old fundamental question in physics: How does the Universe create the heaviest elements?

[3212] (G*) Marginally Outer Trapped (Open) Surfaces in Rotating 5D Black Holes (16:30, 15 minutes)

Presenter: MUTH, Sarah

In astrophysically realistic black holes – for instance, binary black hole mergers – the surface of most obvious interest is the Event Horizon. However, this surface is often computationally difficult to locate due to its global definition. Instead, it is useful to turn to quasi-local characterizations of black hole boundaries, such as Marginally Outer Trapped Surfaces (MOTS), which have the benefit of being defined for a single time slice in a spacetime, while the outermost of which is also (generally) the apparent horizon. My talk, which was the subject of my master’s thesis, will describe work which seeks to understand MOTS in the interior of five-dimensional black holes; in particular, I will focus on our results in studying the rotating case (Myers-Perry). Similar to the four-dimensional Schwarzschild case studied by my collaborators, and the five-dimensional static case I presented last year at CAP, we find self-intersecting MOTS, and in doing so provide further support for the claim that self-intersecting behaviour is rather generic. I will conclude by discussing new oscillating MOTS-like surfaces, first seen in this study of 5D rotating black holes, and now reproduced for other types of rotating black holes in other dimensions.

[3227] (G*) Evaporating Black Holes in 2D Models of Gravity (16:45, 15 minutes)

Presenter: BARENBOIM, Jonathan

Black holes evaporate through Hawking radiation but without a full quantum treatment of gravity the endpoint of this process is not yet entirely understood. For example it's been suggested that information that enters a black hole is irreversibly lost after it evaporates, an apparent contradiction with quantum mechanics. Studying the behaviour of information in black hole evaporation in effective models of gravity may provide insight into theories of quantum gravity. Of particular interest are non-singular black holes since quantum theories of gravity are expected to resolve the singularities that are pervasive in general relativity. Two dimensional theories of gravity are useful as toy models for studying black hole dynamics. This talk will discuss a generalized model of collapsing and evaporating black holes incorporating backreaction in 2D dilaton gravity, including non-singular black holes. A numerical code that solves generic systems on the full spacetime is presented.

[3298] (U*) Extracting mutual information from a BTZ black hole spacetime (17:00, 15 minutes)

Presenter: Ms BUELEY, Kendra

Two particle detectors locally interacting with a quantum field can be correlated, even if they are spacelike separated, due to pre-existing field correlations. Such an extraction protocol is called entanglement harvesting. Less well-studied is extraction of more general correlations, as parametrized by mutual information (the total classical and quantum correlations). We investigate the mutual information harvested by two pointlike particle detectors (or qubits) from a massless scalar field in a black hole spacetime. We consider the (2+1)-dimensional BTZ black hole, placing the detectors at different separations from and angles around the black hole. We compute the mutual information for these various settings. In conjunction with previous studies of harvested entanglement for this case, we obtain a more complete picture of the structure of scalar field vacuum correlations in the vicinity of a black hole.

M3-6 Accelerator Applications (DAPI) | Applications des accélérateurs (DPAI) - MDCL 1016 (16:00 - 17:30)

-Conveners: Robert Edward Laxdal

[3532] ACCELERATORS AND NUCLEAR FACILITIES AT McMASTER UNIVERSITY (16:00, 30 minutes)

Presenter: HARPER, Ross

McMaster University is home to a unique suite of facilities in a Canadian university environment, welcoming researchers from across Canada and abroad. In addition to Canada's most powerful nuclear research reactor, the McMaster Nuclear Reactor, McMaster University is the location of six particle accelerators which enable experimental programs in non-invasive assessment of biological composition; effects of radiation on biological systems; production of radioisotopes; and imaging of materials in support of nuclear power generation aging management. Accelerator configurations are flexible depending on experimental requirements, and within the scope of regulatory requirements. Presented is a brief history, current state and projects, and future plans of the accelerator facilities.

[3231] (G*) Design Considerations for a Proton Linac for a Compact Accelerator Based Neutron Source (16:30, 15 minutes)

Presenter: ABBASLOU, Mina

Compact Accelerator-based Neutron Sources (CANS) offer the possibility of an intense source of pulsed neutrons with a capital cost significantly lower than spallation sources. A prototype, Canadian compact accelerator-based neutron source (PC-CANS) is proposed for installation at the University of Windsor. The PC-CANS is envisaged to serve two neutron science instruments, a boron neutron capture therapy (BNCT) station and a beamline for fluorine-18 radioisotope production for positive emission tomography (PET). To serve these diverse applications, a linear accelerator solution is selected, that will provide 10 MeV protons with a peak current of 10 mA within a 5% duty cycle. The accelerator is based on an RFQ and DTL with a post-DTL pulsed kicker system to simultaneously deliver macro-pulses to each end-station. Several choices of Linac technology are being considered and a comparison of the choices will be presented.

[3307] (G*) Accelerator Mass Spectrometry measurements of chlorine-36 using the Isobar Separator for Anions (16:45, 15 minutes)

Presenter: FLANNIGAN, Erin L. (A.E.Lalonde AMS Laboratory, University of Ottawa)

Accelerator Mass Spectrometry (AMS) provides high sensitivity measurements (typically at or below 1 part in 10^{12}) for rare, long-lived radioisotopes. These high sensitivities are achieved when isobars, elements with the same atomic weight as the isotope of interest, are eliminated. AMS laboratories use established techniques to suppress interfering isobars of some light isotopes. However, smaller, low energy (≤ 3 MV) AMS systems are unable to separate abundant isobars of many isotopes. Larger accelerators are still unable to separate the interfering isobars of some heavier isotopes. The Isobar Separator for Anions (ISA) is a radiofrequency quadrupole (RFQ) reaction cell that provides selective isobar suppression in the low energy system of the accelerator beamline. The ISA accepts a 20-35 keV mass analyzed beam from the ion source and reduces the energy to a level that the reaction cell can accept, using a DC deceleration cone. The reaction cell is filled with an inert cooling gas, to further lower the ion energy, and a reaction gas to preferentially react with the interfering isobar. RFQ segments along the length of the cell create a potential well which confines the traversing ions. DC offset voltages on these segments maintain a controlled ion velocity through the cell. The beam is then reaccelerated before exiting the ISA chamber. The ISA has been integrated into a second injection line of the 3 MV tandem accelerator at the A. E. Lalonde AMS Laboratory, University of Ottawa. The ISA-AMS system has facilitated the measurement of chlorine-36, which is typically not achievable by smaller accelerators due to the interference of its abundant isobar, sulfur-36. The cooling gas has been experimentally selected based on chlorine beam transmission through the ISA. Using nitrogen dioxide as the reaction gas, seven orders of magnitude reduction of sulfur to chlorine has been observed. A chlorine-36/chlorine abundance sensitivity of ~1x10^{-14} was achieved by combining the sulfur suppression from the ISA and the degree of dE/dx separation in the detector offered by the 3MV-AMS system. The linearity and stability of the system have been tested over a range of chlorine-36/chlorine ratios using a diluted NIST chlorine-36 standard.

M3-7 Fundamental Symmetries and New Physics at Low Energy I (DNP) | Symétries fondamentales et nouvelle physique à basse énergie (DPN) - MDCL 1110 (16:00 - 17:30)

-Conveners: Gwinner, Gerald (University of Manitoba)

[3451] (I) The Nab experiment: A precise measurement of the neutron beta decay parameters “little a” and “little b” at Oak Ridge National Lab. (16:00, 30 minutes)

Presenter: MAMMEI, Russell

The Nab collaboration aims to make the world's most precise, by about a factor of 10, measurement of the electron-neutrino angular correlation parameter “a” and the Fierz interference term “b” in cold neutron beta decay. Along with the neutron lifetime, this will allow the testing of various extensions to the standard model and will help home in on a correct theory describing what makes up our world. Nab is 4m tall asymmetric time of flight spectrometer with custom 100 mm^2, 127 pixel Si detectors on either end. Nab is currently in its commissioning phase at the Spallation Neutron Source at Oak Ridge National Lab in the USA and will collect physics data from 2022-2025. The Canadian Nab group is responsible for testing the novel large area Si detectors used in the experiment where we have built a steerable 30 keV proton accelerator at the University of Manitoba for this purpose. This talk will motivate and provide an overall status of the Nab experiment and present the 30 keV proton source at UofM with recent detector testing results.

[3294] The TUCAN magnetics lab at TRIUMF – research and development towards a neutron electric dipole moment search (16:30, 15 minutes)

Presenter: FRANKE, Beatrice

A non-zero electric dipole moment (EDM) of the free neutron violates CP symmetry. Searching for this elusive quantity can thus reveal information about the matter-antimatter asymmetry of our Universe. The TUCAN collaboration intends to improve the current upper limit on the neutron EDM by one order of magnitude and push into the low 10^{-27} ecm sensitivity regime. During a neutron EDM measurement, electric and magnetic fields are applied, and the spin precession of polarized neutrons is observed. To achieve competitive sensitivity it is crucial to have precise control over the magnetic fields. Accurate knowledge of its properties, such as stability and homogeneity, as these properties affect both the systematic and statistical precision of a neutron EDM measurement. In this presentation I want to introduce ongoing development work at a magnetics laboratory at TRIUMF. We are working on several prototype setups of magnetic field and magnetometry infrastructure, such as a small-scale magnetic shield, a magnetization detection device, a non-magnetic robot to create field maps, and others. I will discuss how these activities inform the detailed design of the next generation TUCAN neutron EDM spectrometer.

[3198] (G*) Mapping the Magnetically Shielded Room for the Neutron Electric Dipole Moment Experiment at TRIUMF (16:45, 15 minutes)

Presenter: LAVVAF, Maedeh

Discovering a nonzero neutron electric dipole moment (nEDM) provides some of the tightest constraints on extensions to the Standard Model that attempts to explain the mechanisms underlying \textit{CP}-violation. The objective of the TUCAN (TRIUMF UltraCold Advanced Neutron) collaboration is to search for a permanent EDM of the free neutron, d_n, with a sensitivity of $\sigma(d_n) \leq 10^{-27} e$cm. The typical experimental method to measure the nEDM uses polarized ultracold neutrons (UCN) and employs the Ramsey method of separated oscillatory fields. Because of their slow movement, measurement of the spin precession frequency of UCNs requires very homogeneous electric and magnetic fields in space and time over the experimental area. A large multi-layer room called Magnetically Shielded Room (MSR) shields the main precession magnetic field produced by an internal coil from the environment magnetic fields. In the nEDM measurement, many possible sources of systematic error can manifest as a false EDM signal. Historically, the dominant systematic errors have come from magnetic field inhomogeneities, reducing the statistical precision of the experiment. Providing a picture of the magnetic field environment within the experiment would help control the system's homogeneity. This presentation will discuss the simulation of mapping the magnetic field inside the MSR to extract quantities relevant to the compensation of systematic effects in the experiment.

[3203] Magnetic resonance requirements and shim coil design for the TUCAN EDM experiment (17:00, 15 minutes)

Presenter: Prof. MARTIN, Jeffery (The University of Winnipeg)

The TUCAN EDM experiment aims to measure the neutron electric dipole moment (EDM) to a precision of $1\times 10^{-27}~e$cm. The experiment is a precise relative measurement of the spin precession frequency of ultracold neutrons stored in a bottle, placed in homogenous magnetic and electric fields. The magnetic field is shielded from external influences by conducting the experiment in a magnetically shielded room (MSR). A main precession field of $B_0=1~\mu$T is produced by an internal coil. Magnetic field inhomogeneity in the coil/MSR system will cause the neutron spins to dephase as they precess, reducing the statistical precision of the experiment. Controlling the homogeneity is also important for false EDM signals. A system of square shim coils, mounted on the surface of a cube surrounding the experiment, is being developed to make adjustments to the field. This presentation will discuss quantitatively the magnetic homogeneity requirements, and demonstrate the ability of the shim coil design to meet them.

[3382] (G*) The Search for a Permanent Electric Dipole Moment (17:15, 15 minutes)

Presenter: SIMPSON, Rane Alexander (TRIUMF (CA))

The matter-antimatter asymmetry in the universe is one of the core physics questions that remains unsolved in the modern era. While there have been attempts to delve into the cause of this mystery, none have yet to provide a comprehensive solution. One possible explanation is linked to the combined violation of charge-conjugation (C) and parity (P) symmetry, an example of which would be the presence of a permanent electric dipole moment (EDM) of a fundamental particle or system. MIRACLS is an experiment in development at CERN and TRIUMF to identify molecules with unprecedented sensitivity in EDM searches. Performing laser spectroscopy on atoms and even molecules is not revolutionary, but there are two components which set MIRACLS apart from previous searches. The first is its ambition to study radioactive molecules which have recently introduced as intriguing precision probes for new physics, including EDM searches. The second component is its cryogenic Paul trap and Multi-Reflection Time-of-Flight (MR-ToF) device used in the ion-trapping. Containing the radioactive ionic species exposes them to a much longer study-period, allowing the sensitivity and/or precision of the spectroscopy measurements to be much greater. The result of this new probing mechanism is a superior sensitivity in a most intriguing research. The aforementioned techniques and concept of the experiment will be discussed in further detail. A brief outlook to a dedicated precision laboratory for radioactive molecules at TRIUMF will be given.

High School Day Extra Workshop | Atelier supplémentaire de la journée du secondaire - LRW Building (16:15 - 17:15)

-Conveners: Reza Nejat; Meyer, Chris (Toronto District School Board, Canada); Schmidt, Miranda (McMaster University)

High School Day Social | Activité sociale de la journée du secondaire - MUSC Marketplace (17:00 - 19:30)

-Conveners: Reza Nejat; Schmidt, Miranda (McMaster University); Meyer, Chris (Toronto District School Board, Canada)

Welcome Reception with BBQ | Réception d'accueil avec BBQ - MUSC Marketplace (17:30 - 19:15)

M-HERZ Herzberg Memorial Public Lecture | Conférence publique commémorative Herzberg - D. Strickland, U. Waterloo - MDCL 1305/07 (19:30 - 21:00)

-Conveners: Manu Paranjape

[3251] Generating High-Intensity, Ultra-short Optical Pulses (19:30, 1 hour)

Presenter: STRICKLAND, Donna (University of Waterloo)

With the invention of lasers, the intensity of a light wave was increased by orders of magnitude over what had been achieved with a light bulb or sunlight. This much higher intensity led to new phenomena being observed, such as violet light coming out when red light went into the material. After Gérard Mourou and I developed chirped pulse amplification, also known as CPA, the intensity again increased by more than a factor of 1,000 and it once again made new types of interactions possible between light and matter. We developed a laser that could deliver short pulses of light that knocked the electrons off their atoms. This new understanding of laser-matter interactions, led to the development of new machining techniques that are used in laser eye surgery or micromachining of glass used in cell phones.

time	[id] title	presenter
20:30	Questions (30 minutes)	

Lecture Hall Available for Mingling / Salle de conférence disponible pour échanges - MDCL 1305/07 (21:00 - 22:00)

Sidewalk Astronomy │Astronomie de trottoir - Meet in MDCL Lobby (21:00 - 22:00)

Tuesday, 7 June 2022

Congress Registration and Information (07h30-17h00) | Inscription au congrès et information (07h30-17h00) - MDCL Lobby (07:30 - 07:55)

Exhibit Booths Open 08:30-16:00 | Salle d'exposition ouverte de 08h30 à 16h00 - MDCL Hallways (08:05 - 08:30)

T1-8 Precision Techniques in Spectroscopy (DAMOPC) | Techniques de précision en spectroscopie (DPAMPC) - MDCL 1016 (08:30 - 10:15)

-Conveners: Jens Lassen

time	[id] title	presenter
08:30	Detailed program to come (1h 45m)	

T1-5 Private Sector Physicists - STARTS AT 10:45 (CAP-DAPI) | Physicien(ne)s dans le secteur privé - DÉBUT À 10h45 (ACP-DPAI) - MDCL 1009 (08:30 - 10:15)

This symposium is organized by the CAP's Director of Professional Affairs, Daniel Cluff, and Director of Private Sector Physics, Ian D'Souza, in collaboration with the Division of Applied Physics and Instrumentation (DAPI).

-Conveners: Cluff, Daniel (University of Exeter)

T1-4 Hot Topics From Theory Made Accessible (DTP) | Sujets chauds de la théorie rendus accessibles (DPT) - MDCL 1102 (08:30 - 10:15)

-Conveners: Randy Lewis

[3250] Werner Israel Memorial Session on Gravitation (08:30, 1 hour)

Presenters: POISSON, Eric (University of Guelph), LEHNER, Luis

All are welcome to this session that will honour the life of Professor Werner Israel and his enormous contributions to theoretical physics.

[3263] (I) Active Learning in a Quantum Field Theory Course (09:30, 45 minutes)

Presenter: LEPAGE, Peter

Active-learning techniques are as useful for teaching graduate-level quantum field theory (QFT) as they are for introductory physics courses. This talk will describe the speaker’s experience using these techniques in a QFT course. Students completed readings and online questions ahead of each class and spent class time working through problems that required them to practice the decisions and skills typical of a theoretical physicist. The instructor monitored these activities and regularly provided timely feedback to guide their thinking. Instructor-student interactions and student enthusiasm were similar to that encountered in one-on-one discussions with advanced graduate students. Course coverage was not compromised. The teaching techniques described here are well suited to other advanced courses.

T1-3 New Directions in Accelerator-Based Experiments: Future Collider Experiments - Energy Frontier (PPD) | Nouvelles voies fondées sur des accélérateurs: expériences futures avec collisionneurs - frontière d'énergie (PPD) - MDCL 1105 (08:30 - 10:15)

-Conveners: Danninger, Matthias (Simon Fraser University (CA))

[3446] (I) Future Collider Pheno talk (invited talk by David McKeen) (08:30, 25 minutes)

Presenter: MCKEEN, David (TRIUMF)
Placeholder for invited talk

[3309] (I) Physics in the High-Luminosity Era with the ATLAS Detector (08:55, 25 minutes)

Presenter: SWIATLOWSKI, Maximilian J (TRIUMF (CA))
Scheduled to begin data taking in 2029, the High-Luminosity Large Hadron Collider (HL-LHC) will be the pre-eminent energy frontier collider for the forseeable future. Its unique dataset of unprecedented size will allow for a huge range of precision measurements and searches for new physics. This talk will outline the physics opportunities for the ATLAS detector in utilizing this dataset, highlighting in particular what we expect to learn about the Higgs boson and the mechanism of electroweak symmetry breaking. Challenges related to operating at extremely high pile-up will be discussed, as well as plans to exploit the capabilities of the upgraded ATLAS detector. Finally, the complementary and critical role that the HL-LHC plays in the landscape of future colliders will be described.

[3153] (I) The ATLAS Detector Phase-II Upgrades for the HL-LHC (09:20, 25 minutes)

Presenter: KOFFAS, Thomas (Carleton University (CA))
Scheduled to begin operation early in 2029, the High-Luminosity LHC (HL-LHC) will be the largest collider ever built. With an instantaneous luminosity ten times larger than that of the LHC, it will allow for an exciting physics program and for discoveries that could signal new physics beyond the Standard Model. These excellent possibilities do come with major experimental and technological challenges. To address these the ATLAS detector will undergo an extensive upgrade program known as the Phase-II detector upgrades. In this presentation, an overview of the detector upgrades will be provided with emphasis on those with extensive Canadian participation. As an outlook, new technology opportunities for future collider applications and the opportunities for Canadian involvement will be briefly outlined.

[3096] (I) Instrumentation and Accelerator Technologies for ILC and Other Future Colliders (09:45, 25 minutes)

Presenter: BELLERIVE, Alain (Carleton University (CA))
The Standard Model is the most comprehensive present day precision theory of particle interactions. Nonetheless, many key questions in subatomic physics and cosmology remain unanswered. The discovery of the Higgs boson at the Large Hadron Collider (LHC) has raised new questions. The International electron-positron Linear Collider (ILC) is ready to be deployed as the next high-energy world facility for particle physics. First, the ILC project status will be summarized. Then, a set of other potential lepton colliders, that could operate in the energy region from the Z boson mass to the TeV scale, will be presented . These colliders have a common goal of producing large samples of Higgs bosons, although they can also be operated to study other physics phenomena. Precision experiments at future colliders will be essential in unambiguously interpreting LHC physics discoveries. TeV scale physics demands much better performance than previous or current collider detectors have achieved. The collider and detector challenges will be described with focus on specific tracking, calorimetry and accelerator R&D activities in Canada. The overview will also cover a potential TRIUMF accelerator wire-corrector systems for the HL-LHC, depict ILC opportunities, and look at ways to nurse instrumentation for a new generation of particle detectors.

T1-2 Plasma Physics Symposium I (DPP) | Symposium de physique des plasmas I (DPP) - MDCL 1010 (08:30 - 10:15)

-Conveners: Ahmad Hamdan

[3039] (I) Plasma-catalysis: From catalyst synthesis to control of plasma chemistry (08:30, 30 minutes)

Presenter: COULOMBE, Sylvain
Plasma provides the unique processing conditions for the synthesis of nanocatalysts and gas conversion, as well as the direct coupling of renewable electricity with chemical processing. Catalysis unlocks efficient reaction pathways and enables the performances necessary for process industrialization. Both combined provide unique avenues for chemical process electrification, an essential transition vector of the sustainability transition. Over the last twenty years, our laboratory has developed elementary units and accompanying processes linking the green electron from the electrical outlet to the green chemical and process of the energy transition. The journey begins with electrical power supply and reactor design to achieve uniquely controlled plasma chemistry. I will describe our recent work on nanosecond-radiofrequency (RF) plasma sources for transient/repetitive plasma generation under the challenging conditions of reactive gas mixtures and pressures above atmospheric. I will describe how pulsed laser ablation combined with RF plasma functionalization is used to synthesize unique nanocatalysts with reduced environmental footprint. Preliminary results with the dry reforming of methane and ammonia synthesis will be presented. In the second part of the talk, I will introduce the limits of the state-of-the-art gas conversion plasma reactor technologies and introduce promising opportunities enabled by topological design and recent advances in additive manufacturing. These novel approaches pave the way to plasma process intensification via reactor

miniaturization, parallelization and integration.

[3029] (I) Investigation of the Pre-ionization Mechanisms in Atmospheric Pressure Townsend Discharges Obtained in Various Gases (09:00, 30 minutes)

Presenter: DAP, Simon

Dielectric barrier discharges are an easy way to generate cold atmospheric pressure plasmas. For millimeter-range gas gap, a streamer breakdown generally occurs resulting in filamentary discharges. They are made of several short-lived plasma channels randomly distributed along the gas gap, which can be a serious drawback for example in the frame of surface coating processes when a homogeneous and dense layer is required [1]. Nevertheless, the possibility to obtain homogeneous discharges in similar conditions has been evidenced for a long time [2]. To do so, it is necessary to promote a Townsend breakdown by slowing down the ionization process; it can be done by supplying seed electrons before the discharge ignition. These so called pre-ionization mechanisms generally result from the previous discharges and are thus called memory effect. The latter strongly depends on the operating conditions such as the background gas or the dielectric materials properties and can occur both in the gas bulk or at the surface. Discharges generated in different mixtures of N2 and O2 provide a good representation of the mechanisms diversity. In pure nitrogen, it is now well accepted that N2(A) metastable molecules play a significant role. As they diffuse towards the dielectric surface, they can be responsible for the release of trapped electrons from the surface. When a very little amount of O2 (up to 500 ppm) is added, the number of seed electrons dramatically increases suggesting that a new mechanism arises. A possible explanation involve associative ionization reactions between N(2P) metastable atoms generated by N2(A) and O(3P) atoms [3,4]. For larger concentration of oxygen, the strong quenching of N2(A) dramatically reduces its lifetime. In these conditions, it is very likely that surface processes such as spontaneous electron desorption are responsible for the pre-ionization of the gas. During this presentation, a non-exhaustive overview of the different pre-ionization mechanisms will be provided. This understanding will then be used to address the main keys allowing to obtain operate homogeneous discharges in various gases such as Nitrogen, Nitrogen + oxidizing gazes, Air, CO2 … References [1] https://doi.org/10.1002/ppap.201200029 [2] https://doi.org/10.1051/epjap/2009064 [3] https://doi.org/10.1088/1361-6463/ab7518 [4] https://doi.org/10.1088/1361-6463/aad472

[3387] Hydrophobic Recovery of Plasma Modified Electro-spun versus Smooth Polymer Surfaces (09:30, 15 minutes)

Presenter: PATTYN, Cédric

Synthetic polymers are well known to be hydrophobic (non-wetting) in their natural state, due to their inherently low surface free energy, γ (in mN/m). Surface modification of polymers by exposure to cold plasma for enhanced wettability is practiced on vast industrial scales (i) by atmospheric pressure (AP) “corona” discharges since the 1940s; (ii) by other cold plasma processes, either at AP or under partial vacuum in more recent decades. Hereby, polar functional groups, usually bearing O and/or N atoms, become covalently grafted to the outermost polymer surface. A well documented drawback of such grafting reaction by (i) and (ii) above is known as “hydrophobic recovery” or “ageing”: thereby, the increased γ of freshly treated polymer partially reverts to its initial low value (about 28 mN/m for polyethylene or polypropylene, from values as high as > 50 mN/m immediately after treatment). The reason for this thermodynamically driven phenomenon is that polar moieties become buried up to tens of nm below the outer surface by macromolecular “reptation”, motion that occurs at normal (non-cryogenic) temperature. This laboratory has for many years been modifying polymer surfaces by plasma to promote adhesion of living cells for biomedical applications. The solid polymers have been either (a) normal films, typically 50 µm thick and possessing smooth top surfaces; (b) fibrous mats composed of > 90% void random networks of sub-micrometric electro-spun fibrils. We have certain evidence, based on time-dependence of water contact angle (WCA) measurements, that (b) might resist ageing more than (a). A possible reason for this might be much higher surface-to-volume ratio of (b), which favours surface-near cross-linking of polymer chains by ion bombardment and/or VUV irradiation. We present preliminary results based on WCA and surface analytical (XPS) measurements.

[3405] (G*) Time-resolved optical emission spectroscopy of a nanosecond, pulsed microwave plasma ignited by time reversal (09:45, 15 minutes)

Presenter: Mrs DRIOLLET, Amaia (Université de Montréal)

Microwave plasmas are hugely-studied plasmas, they have characteristics that make them unique, they can be generated for low and high-pressures, they have relatively high densities of charged particles, and can be generated in different cavity geometries. A new way to ignite microwave plasmas was recently developed using time reversal and a nanosecond pulsed generator. This method allows the dynamic control of the plasma position and the study of plasmas on timescales rarely studied. The ignition method of such plasmas was investigated [1], but the time- and space-resolved plasma characteristics remain unexplored. Some imaging measurements were performed for different pressures. It was found that in nominally pure argon plasmas, the space-integrated light emission intensity sharply increases over a few tens of nanoseconds and then decreases with timescales in the hundred of nanoseconds. In this work, optical emission spectroscopy of argon 4p-4s transitions coupled with collisional-radiative modeling [2] is used to examine the behavior of the electron temperature and excited states populations during ignition and extinction stages. For pressures between 1.5 and 4 Torr, even with maximum plasma dimensions in the centimeter range, it is found that radiation trapping play a significant role on the analysis of argon line emission intensities. In addition, the populations of argon 4s states and charged species also influence discharge ignition through a so-called memory effect between subsequent discharges. 1. V.Mazières and al. “Spatio-temporal dynamics of a nanosecond pulsed microwave plasma ignited by time reversal” 2020 Plasma Sources Sci. Technol. 29 2. A. Durocher-Jean, E. Desjardins and L. Stafford. “Characterization of a microwave argon plasma column at atmospheric pressure by optical emission and absorption spectroscopy coupled with collisional-radiative modelling ». In: Physics of Plasmas vol. 26, n°6, pp. 063516, juin 2019

[3385] (G*) Microscale electric field detection improvements: Steps toward tailoring cold atmospheric pressure plasma (10:00, 15 minutes)

Presenter: Mr HOGUE, Justin

Cold atmospheric plasma science is a continuously growing domain. Agriculture, material synthesis, medicine, air and surface decontamination, food processing, among many more, applications fields of this omnipresent, yet invisible to broad society, technologies seem limitless. The knowledge about plasma sources and the underlying physics is constantly improved with new designs and multidisciplinary applications. The ability of cold atmospheric pressure plasma to generate reactive species (RONS) relevant for the most prominent applications, such as wound healing, pathogen inactivation, methane reforming, originates from the electric field characteristics of the plasma. It is thus of the utmost importance to have an efficient, sensitive, and high-resolution detection technique to determine the plasma electric field in time and space. The method of choice is electric field-induced second harmonic (E-FISH), a by now well-established nonperturbative technique for measuring the amplitude and orientations of cold atmospheric plasma electric fields. It exploits the appearance of hyperpolarizability in gas when subject to an electric field. A laser is used to probe the medium and the optical second harmonic signal is detected to determine the electric field in the gas. Although E-FISH allows tunable time resolution, only limited by the pulse duration of the used laser, which can go down to the femtosecond, it has been shown that E-FISH presents some issues. Spatial resolution along the beam axis is of the order of the interaction length of the beam and the plasma, and sensitivity only goes down to the order of 100V/cm using a PMT for detection. Work on enhancing these two characteristics of E-FISH have been made by our team and collaborators. Using a femtosecond laser, novel approaches were developed and optimized. The presented results confirmed the improvement of the electric field detection technique, the E-FISH, and will certainly deepen our knowledge on the spatio-temporal electric field distribution of cold atmospheric plasma.

T1-6 Physics at the EIC Symposium: Electron-Ion Collider, An Overview (DNP) | Symposium sur la physique à l'EIC: collisionneur électrons-ions, un survol (DPN) - MDCL 1008 (08:30 - 10:15)

-Conveners: Garth Huber

[3491] (I) Electron-Ion Collider: Project Overview (08:30, 30 minutes)

Presenter: FATEMI, Renee (University of Kentucky)

The Electron-Ion Collider (EIC) is a pioneering new particle accelerator that will be built on the current site of the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. It will provide high energy collisions of polarized electrons with polarized protons and ions, allowing for experiments that probe the nature of strong interactions to unprecedented precision. The EIC Project has grown and evolved rapidly since the official launch by the U.S. Department of Energy in 2020. This talk will discuss the primary physics themes driving the EIC effort, the recent milestones achieved by the project and the efforts to establish two complementary detectors at adjacent interaction regions.

[3492] (I) The Complementary International EIC Experimental Program (09:00, 30 minutes)

Presenter: ASCHENAUER, Elke-Caroline (Brookhaven National Lab)

Understanding the properties of nuclear matter and its emergence through the underlying partonic structure and dynamics of quarks and gluons requires a new experimental facility in hadronic physics known as the Electron-Ion Collider (EIC). The EIC will address some of the most profound questions concerning the emergence of nuclear properties by precisely imaging gluons and quarks inside protons and nuclei such as their distributions in space and momentum, their role in building the nucleon spin and the properties of gluons in nuclei at high energies. In January 2020 the EIC received CD-0 and Brookhaven National Laboratory was selected as site, and June 2021 CD-1 was granted to the EIC Project. This presentation will highlight the experimental program, the plans to have two complementary general purpose detectors to be built by the vibrant international EIC user community around the world.

[3493] (I) Canadian Participation in the Electron-Ion Collider (09:30, 15 minutes)

Presenter: DECONINCK, Wouter

As part of large international collaborations, several Canadian universities are shaping the development of the Electron-Ion Collider, its experiments and their detectors technologies. In this presentation I will give an overview of the current and future Canadian activities from coast to coast, and present opportunities for researchers to join these efforts.

T1-7 Fluctuations and Disorder in Condensed Matter (DCMMP) | Fluctuations et désordre en matière condensée (DPMCM) - MDCL 1309 (08:30 - 10:15)

-Conveners: Robert Wickham

[3408] (I) Physical mechanisms of regulating mitochondrial protein transport (08:30, 30 minutes)

Presenter: BROWN, Aidan (Ryerson University)

For living cells to maintain spatial organization and functional capacity, they must deliver certain proteins to particular organelles and distribute the proteins within the organelles. This talk will focus on the physics of protein localization in mitochondria, an organelle that forms dynamic spatial networks that can span much of the cell volume. I will describe how protein translation and cellular geometry combine to push localization of mRNA to mitochondria out of equilibrium. Small mRNA numbers cause the nature of mRNA association to mitochondria to impact the scale of protein concentration fluctuations within mitochondria, which can be smoothed out with the help of mitochondrial fusion and fission dynamics. From these mitochondrial dynamics emerge spatial networks, formed from extended and branched mitochondrial tubes, that facilitate protein transport. I will describe how spatial network characteristics control the diffusive search time to a target. Overall, diffusion, geometry, and nonequilibrium conditions can combine to regulate protein localization to mitochondria.

[3409] (I) Bacterial condensates under stress (09:00, 30 minutes)

Presenter: Prof. WEBER, Stephanie (McGill University)

Living cells are divided into functional compartments called organelles. In eukaryotes, lipid membranes separate organelles from the cytoplasm such that each compartment maintains a distinct biochemical composition that is tailored to its function. In contrast, prokaryotes typically lack internal membranes and instead must use other mechanisms to spatially organize the cell. Using fluorescence imaging and single-molecule tracking, we show that E. coli RNA polymerase (RNAP) organizes into clusters through liquid-liquid phase separation (LLPS). RNAP clusters, or "condensates", increase cell survival during stress, and appear to regulate ribosome biogenesis in response to nutrient availability. Our results demonstrate that bacteria, like eukaryotic cells, use LLPS to generate membraneless organelles that spatially organize biochemical processes to optimize cell fitness in various environments.

[3433] (I) Prion propagation and loss dynamics in single cells (09:30, 30 minutes)

Presenter: POTVIN-TROTTIER, Laurent (Center for Applied Synthetic Biology, Concordia University)

Prion proteins are proteins that can fold in different structures, where one fold (the prion form) can self-propagate by converting their normally folded proteins into the prion form. In mammals, prions are the cause of untreatable neurodegenerative diseases such as Creutzfeldt-Jakob disease. Intriguingly, prion domains (often disordered sequences) are commonly found in yeast but have also recently been found in bacteria and higher eukaryotes, where they act as a non-pathogenic bistable switch to propagate a functionally distinct cellular state. In bacteria, the prion can be propagated for hundreds of cell divisions, but is stochastically lost through an unknown mechanism in a fraction of the population. It is also unknown whether these bacterial prion domains can attain different prion folds (known as strains or variants) like their mammalian counterparts, and whether the presence of the prions has a general physiological impact on the cell. In this talk, we answer these questions by following thousands of single cells propagating prions for dozens of cell divisions using a microfluidic device and quantitative time-lapse microscopy. We build a stochastic model of the chemical reaction kinetics to recapitulate the properties of the system. I will end by discussing how our findings can provide insights on the biological role of prions in bacteria and on the molecular mechanisms of prion propagation in other organisms.

T1-1 Advances in Physics in Biology and Medicine Symp.: Protein system dynamics (DPMB) | Symposium sur les progrès en physique dans la biologie et la médecine: dynamique des systèmes de protéines (DPMB) - MDCL 1110 (08:30 - 10:15)

-Conveners: Valerie Booth

[3438] (I) Limiting noise in biochemical reaction networks (08:30, 30 minutes)

Presenter: HILFINGER, Andreas

Biological processes are stochastic reaction networks that operate far from thermodynamic equilibrium. Furthermore, even the best-known biological processes are not completely characterized in terms of mechanistic interactions between components. This combination makes analyzing noise properties challenging because small differences in rate functions or network topology can drastically affect stochastic dynamics in complex systems. Instead of ignoring or guessing unknown details we analyze classes of systems that share some features but are left to vary arbitrarily in all unknown features. Such an approach allows us to derive inequalities that can reveal general trade-offs in controlling noise in biological processes. I will present proven or conjectured bounds on stochastic fluctuations in systems that achieve robust steady states, systems with finite molecular lifetimes, and systems that attempt to suppress spontaneous fluctuations in specific components.

[3365] (G*) Force Without Form: Delineating a Disordered Protein Complex with Single-Molecule Fluorescence Spectroscopy (09:00, 15 minutes)

Presenter: SMYTH, Spencer

Intrinsically disordered proteins (IDPs) play critical roles in regulatory protein interactions, but detailed structural/dynamics characterization of their ensembles remain challenging, both in isolation and they form dynamic ‘fuzzy’ complexes. Such is the case for mRNA cap-dependent translation initiation, which is regulated by the interaction of the predominantly folded eukaryotic initiation factor 4E (eIF4E) with the intrinsically disordered eIF4E binding proteins (4E-BPs) in a phosphorylation-dependent manner. Fluorescence spectroscopy provides crucial insights into the dimensions and dynamics of IDPs which inform the molecular basis of their function. Single-molecule Förster resonance energy transfer showed that the conformational changes of 4E-BP2 induced by binding to eIF4E are non-uniform along the sequence; while a central region containing both motifs that bind to eIF4E expands and becomes stiffer, the C-terminal region is less affected. Fluorescence anisotropy decay revealed a nonuniform segmental flexibility at different sites along the chain. Dynamic quenching of these fluorescent probes by intrinsic aromatic residues measured via fluorescence correlation spectroscopy report on transient intra- and inter-molecular contacts on ns-□s timescales. The chain rigidity around sites in the C-terminal region far away from the two binding motifs significantly increased upon binding to eIF4E, suggesting that this region is also involved in the highly dynamic 4E-BP2:eIF4E complex. Our time-resolved fluorescence data paint a sequence-level rigidity map of three states of 4E-BP2 differing in phosphorylation or binding status and distinguish regions that form contacts with eIF4E. We are now conducting single-molecule experiments aimed at resolving site-specific interactions and kinetics of the eIF4E:4E-BP2 complex. Our results constitute an important step towards a mechanistic understanding of the biological function of IDPs via integrative modelling.

[3004] Near-Infrared Photobiomodulation of Living Cells, Tubulin, and Microtubules in Vitro (09:15, 15 minutes)

Presenter: Dr STAELENS, Michael (University of Alberta)

We report the results of experimental investigations involving photobiomodulation (PBM) of living cells, tubulin, and microtubules in buffer solutions exposed to near-infrared (NIR) light emitted from an 810 nm LED with a power density of 25 mW/cm^2 pulsed at a frequency of 10 Hz. In the first group of experiments, we measured changes in the alternating current (AC) ionic conductivity in the 50 - 100 kHz range of HeLa and U251 cancer cell lines as living cells, exposed to PBM for 60 minutes, and observed increased resistance compared to the control experiments. In the second group of experiments we investigated the stability and polymerization of microtubules under exposure to PBM. The protein buffer solution used was a mixture of Britton-Robinson buffer (BRB80 aka PEM) and microtubule cushion buffer. Exposure of Taxol™-stabilized microtubules (~ 2 μM tubulin) to the LED for 120 minutes, resulted in gradual disassembly of microtubules observed in fluorescence microscopy images. These results were compared to controls where microtubules remained stable. In the third group of experiments we performed turbidity measurements (absorbance readings at 340 nm) throughout the tubulin polymerization process to quantify the rate and amount of polymerization for exposed versus unexposed tubulin samples, using tubulin re-suspended to final concentrations of ~22.7 μM and ~45.5 μM in the same buffer solution as before. Compared to the unexposed control samples, absorbance measurement results demonstrated a slower rate and reduced overall amount of polymerization in the less concentrated tubulin samples exposed to PBM for 30 minutes with the same parameters mentioned above. Paradoxically, the opposite effect was observed in the 45.5 μM tubulin samples, demonstrating a remarkable increase in the polymerization rates and total polymer mass achieved after exposure to PBM. These results on the effects of PBM on living cells, tubulin, and microtubules are novel, further validating the modulating effects of PBM and contributing to designing more effective PBM parameters. Finally, potential consequences for the use of PBM in the context of neurodegenerative diseases are discussed.

[3050] (G*) Stochastic Simulations of Protein Clustering on Tubular Networks (09:30, 15 minutes)

Presenter: KISCHUCK, Liam (Ryerson University)

Protein clustering occurs in living cells, often involving phase transitions, and can be an essential step in signal transduction in cells. Protein-protein interaction strength and diffusion times dictate when and how clusters occur, and with diffusion times dependent on geometric properties of cell compartments. The evolution of protein cluster sizes, and any signals sent by the clusters, can be controlled by coarsening dynamics. We investigate the effects of geometry on controlling phase behaviour of proteins on the endoplasmic reticulum (ER), a tubular network that spans much of the cell. The protein IRE1α resides on the surface of the ER and performs essential signaling as part of the Unfolded Protein Response, which is critical for the healthy function of the cell. Using stochastic simulations, we explore how the geometry of the tubular surface of the ER, and the network that they form, affects the diffusion and the clustering of the IRE1α proteins on the ER's tubular surface. The simulation applies a kinetic Monte Carlo algorithm to represent the IRE1α proteins as a lattice gas on a single tube. We find that clustering substantially increases on tubes that are narrower than the typical ER tube diameter of 100nm. Furthermore, the simulations yield IRE1α protein clustering at physiological IRE1α protein concentrations, estimated to be only 1 □ 10 proteins per micrometre of tube length. We also explore the role of tube geometry in determining the typical cluster formation times. IRE1α signaling is integral to cell health and function, and its malfunction is tied to the development of neurodegenerative diseases and cancer. We aim to further our understanding of protein clustering on the ER to provide insight into geometric regulation of phase behaviour and cellular signaling.

[3369] (U*) Finding Order in Disorder: Modelling the Disordered Protein 4E-BP2 (09:45, 15 minutes)

Presenter: TSANGARIS, Thomas

The 120-residue 4E-BP2 (BP2) protein undergoes a transition from disordered to partially folded upon multi-site phosphorylation, reducing its binding affinity with eIF4E (4E) and thus regulating the initiation of translation in neuronal cells. Although BP2 is an attractive target of anticancer drugs, its disordered nature makes it challenging to model. An initial ensemble of BP2 conformers were generated using FastFloppyTail (FFT), a Rosetta-based program. The non-phosphorylated (NP) conformers were generated by applying the FFT algorithm to the entire 120-residue chain, while the 5-phosphorylated (5P) structures were produced by fixing the 18-62 folded domain and applying FFT sampling to the N- and C-terminal tails only. To obtain a compromise between uncertainties in the biophysical experiments and in the initial conformational ensemble, a Bayesian method of structural refinement was applied through the Bayesian-Maximum-Entropy (BME) method. The degree of reweighting is determined by optimizing agreement with various restraints on both local and nonlocal scales: Small-Angle X-ray Scattering (SAXS), Chemical Shifts (CS) and single molecule Forster Resonance Energy Transfer (smFRET). Paramagnetic Relaxation Enhancement (PRE) data were withheld and used as validation criteria, external to the refinement process. By implementing differential weighting of restraints and mitigating overfitting, the resulting NP and 5P BP2 ensembles were found to be in good agreement with all available experimental data. Secondary structure analysis reveals local structure of biological relevance for both BP2 phosphoforms and the replication of the canonical 4E-binding helix in NP BP2. Applying clustering algorithms to partition the conformational landscape leads to distinct and significantly populated structural states that provide new insights into the extended dynamic interaction interface between 4E-BP2 and eIF4E.

[3166] (G*) Inferring gene regulation from static snapshots of gene expression variability (10:00, 15 minutes)

Presenter: JOLY-SMITH, Euan (Department of Physics, University of Toronto)

A key challenge of systems biology is to translate cell heterogeneity data obtained from single-cell sequencing or flow cytometry experiments into causal and dynamic interactions. We show how static population snapshots of gene expression reporters can be used to infer causal and dynamic properties of gene regulatory networks without using perturbations. For instance, we derive correlation conditions that detect causal interactions and closed-loop feedback regulation in gene regulatory networks from snapshots of transcript-levels. Furthermore, we show how oscillating transcription rates can be identified from the variability of co-regulated fluorescent proteins with unequal maturation times. Our approach exploits the fact that unequal fluorescent reporters effectively probe their upstream dynamics on separate time-scales such that their correlations implicitly encode information about the temporal dynamics of their upstream regulation. Synthetic genetic circuits provide exciting opportunities to verify these co-variability conditions with well characterized engineered systems. Lastly we report on ongoing experiments where we quantitatively test our theory with variants of a synthetic oscillator, the Repressilator, in single-cells using time-lapse microscopy and microfluidics.

Health Break with Exhibitors | Pause santé avec exposants - MDCL Hallways (10:15 - 10:45)

T2-3 New Directions in Accelerator-Based Experiments: Future Collider Experiments - Energy and Precision Frontier (PPD) | Nouvelles voies fondées sur des accélérateurs: expériences futures avec collisionneurs - frontière d'énergie et de précision (PPD) - MDCL 1105 (10:45 - 12:15)

-Conveners: Piro, Marie-Cécile (University of Alberta)

[3216] (G*) Projection studies of non-resonant Higgs boson pair production in the bb¯bb¯ final state at the HL-LHC using the ATLAS detector (10:45, 15 minutes)

Presenter: SAM, Colm (University of British Columbia (CA))

Ten years have passed since the discovery of the Higgs Boson back in 2012 at the Large Hadron Collider (LHC), in that time the properties of single Higgs production has been extensively probed and has all shown to be in an astounding agreement with the Standard Model (SM) and as a result no new physics. However due its significantly lower cross section the pair production of the Higgs boson has yet to be observed and have its properties studied. The pair production of the Higgs due to its self-interaction is of particular interest since it helps directly determine the shape of the Higgs potential which in turn has profound theoretical consequences. For example, the minimum the universe currently finds itself in within the Higgs potential might not be the true minimum depending on the Higgs potential shape, and so the universe could consequently transition via quantum tunnelling to this true minimum which could result in a complete alteration of the universe and its physical laws. The shape of the Higgs potential also tells a great deal about how it transitioned from the shape it had during the early stages of universe to the shape it has today, and the possibility of electroweak baryogenesis happening in between, which could explain the matter-antimatter asymmetry we also observe today. Projection studies of non-resonant Higgs boson pair production in the $b\bar b b \bar b$ final state with the ATLAS detector are presented here. Based on the Run 2 analysis, these studies are extrapolated to conditions expected at the High-Luminosity LHC (HL-LHC) and show a substantial improvement over previous results.

[3008] (I) The MoEDAL-MAPP Experiment – The Upgrade of the LHC's 1st Dedicated Search Experiment for LHC's Run-3 and Beyond (11:00, 25 minutes)

Presenter: PINFOLD, James (University of Alberta (CA))

The MoEDAL experiment deployed at IP8 on the LHC ring was the first dedicated search experiment to take data at the LHC in 2010. It was designed to search for Highly Ionizing Particle (HIP) avatars of new physics such as magnetic monopoles, dyons, Q-balls, multiply charged particles, massive slowly moving charged particles and long-lived massive charge SUSY particles. An upgrade to MoEDAL, the MoEDAL Apparatus for Penetrating Particles (MAPP), approved by CERN's Research Board in now the LHC's newest detector. The MAPP detector, positioned in UA83, expands the physics reach of MoEDAL to include sensitivity to milli-charged particles with charge as low as 10-3 e (where e is the electron charge) and, in conjunction with MoEDAL's trapping detector, to extremely long-lived charged particles. MAPP also has some sensitivity to long-lived neutral particles. We shall also briefly discuss the MAPP-2 upgrade to the MoEDAL-MAPP experiment planned for the High Luminosity LHC (HL-LHC) in the UGC1 gallery near to IP8. This phase of the experiment is designed to maximize the MoEDAL-MAPP sensitivity to long-lived neutral messengers of physics beyond the Standard Model.

[2997] (I) Prospects for Long Lived Particle searches with MATHUSLA (11:25, 25 minutes)

Presenter: ROBERTSON, Steven (McGill University, (CA))

Although Long Lived Particles (LLPs) are predicted in many models of physics beyond the Standard Model, general purpose accelerator-based experiments are limited in their ability to directly detect them, as they typically decay outside of the tracking acceptance of the detectors. While "missing energy" searches are possible, these are limited in scope by resolution effects and high background rates, particularly for the relatively light masses of LLPs favoured by many "dark sector" models. MATHUSLA is a dedicated LLP detector proposed for the HL-LHC, designed to directly detect the decays of LLPs across a broad range of masses and lifetimes. The detector is foreseen as a 100mx100mx25m instrumented decay volume constructed on the surface approximately 100m from the CMS interaction point. Decays of LLPs within this volume are reconstructed and vertexed by tracking their decay products. In this presentation I will present the physics case for such an experiment, and discuss the ongoing detector development activities within Canada and internationally.

[3360] (I) Chiral Belle: Upgrading SuperKEKB with a Polarized Electron Beam (11:50, 25 minutes)

Presenter: RONEY, Michael

Upgrading the SuperKEKB e+e− collider with polarized electron beams is under consideration as it opens a new program of precision electroweak physics at the $\Upsilon(4S)$. This Chiral Belle physics program includes determining $\sin^2\theta_W$ via separate left-right asymmetry (A_{LR}) measurements in e^+e^- annihilations to pairs of electrons, muons, taus, charm and b-quarks using the Belle II detector. The precision that can be obtained matches that of the LEP/SLC world average and enables the probing of neutral current couplings with unprecedented precision in a manner sensitive to their running. At SuperKEKB, the measurements of the individual neutral current vector coupling constants to b-quarks, c-quarks and muons in particular will be substantially more precise than current world averages and the current 3σ discrepancy between the SLC A_{LR} measurements and LEP A_{FB}^b measurements of $\sin^2\theta_W^{eff}$ can be addressed. It can also provide the highest precision measurements of neutral current universality ratios. In addition, having a polarized electron beam enables measurements of tau lepton properties, including the tau g-2, with unrivaled precision. This presentation will cover the physics motivation and status of the R&D necessary for the upgrades to achieve and measure the SuperKEKB e- beam polarization.

T2 -1 Advances in Physics in Biology and Medicine Symp.: Protein design and diffusion (DPMB) | Symposium sur les progrès en physique dans la biologie et la médecine: conception de protéines et diffusion (DPMB) - MDCL 1110 (10:45 - 12:15)

-Conveners: Ozzy Mermut

[3442] (I) Fast and precise: How transcription factors find their targets (10:45, 30 minutes)

Presenter: FRADIN, Cecile (Dept. of Physics and Astronomy, McMaster University)

Protein diffusion plays a ubiquitous role in molecular signalling pathways. As our understanding of the organization and compartmentalization of the cellular environment progresses, we start to better appreciate the complexity of the diffusive transport of proteins, and the control this transport may exert in signalling. One striking example of a diffusion-controlled process is the search of transcription factors for their target genes inside cell nuclei. We have investigated the target search strategies of two specific transcription factors active in the early fly embryo, Bicoid and Capicua, using different fluorescence methods. We observe the existence of a slow fraction of these proteins, which we attribute to the formation of small mobile phase-separated molecular condensates. I will discuss here how condensate formation may help target search efficiency, and increase both the speed and the precision with which gene expression can be activated or repressed.

[3395] Probing the Stochastic Properties of DNA Driven by Topology-relaxing Enzyme Activity (11:15, 15 minutes)

Presenter: Dr KILFOIL, Maria (University of Prince Edward Island, Dept of Physics)

DNA topology-relaxing enzymes in the cell nucleus produce simplified topology, allowing entangled duplex DNA strands to pass one through another, essential for many critical cell nuclear processes including successful DNA segregation during cell division. Here, we carry out 1-point and 2-point microrheology on a model system of DNA at physiologically-relevant concentrations with and without enzyme activity of topoisomerase II. We find that the aggregate, incoherent effect of the enzyme activity creates randomly fluctuating forces, which drive diffusive-like, non-thermal motion. We combine these measurements of random motion with independent micro mechanical measurements and show that the enzyme-driven fluctuations are quantitatively consistent with $1/f$ noise, far from what is expected for thermal motion, and of a completely different `colour' from non-equilibrium fluctuations in the cytoplasm driven by processive cytoskeleton motors. Our measurements at different energy fluxes could shed light on the connection between the enzyme's maintenance of the system away from thermodynamic equilibrium and its simplification of topology over large length scales so key to enhancing nuclear transport for many processes.

[3186] The lawnmower: an artificial protein-based burnt-bridge molecular motor (11:30, 15 minutes)

Presenter: KOROSEC, Chapin (York University)

Molecular motors are essential for powering directional motion at the cellular level, including transport and sorting of cargo, cell locomotion and division, and remodelling of the extracellular environment. Such molecular motors are made out of proteins whose directed motion is coupled to the consumption of chemical free energy. Inspired by such biological machines, significant strides have been made to design and implement synthetic devices capable of directed motion on the nanoscale and the microscale. While these have been impressive achievements, thus far, directed motility of a synthetic protein-based motor has not been demonstrated. In this talk I will present our synthesis and characterization of a novel protein-based microscale motor we dub the lawnmower. It is comprised of a spherical hub decorated with trypsin enzymes; its “burnt-bridge” motion is directed by cleavage of a peptide lawn, which promotes motion towards fresh substrate. We characterize the dynamics of the lawnmower on a 2D surface and in a 1D confined geometry; we characterize its dynamics via its mean-squared displacement and speeds. The lawnmower is the first example of an autonomous protein-based synthetic motor purpose-built using nonmotor protein components. (Current paper draft: arXiv:2109.10293v2)

[3020] (G*) Protein folding and fold switching of the C-terminal domain of transcription factor RfaH. (11:45, 15 minutes)

Presenter: SEIFI, Bahman

The classical view holds that proteins fold into a three-dimensional structure or native state, which determines the biological function of the protein. According to the energy landscape theory, folding proceeds on a rough funnel-shaped multidimensional free energy surface to the native conformation. However, some proteins have recently been discovered to reversibly switch between two entirely different native states, which are exceptions to this rule. Do these so-called metamorphic proteins exhibit energy landscapes with multiple deep funnels corresponding to the different native states? We used an all-atom hybrid model with a potential energy function formed as a linear mixture of physics-based and structure-based potentials. As a case study, we focus on the C-terminal domain (CTD) of the transcription factor RfaH. The CTD undergoes a large-scale structural transition from an α-helical hairpin fold to a 5-stranded β-barrel fold upon dissociation from the N-terminal domain (NTD), which remains structurally stable. We show that our hybrid model demonstrates the crucial thermodynamic behavior of RfaH CTD, i.e., a switch in the global free energy minimum from one fold to the other upon domain dissociation. Our model suggests that for the isolated CTD, the free energy landscape has a single funnel related to the β-barrel fold and no detectable funnel for the α-helical state. This behavior is consistent with data from NMR on the isolated CTD and shows that a multi-funnel landscape cannot be assumed for metamorphic proteins.

[3390] (G*) Tracking Diffusion and Oligomerization of M2 Receptors in Live Cells (12:00, 15 minutes)

Presenter: ZHOU, Xiaohan

Important insights about the signaling mechanisms of G Protein Coupled Receptors (GPCRs) can be learned from their supramolecular assembly. Recent studies in our lab have shown that the M2 muscarinic receptor (M2R), as well as its cognate G protein (Gi), can be purified as oligomers, yet the size and the dynamics of these oligomers, as well as their function are not fully understood in vivo. We used single-molecule fluorescence techniques, such as single-particle tracking (SPT) and single-molecule photobleaching (smPB) to identify the oligomers of M2R in live HEK293 cells. The receptors have been expressed with a HaloTag at their extracellular interface, allowing for labelling with fluorophores with HaloTag ligand (HTL), such as JF549 HTL. The movement of M2 receptors in the cell membrane is spatially and temporally heterogeneous, transitioning between normal and anomalous diffusion regimes. As controls, SPT measurements were performed on pure monomeric (CD86) and dimeric (CD28) membrane proteins. Intensity traces of immobile, single receptor complexes in the membrane of fixed cells was analyzed using in-house smPB code based on change-point and Bayesian algorithms. The results show a distribution of multiple stepwise decreases and indicate that the M2R mediated signaling proceeds, at least in part, via oligomers of receptors and G proteins.

<u>T2-5 Private Sector Physicists (CAP-DAPI) | Physicien(ne)s dans le secteur privé (ACP-DPAI)</u> - MDCL 1009 (10:45 - 12:15)

-Conveners: Cluff, Daniel (University of Exeter)

[3539] (I) Career Opportunities in Physics - What to do Next? / Opportunités de carrière en physique - Quel chemin prendre ? (10:45, 30 minutes)

Presenter: DION-BERTRAND, Laura-Isabelle

This talk will go over the different skills that physicists will acquire during their undergraduate and graduate studies. An overview of the different career paths will be given as well as tips to network. Finally, we will discuss salaries and how to prepare for interviews. Cette conférence passera en revue les différentes compétences que les physiciens acquerront au cours de leurs baccalauréat,maîtrise et doctorat. Un aperçu de différentes carrières possible sera donné ainsi que des astuces pour réseauter. Enfin, nous discuterons de la préparation de l'entrevue et des salaires.

[3484] (I) Optical Communication for Space Based Applications (11:15, 30 minutes)

Presenter: HUDSON, Danya (Honeywell Aerospace)

The narrow beam divergence of an optical communication link results in low probability of interference, improved privacy, and licence-free operation. It also allows significantly higher data rates than traditional RF communication, with lower power consumption. These advantages are of interest for satellite mission applications such as deep-space communication and earth observation satellites which generate large data volumes, and are critical to LEO mega-constellation communication networks which require hundreds of intersatellite links to support terrestrial communication for the general public on Earth. To support the mega-constellation business concepts, the satellite terminals must achieve demanding performance objectives despite aggressive targets for cost and production rates. Honeywell has leveraged decades of experience in reliable space optics and mass production of space hardware to develop a low-cost optical communication terminal designed for manufacturability. Multiple iterations of our baseline terminal design have been built and tested, and we are now expanding into customized terminals for specific use cases. This presentation will describe the Honeywell baseline terminal and discuss some of the options needed for specific mission applications. It will also look at the development process and some of the key challenges for creating high performance optical instruments for use in space.

[3538] (I) From Physics to Finance and Risk Management in Times of a Pandemic (11:45, 30 minutes)

Presenter: STOCK, Rene (Scotiabank)

For the last 20-30 years, quantitative finance has been a prime destination for physicists moving away from academic careers and to modeling of an increasingly complex financial system. During the 2008 financial crisis the role of physicists and mathematicians promised to be redefined in risk management: What could physicists do to prevent the next financial crisis? Did they cause the last one? I will discuss some of the questions of interest to physicists entering a new career in finance and risk management at this time: What are some of the interesting questions coming up in finance in the next few years? How do I get started? What background do I need? Should I do data science? Will an MBA help? Will I have impact?

T2-6 Physics at the EIC Symposium: Accelerator Developments at the EIC (DNP) | Symposium sur la physique à l'EIC: avancées d'accélérateurs à l'EIC (DPN) - MDCL 1008 (10:45 - 12:15)

-Conveners: Hornidge, David (Mount Allison University)

[3237] (I) Electron-Ion Collider Accelerator Development (10:45, 30 minutes)

Presenter: SERYI, Andrei (Jefferson Lab)

The Electron-Ion Collider will be a new discovery machine for unlocking the secrets of the "glue" that binds the building blocks of visible matter in the universe. The EIC will consist of two intersecting accelerators, one producing an intense beam of electrons (Electron Storage Ring), the other a high-energy beam of protons or heavier atomic nuclei (Hadron Storage Ring), which are steered into collisions of spin-polarized beams in the Interaction Region. The EIC design will make use of existing ion sources, a pre-accelerator chain, a superconducting magnet ion storage ring, and other infrastructure of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The Rapid Cycling Synchrotron will provide injection into ESR, while preserving beam polarization. The Strong Hadron Cooling system will preserve emittances of the proton beam during collision run. The EIC project has recently received Critical Decision 1 (CD-1) approval from DOE, and the project team is now working on the next milestone – CD-2. The EIC project will be delivered in a collaboration of domestic and international partners. In this talk, the status of EIC accelerator will be reviewed.

[3184] (I) EIC Accelerator Technology Challenges (11:15, 30 minutes)

Presenter: Prof. KESTER, Oliver (TRIUMF)

An understanding of how the properties of matter originate from the deeply fundamental constituents of QCD is the primary goal of nuclear physics and the motivation for a new facility, the Electron-Ion Collider (EIC). The EIC will be constructed at Brookhaven National Lab and will take advantage of the entire existing Relativistic Heavy Ion Collider (RHIC) facility, but requires challenging modification and additions to provide unprecedented beam intensities while maintaining a high degree or polarization. The well-established beam parameters of the present RHIC facility are close to what is required for the highest performance of the EIC, with the exception of three times the hadron beam current that will be achieved by increasing the number of bunches. The addition of an electron storage ring (ESR) inside the present RHIC tunnel will provide polarized electron beams up to 18 GeV for collisions with the polarized protons or the heavy ions of RHIC. The EIC accelerator design must satisfy all the requirements of the science program while having acceptable technical risks, reasonable cost, and a clear path to achieving design performance after a ramp-up period.

T2-7 Fluctuations and Disorder in Condensed Matter (DCMMP) | Fluctuations et désordre en matière condensée (DPMCM) - MDCL 1309 (10:45 - 12:15)

-Conveners: Shi, An-Chang (McMaster University)

[3410] (I) Recent Advances on the Glass Problem (10:45, 30 minutes)

Presenter: Prof. CHARBONNEAU, Patrick (Duke University)

Over the last decade, theoretical advances by Giorgio Parisi, Francesco Zamponi and coworkers have provided an exact solution to the glass problem in the limit of infinite spatial dimension. Interestingly, the dynamical arrest this work predicts is consistent with the mode-coupling theory of glasses, and the ensuing entropy crisis at the Kauzmann transition with the random first-order transition scenario. However, what survives of these features and what other processes contribute to the dynamics of three-dimensional glass formers remain largely open questions. In this talk, I present our recent advances toward a microscopic understanding of the finite-dimensional echo of these infinite-dimensional features, and of some of the activated processes that affect the dynamical slowdown of simple yet realistic glass formers.

[3411] (I) Linking placement of associating groups along polymer chains to phase behavior of polymer blends using PRISM theory and molecular simulations (11:15, 30 minutes)

Presenter: Prof. JAYARAMAN, Arthi (University of Delaware)

Phase behavior of polymer blends (i.e., the miscibility or phase separation of the two or more polymer chemistries in the blend) can be tuned by incorporation of functional groups that allow for favorable association between the polymers in the blend. In this talk, we will present our current work involving Polymer Reference Interaction Site Model (PRISM) theory and coarse-grained molecular dynamics simulations to predict the blend morphology (i.e., macrophase separated, disordered with concentration fluctuations, microphase separated) as a function of placement and fraction of associating groups along polymer chains at varying strengths of association. The features in structure factors [S(k) vs. k] calculated using PRISM theory for varying polymer design and association strengths are used to identify the morphologies within the phase diagram. For the disordered morphologies that exhibit concentration fluctuations, we calculate how the length scales of concentration fluctuations change with the associating group placement for similar fraction of association groups. Then, we use molecular simulations to visualize and quantify the molecular packing that explain these results obtained from PRISM theory. Using this combination of PRISM theory and molecular simulations we are able to explore a large polymer design space with reduced computational intensity and more reliable structure factors than would be possible with an approach involving only molecular simulations. This work was funded by U.S. Department of Energy, Office of Science (DE-SC0017753)

[3412] (I) Building blocks of soft matter crystals: Complex symmetries via frustrated packing of ‘mesoatomic’ elements in block copolymer melts (11:45, 30 minutes)

Presenter: Prof. GRASON, Gregory (University of Massachusetts Amherst)

Supramolecular soft crystals are periodic structures formed by the hierarchical assembly of macromolecular constituents and occur in a broad variety “soft matter” systems, from polymers and liquid crystals to biological matter. Often the building blocks consist of groups of molecules, termed “mesoatoms,” such collections are readily reconfigurable individually and collectively at the sub-unit cell scale, strongly coupling to periodic symmetries at supra-unit cell scale. In this talk I describe structure formation of soft crystals deriving from the assembly block copolymer (BCP) melts, a prototype for a broader class of supramolecular materials. While supramolecular crystals are observed to form crystal symmetries whose complex symmetries rival their hard atomic counterparts, rational frameworks for understanding and guiding these complex symmetry based on properties of the molecular constituents lag far behind. I will describe theoretical models that map thermodynamics of soft crystal formation in BCP onto geometric models which encode two competing tendencies. On one end, generically repulsive interactions favors *minimal* area of the inter-material dividing surface (IMDS) between unlike chemistries with mesoatomic domains. At the same time, the entropic cost of extending polymeric blocks to fill space evenly in these domains tends for favor uniformity in domain “thickness”. I will describe how assembly thermodynamics maps onto models that integrate generalizations of the *Foam (or ‘Kelvin’) problem* , and the *Quantizer problems* which seek, respectively, tessellations of space that minimize area and minimize second moments of distance within cells. I will discuss two applications of this geometric formulation of thermodynamic principles. In the first, I will briefly describe a model of complex crystals of “quasi-spherical” mesoatomic units that describes the thermodynamic competition between complex phases including the Frank-Kasper phases, which have recently been observed in BCP and number of supramolecular systems [1]. Second, I will describe recent attempts to generalize the “mesoatomic picture” to BCP crystals of polycontinuous and inter-catenated network topologies. I will describe a basic framework to deconstructing these more complex domain topologies into elementary units whose non-convex shapes and packing may shed new light on the process of their formation. Additionally, I will describe how complex and non-uniform network domains motivate a generic picture for space filling in arbitrary complex BCP domains, known as the *medial packing* [2]. I will describe a (strong-stretching) theoretical model for medial packing in triply-periodic double network crystals (e.g. the double-gyroid and double-diamond) phases, whose predictions suggests this geometric principle may be the key to resolving a long-standing problem in BCP assembly regarding the their thermodynamic stability [3]. References: 1) A. Reddy, M. B. Buckley, A. Arora, F. S. Bates, K. D. Dorfman and G. M. Grason, "Stable Frank-Kasper phases of self-assembled, soft matter spheres", Proceedings of the National Academy of Sciences USA 115, 10233-10238 (2018). 2) A. Reddy, X. Feng, E. L. Thomas and G. M. Grason, "Block Copolymers Beneath the Surface: Measuring and Modeling Complex Morphology at the Subdomain Scale ", Macromolecules 54, 9223-9257 (2021). 3) A. Reddy, M. S. Dimitriyev and G. M. Grason, "Medial packing and elastic asymmetry stabilize the double-gyroid in block copolymers", submitted, arXiv: 2112.06977 (2022).

T2-8 Precision Techniques in Spectroscopy (DAMOPC) | Techniques de précision en spectroscopie (DPAMPC) - MDCL 1016 (10:45 - 12:15)

-Conveners: Jens Lassen

[3525] (I) Probing a Structural Phase Transition of Trapped Ions in the Quantum Regime (10:45, 15 minutes)

Presenter: HALJAN, Paul C (Simon Fraser University Physics)

We experimentally characterize the 1D linear to 2D zigzag structural transition for arrays of ions confined in a linear Paul trap and cooled to near their ground state of motion. Raman sideband spectroscopy is used as a probe to reveal both the energy level structure and the motional population distribution of the ion crystal near the critical point. The nature of the transition will be discussed, prospects for coherence assessment near the critical point as well as potential applications in in-situ sensing of electric field noise.

time	[id] title	presenter
11:00	Detailed program to come (1 hour)	

T2-2 Plasma Physics Symposium II (DPP) | Symposium de physique des plasmas II (DPP) - MDCL 1010 (10:45 - 12:15)

-Conveners: Reuter, Stephan (Polytechnique Montreal)

[3146] (I) Influence of discharge parameters on the mode-coupling instability in two-dimensional complex plasma crystals (10:45, 30 minutes)

Presenter: COUEDEL, Lenaic

The dependence of the mode-coupling instability threshold in two-dimensional complex plasma crystals is studied. It is shown that for a given microparticle suspension at a given discharge power there exist two thresholds in pressure. Above a specific pressure p_cryst , the monolayer is always in the crystal phase. Below a specific pressure p MCI , the crystalline monolayer undergoes the mode-coupling instability and the monolayer is in the fluid phase. In between p_MCI and p_cryst, the crystal will be in the fluid phase when increasing the pressure from below p_MCI until it reaches p_cryst where it recrystallises, while it remains in the crystal phase when decreasing the pressure from above p_cryst until it reaches p_MCI. A simple self-consistent sheath model is used to calculate the rf sheath profile, the microparticle charges and the microparticle resonance frequency as a function of power and background argon pressure. Combined with calculation of the lattice modes the main trends of p_MCI as a function of power and background argon pressure are recovered. The threshold of the mode-coupling instability in the crystalline phase is dominated by the crossing of the longitudinal in-plane lattice mode and the out-of-plane lattice mode induced by the change of the sheath profile. Ion wakes are shown to have a significant effect too. References [1] L. Couëdel and V. Nosenko, Stability of two-dimensional complex plasma monolayers in asymmetric capacitively-coupled radio-frequency discharges, Phys. Rev. E 105, 015210(2022)

[2994] (I) The century old Langmuir probe inference problem: Beyond analytic approximations with machine learning techniques. (11:15, 30 minutes)

Presenter: Prof. MARCHAND, Richard (University of Alberta)

The inference of basic plasma parameters such as density and temperature, is a century old problem, starting with the seminal work of Tonks and Langmuir in the early 1900. Several theories have been developed to determine probe characteristics; that is, collected currents as a function of bias voltage, under diverse laboratory and more recently, space plasma conditions. The advantage of the resulting theoretical analytic characteristics, is that they enable relatively simple algorithm, making it possible to infer plasma parameters quickly, with modest computing resources. On the downside however, all theories rely on simplifying assumptions in order to make the solution of the probe characteristic problem analytically tractable. In actual plasma, these assumptions are typically not all satisfied, which results in errors and uncertainties which are often difficult to quantify. A solution to this predicament would consist of using computer simulations to determine probe characteristics under more realistic conditions, and from there, infer parameters of interest. A direct use of simulations is unfortunately not practical, because of the large computing resources (days to months of computing on supercomputers, depending on the complexity of the system) required to determine a single characteristic. An alternative to the direct simulation approach is to use simulations to pre-compute probe, and more generally particle sensor responses in a range of relevant plasma conditions, and construct a solution library consisting of probe collected currents with, for example, corresponding plasma density, temperature, flow velocity, or ion effective mass. This synthetic solution library in turn can be used to train regression models from which inferences with quantifiable uncertainties. Examples are presented where such models are constructed and applied to in different situ space plasma measurements.

[3084] (I) Extreme plasma heating and flows in Earth’s ionosphere (11:45, 30 minutes)

Presenter: KNUDSEN, David

During quiet times, Earth’s ionosphere is characterized by relatively cool temperatures of 2,000 K (~0.2 eV) and less. However, the ionosphere can be highly disturbed in the presence of the aurora, which during active periods deposits hundreds of GW into the high-latitude atmosphere via the ionosphere. This energy comes from the magnetosphere in the form charged particle precipitation, Joule or frictional heating in the lower ionosphere, and wave-particle interactions at higher altitudes. The latter pathway can result in ion temperatures of the order of a million K – comparable the temperature of the solar corona. While such extremes have been measured for many decades in the magnetosphere, until recently they were not reported below 500 km altitude – within the main ionosphere – presumably due to damping and dissipation caused by collisional interaction with the neutral atmosphere. However, high-time-resolution imaging of particle distribution functions made possible by the Swarm and ePOP satellite missions has in fact revealed the presence of extreme temperatures within the main ionosphere (Shen et al.,2018) - typically in highly localized regions of the order or less than 1 km wide, which are traversed in only a fraction of a second by a satellite in low Earth orbit. This talk will describe a new generation of particle instrument that has made possible the detection and characterization of these extreme regions, and their importance to geophysics and plasma physics. Shen, Y. et al. (2018). Low□altitude ion heating, downflowing ions, and BBELF waves in the return current region. Journal of Geophysical Research: Space Physics, 123(4), pp.3087-3110.

T2-4 Hot Topics From Theory Made Accessible (DTP) | Sujets chauds de la théorie rendus accessibles (DPT) - MDCL 1102 (10:45 - 12:15)

-Conveners: Frank, Mariana (Concordia University)

[3139] (I) Teaching quantum computers to simulate gauge theories for particle physics (10:45, 30 minutes)

Presenter: MUSCHIK, Christine

Gauge theories are the basis of our understanding how the elementary constituents of matter such as quarks and gluons interact and form therefore the backbone of the standard model of particle physics. Numerical simulations of gauge theories are key for understanding the physics of the standard model and have developed into a thriving and extremely successful field. There are however important problem classes that are plagued by sign-problems, and that are therefore out of reach for current simulation methods, even for future supercomputing centers. Quantum computers represent an enormous scientific opportunity to make inroads towards answering fundamental open questions that are insurmountable for current computing methods. But doing so requires developing the theoretical framework and concrete protocols that will allow quantum computers to simulate fundamental particles and their interactions. This talk will be devoted to recent developments in quantum computing that strive to develop quantum-enhanced simulation methods for simulating particle physics.

[2995] (I) Faster-Than-Light Travel and Time Travel: Science or Science Fiction? (11:15, 30 minutes)

Presenter: SHOSHANY, Barak

Time and causality are two of the most fundamental concepts in physics, and yet they remain ill-understood. In my research I use general relativity and quantum mechanics, two cornerstone theories of physics with great theoretical and experimental success, to investigate one of the most exciting and thought-provoking questions about time and causality: whether causality can be violated. The two most commonly known manifestations of causality violation are faster-than-light (FTL) travel and time travel. In time travel, the traveler directly violates causality by traveling to their own past. In FTL travel, the traveler merely travels so fast that they can causally influence events they could not have otherwise - but as it turns out, FTL travel can often be used to facilitate time travel. Can these concepts be transformed from science fiction into real science, even just in principle? The answer to this question is currently unknown, and this indicates a major deficiency in our understanding of the universe. A positive answer would revolutionize physics and require substantial rewriting of our existing theories. A negative answer would provide valuable insights into the inner workings of our theories, by figuring out the mechanisms by which our universe protects causality, as first conjectured by Stephen Hawking. In this talk I will discuss the possibility of FTL travel and time travel within the established framework of general relativity and quantum mechanics, including recent progress made by myself and my students.

[3397] (I) Novel Directions in the Search for New Physics (11:45, 30 minutes)

Presenter: ARVANITAKI, Asimina

The Standard Model has been successful in describing phenomena that we observe from galactic down to subatomic scales. Nevertheless, it is not complete. The extreme weakness of gravity or the nature of Dark Matter are examples of puzzles that suggest the presence of new physics. Traditionally, we look for answers at colliders. In the last few years, we realized some of these answers may come from precision experiments that look for the tiny signals with which new physics may manifest itself. In this talk, I will review some of these ideas and the motivation behind them.

CJP Editorial Board Meeting | Réunion du comité de rédaction de la RCP - MDCL 2230 (12:00 - 13:30)

-Conveners: Robert Mann

Break for Lunch (12h15-13h15) | Pause pour dîner (12h15-13h15) - MDCL Hallways (12:15 - 13:15)

T3-1 Advances in Physics in Biology and Medicine Symp.: Physics in Medicine (DPMB) | Symposium sur les progrès en physique dans la biologie et la médecine: la physique en médecine (DPMB) - MDCL 1110 (13:15 - 14:45)

-Conveners: Cornelia Hoehr

[3441] (I) Novel cancer treatment in a FLASH – development towards reducing side effects of cancer therapy using X-rays, electrons and protons at TRIUMF (13:15, 30 minutes)

Presenter: GOTTBERG, Alexander (TRIUMF (CA))

Over the last half century, cancer has remained a major cause of death in Canada and worldwide. Although therapy-induced cure rates have gradually improved for some cancers and early detection has improved survival for others, cancer is still among the most straining healthcare burdens. Radiotherapy has contributed to improvements in treatment through technological advances and refinements of dose fractionation and is currently responsible for approximately 80% of all non-surgical cancer cures. However, about half of patients treated with radiotherapy are not cured, creating a significant unmet need for continued improvement to therapeutic options. Recent enthusiasm in the radiotherapy community surrounding the concept of FLASH radiotherapy, delivering large doses of radiation as a single dose at ultra-high rates, is founded on the enormous potential impact of FLASH on radiotherapy cure rates and improved quality of life for patients. The current interest in FLASH was catalyzed by recent publications reporting a significant increase in the therapeutic index compared with conventional radiotherapy. The key observation driving further research is that, in FLASH, normal tissue damage is reduced whilst tumour control is maintained, enhancing the therapeutic index. Obviously, if borne out in clinical trials, FLASH radiotherapy would be a momentous step forward in radiotherapy, providing opportunity for improvement in response, cure rates, access to treatment, treatment capacity and healthcare economics. While the FLASH radiation concept has generated significant interest, advancing the data is somewhat limited by the availability of suitable accelerator systems and comparability of existing experimental data. Many groups are pursuing FLASH radiation research with a plethora of sources and models with mixed results, making interpretation of the precise conditions in which FLASH-mediated normal tissue sparing occurs difficult. Together with its partners, TRIUMF possesses unique expertise, technology and capabilities to conduct comprehensive and systematic studies to investigate the FLASH phenomena using protons, photons and electrons in a single biomedical reference environment. Dedicated infrastructure for generating FLASH-relevant dose rates has recently been commissioned or is under construction at TRIUMF. The key technical cornerstones of this campaign, as well as dosimetry and early biological results will be presented.

[3271] (G*) Analysis of cytotoxicity trends in breast cancer cells using total reflection X-ray fluorescence (TXRF) (13:45, 15 minutes)

Presenter: HEDDEN, Natasha (Ryerson University)

Gold nanoparticles (AuNPs) have unique physical and optical properties that make them ideal for various medical uses such as biomedical imaging, photothermal therapy, and drug delivery. With higher concentrations used in cancer therapy, it is imperative to understand both the benefits and potential side effects of AuNPs. Several studies have been done to quantify the toxicity of naked AuNPs. Still, it is unclear whether the trends in toxicity can be attributed to variations in the cell line, size, and shape of the AuNPs, or to the absolute gold nanoparticle mass taken up by the cell. Utilizing the total reflection X-ray fluorescence (TXRF), rapid and precise uptake quantification for trace-levels of gold, complemented with a cell assay to measure short-term toxicity, is proposed. By incubating breast cancer cells MDA-MB-231 with different sizes, concentrations, and shapes of naked AuNPs, while measuring total cellular uptake of gold, the correlation between these parameters is investigated. Following the incubation, cell toxicity is measured using flow cytometry to draw conclusions regarding toxicity trends. We trust that this work will provide insight on the safety of AuNP use in vitro, which could be extrapolated to the safe in vivo clinical use of AuNP.

[3169] (U*) An augmented-reality setup to improve accuracy in surgical chronic kidney mice model (14:00, 15 minutes)

Presenter: RAM, Udbhav

The 5/6 nephrectomy is a prevalent model in the analysis of chronic kidney disease. It often takes the form of a surgical resection of 5/6 of the renal mass in two, distinct surgical procedures. The first step involves the resection of 2/3 renal mass from the left kidney. The second stage is a complete resection of the right kidney after one week. The initial 2/3 resection is critical to the success of the model overall and has a large impact on downstream data collection. With increased variability between procedures and operators comes an increase in phenotype variability, with a high discard rate of 36% and waste of animals. We developed a program, along with a fully supported hardware and firmware suite consisting of a high-resolution camera connected to a laptop or tablet. The software identifies the kidney in the image and provides cut points overlaid to the camera image in real-time to the surgeon who then traces along those lines to complete the procedure. Augmented reality and image processing are done using a deep learning approach. Through this research, we hope to significantly increase the precision and reproducibility of the surgery to increase the success rates and decrease the number of animals that meet the resection goal. Software and setup will be made publicly available and shared with research groups worldwide.

[2990] Monte Carlo Simulation of FFF Photon Beam in Radiotherapy (14:15, 15 minutes)

Presenter: Dr CHOW, James (University of Toronto)

Objective: When 3-dimensional conformal radiotherapy is eventually replaced by intensity modulated radiotherapy, the flattening filter (FF) can be removed from the medical linear accelerator (Linac). Although the flattening-filter-free (FFF) photon beam has some advantages such as higher beam output and less head scatter in dose delivery, there is a dosimetric concern over the low-energy photons in the FFF beam. This study investigated dosimetric changes when FF is removed from the Linac in doses of skin, bone and mucosa, beam angle and skin dose enhancement, when patient used topical cream during radiotherapy. Methods: Monte Carlo simulations using the EGSnrc-based code were carried out using various water and heterogeneous phantoms containing bone, air and water. The mean doses on the phantom surface, and at the bone and mucosa were determined with various beam energies (6-10 MV), beam angles (0-90 degree) and presence of FF in the Linac. In addition, the photon energy distribution on the phantom surface and mean photon energies of the bone and mucosa were determined. Results: For the water phantom, the output of the FFF photon beam was found more than two times of the FF beam. The dose at the phantom surface for the FFF photon beam was higher than the FF beam, and the results varied with the beam obliquity. Moreover, lower mean bone dose was found for the FFF photon beam compared to the FF beam, and the FFF beam contained more low-energy photons than the FF beam on the phantom surface. With application of topical cream in the phantom, dependence of dose enhancement on the cream thickness was found sensitive to the beam angle. Conclusion: It is concluded that dosimetric changes are present on the photon beam when FF was removed from the Linac. This change is mainly due to the presence of low-energy photons in the FFF beam.

[2989] Creating a Chatbot for Radiation Safety Training in Radiotherapy (14:30, 15 minutes)

Presenter: Dr CHOW, James (University of Toronto)

Objective: An AI Chatbot was created for radiation safety training in radiotherapy. The Bot was for radiation staff, namely, radiation oncologists, medical physicists and radiotherapists, working in a cancer center, so that they could learn and refresh their radiation safety knowledge without attending the classroom session in the center. This is in particular important in the pandemic period, when face-to-face communication between hospital staff should be kept to a minimum. Methods: The Bot was created on the IBM Watson Assistant Cloud platform. For a human-like communication between the Bot and the user, machine learning feature such as Natural Language Processing provided by the tool of Intent in the Watson platform, was used to determine the specific intent of the user's input. The Bot contained fifteen radiation safety questions, which could be customized according to training needs and timed to fit into the attention span of the end-user. For fine-tuning and commissioning, the Bot was pre-tested in various virtual meetings and conferences. Feedbacks from the test were used to further update and upgrade the Bot continuously. Results: Using the Watson Cloud platform the Bot could be integrated into different channels such as Webchat, WhatsApp and Discord. The Bot was user friendly, and intentionally asked the name of the user and would use the name for further communication. When the user could not provide the expected response from the question, the Bot would provide guidance to the user and help him/her to give the correct answer. Finally, the Bot would report to the user the final results of the training and test, and provide suggestions to the user for further improvement. Conclusion: A chatbot for radiation safety training in radiotherapy was created. The Bot could be accessed from any Internet of things to provide a convenient and efficiency knowledge transfer in radiation safety.

T3-3 New Directions in Accelerator-Based Experiments: Future Experiments at TRIUMF and Brookhaven (PPD) | Nouvelles voies fondées sur des accélérateurs: expériences futures à TRIUMF et Brookhaven (PPD) - MDCL 1105 (13:15 - 14:45)

-Conveners: Stelzer-Chilton, Oliver (TRIUMF (CA))

[3289] (I) Measurement of Beam Polarization at an e^+e^- B-Factory with New Tau Polarimetry Technique (13:15, 15 minutes)

Presenter: MILLER, Caleb

A polarized electron beam is being considered as an upgrade for the SuperKEKB accelerator, which would enable a new precision electroweak physics program at Belle II. Many of these electroweak tests are preformed with experimental measurements of the left-right asymmetry, A_{LR}, where the expected level of precision at Belle II dictates at least one loop calculations from theory. We have tested the level of agreement in NLO calculations of A_{LR} for Bhabhas, against a Monte Carlo generation of the asymmetry with the new ReneSANCe generator. For future experimental measurements of A_{LR} the expected limiting uncertainty is the average beam polarization. A new technique, Tau Polarimetry, has been shown to be capable of measuring the average beam polarization to better than half a percent. This has been implemented at the $B\kern-0.1em{\small A}\kern-0.1em B\kern-0.1em{\small A\kern-0.2em R}$ experiment, a precursor experiment to Belle II, and the average beam polarization of it's associated accelerator, PEP-II, precisely measured. This presentation will present the technique, including its systematic uncertainties, using the full $B\kern-0.1em{\small A}\kern-0.1em B\kern-0.1em{\small A\kern-0.2em R}$ Υ(4S) dataset.

[2988] (I) Hunting for new particles at TRIUMF with the DarkLight experiment (13:30, 25 minutes)

Presenter: PACHAL, Katherine

The nature of dark matter and its relationship to the Standard Model is one of the highest priority open questions in particle physics today. Accelerator-based experiments are a powerful tool in the search for dark matter and the new bosons that may mediate its interactions with the known particles. The DarkLight experiment will search for such a new boson with preferential couplings to leptons in an important uncovered mass range. DarkLight will be based at the TRIUMF e-linac, and this project includes planned upgrades to the accelerator that will both increase its energy and make it accessible to other future experiments.

[3080] (I) The cyclotron based high-yield ultracold neutron source and neutron electric dipole moment experiment (13:55, 25 minutes)

Presenter: Dr PICKER, Rüdiger (TRIUMF)

The neutron itself is an ideal laboratory for studying various beyond-the-standard-model theories. Precise measurements of the neutron lifetime can shed light on light element abundances in the universe, searches for electric dipole moments (EDMs) could reveal mechanisms that created the apparent matter-antimatter asymmetry in the universe. The key to these studies are long observation times of the neutron and high neutron densities in experiments. The first is achieved by using very slow, ultracold neutrons (UCN) that can be studied and manipulated for hundreds of seconds, the latter is achieved by superthermal sources of ultracold neutrons. At TRIUMF the TUCAN collaboration is combining a cyclotron-driven spallation neutron source with a liquid-deuterium moderator and superfluid-helium converter cooled down to around 1 K by a high-power helium-3 cryostat. The UCN are extracted near-horizontally into vacuum guides and transported to a room-temperature EDM experiment. A state-of-the-art magnetically shielded room and self-shielded coils provide a stable magnetic field environment essential for a precise measurement. The presentation will introduce the key principles of source and experiment and provide a status update.

[3455] (I) The Electron-Ion Collider: A New Microscope for Nuclear Matter (14:20, 25 minutes)

Presenter: DECONINCK, Wouter

Most of the visible mass in the universe consists of quarks and gluons bound in protons and neutrons. But, there remain several big questions about some surprisingly basic properties of the protons and neutrons (or nucleons, collectively). How does the mass of the nucleon arise from the much lighter quarks and massless gluons? How does the spin ½ of the nucleon arise from the spin ½ quarks inside it? What are the emergent properties of dense gluons systems? To investigate these questions, the US Department of Energy is building the Electron-Ion Collider (EIC) at Brookhaven National Laboratory on Long Island, NY. Polarized electrons will be accelerated to 5-18 GeV and collide with polarized protons, light ions, or unpolarized heavy nuclei accelerated to 40-275 GeV. The expected peak luminosity will be as high as 1034 cm-2s-1 to allow for precision “nuclear femtography.” As part of large international collaborations, several Canadian universities are shaping the development of the EIC experiments and their detectors.

T3-2 Plasma Physics Symposium III (DPP) | Symposium de physique des plasmas III (DPP) - MDCL 1010 (13:15 - 14:45)

-Conveners: Reuter, Stephan (Polytechnique Montreal); Ahmad Hamdan

[3449] (I) Advances in Laser Induced Breakdown Spectroscopy Assisted with Laser Induced Fluorescence (13:15, 30 minutes)

Presenter: Dr SABSABI, Mohamad (Energy, Mining and Environment Research Center, National Research Council Canada)

The Laser-Induced Breakdown Spectroscopy (LIBS) technique involves serval fields of science, such as laser-matter interaction, plasma physics, atomic physics, plasma chemistry, spectroscopy, electro-optics, and signal processing. The LIBS plasma is transient, unlike an inductively coupled plasma, arc plasma, or glow discharge plasma, which are all stationary plasma. This characteristic makes the LIBS technique suffers from poor sensitivity by comparison to other optical emission spectroscopy techniques. During the last three decades, extensive research has been carried out to improve LIBS sensitivity and performances by several approaches such as double pulse mode, combining LIBS with laser induced Fluorescence (LIF), combining LIBS with microwave among other techniques. The approach of LIBS combined with LIF (LIBS-LIF) is an emerging analytical tool that has the potential to analyse rapidly and in-situ with little or no preparation of any kind of material. LIBS-LIF is therefore a good candidate to fulfil the needs for real time analysis of contaminant traces for environmental applications. The LIBS-LIF approach uses a first conventional laser tuned to a fixed wavelength to ablate the sample and generate the plasma. Then, a second tunable laser (such as an optical parametric oscillator (OPO)) selectively excites the plasmas ablation and thus enhances the emission of spectral lines of interest. Different combination of excitation! Lines as well as plasma generation creation conditions were studied to optimise the performances of the LIBS-LIF for spectrochemical analysis in our laboratory and elsewhere. In this presentation, we will discuss the most significant research contributions for improving the quantitative analysis by LIBS-LIF in terms of sensitivity and accuracy for environmental, agriculture and mining applications. We will present some novel approaches aimed at the improvement of the analytical figure of merit of LIBS-LIF. Finally, a view point on the LIBS and LIBS-LIF combination and their future will be given and discussed.

[3402] (G*) Production of emulsion by discharges at the interface of two immiscible liquids (13:45, 15 minutes)

Presenter: DORVAL, Audren

Pulsed spark discharges in dielectric liquids have various applications such as precise machining, nanomaterial synthesis, or for liquid depollution/reformation. Discharge in liquids produce highly reactive species, in addition to shock waves, heat, and radiation. Discharges at the interface of two immiscible liquids have been recently introduced, and they showed great interests for fundamental as well as for applied studies. For instance, due to E-field enhancement at the interface, it was possible to sustain discharges with 100% of probability of occurrence. These discharges simultaneously dissociate the two liquids, which opens the way to a novel plasma concept. In this work, spark discharges are produced between two-copper electrodes, mounted parallel to the interface of two liquids: distilled water and heptane. The discharges were produced using pulsed high voltage with amplitude of 20 kV and pulse width of 500 ns, at low repetition rate (5 or 50 Hz). The waveforms of the voltage and the current of each discharge were acquired, and then automatically processed, using algorithm, to determine some characteristics. For instance, we determined the temporal evolution of the probability of discharge occurrence as a function of electrode-interface distance. The results have shown that the highest probability is obtained when the electrodes are at the interface. This is because the electric field is intensified by the interface. Moreover, the liquids changed color and became milky. Such change is due to the production of emulsion, i.e. droplets of heptane in water. The size distribution of the emulsion has been determined using dynamic light scattering (DLS). The production of the emulsion is due to the generation of cavitation bubbles that oscillate (series of explosion-implosion motion) at the interface. DLS measurements showed that the spark-generated emulsion has a size distribution range between few tens of nanometer to few micrometers.

[3122] (G*) Combined High-Voltage Pulse and Radiofrequency Excitation for Large-Volume High-Pressure Non-Thermal Plasma Generation (14:00, 15 minutes)

Presenter: FILICE, Dante

Large volume, atmospheric pressure non-thermal plasma volumes are desired for uniform plasma processing applications. Nanosecond (ns) pulsed plasma sources are effective at igniting and sustaining plasmas in atmospheric pressure gases and gas mixtures. These pulses produce large quantities of excited species and highly reactive radicals participating in the desired chemical reaction pathways. When sufficiently separated in time, the power delivery of each pulse is relatively discrete resulting in minimal memory effect. The rapid quenching of the electron and excited species densities causes the discharge to essentially face re-ignition conditions every pulse. This dynamic load impedance leads to the efficiency of power delivery from electrical mains to plasma to be sufficiently low. On the other hand, conventional RF discharges can provide high electrical power-to-plasma chemical energy conversion efficiency, however sustaining a uniform discharge at atmospheric pressure proves to be challenging. Commercially available RF power supplies cannot reach the breakdown voltage thresholds required to ignite electrical discharges at atmospheric pressure in most gas mixtures and useful interelectrode gaps. We are particularly interested in a rather new approach of the combination of a ns pulsed high-voltage source with a continuous RF. The ns pulser causes gas breakdown and electrical discharge formation in the interelectrode gap while supplying a high density of energetic electrons to initiate energetic plasma chemistry. Between ns pulses, the sub-breakdown continuous RF field takes over and provides the typical RF processing characteristics such as large diffuse volumes and moderate energy plasma chemistry. Preliminary testing was performed in parallel-plated geometry with argon as the plasma forming gas at 1 atm. Preliminary results demonstrated the ability to produce a repetitive ns discharge and formation of a uniform glow at sub breakdown voltages in between pulses. Gas mixtures containing increasing amounts of N2 and H2 are introduced to see the effect on the plasma characteristics as well as power delivery. Introducing molecular gasses will give insight on the possibility of using this method of power delivery for reactive gas mixtures. We will report on the efficiency of power delivery as well as general dynamics of the discharges.

[3041] (G*) Streamer Propagation at Water Surface: Influence of Gap Distance and Quantification of Injected Charge. (14:15, 15 minutes)

Presenter: Mr HERRMANN, Antoine

A streamer discharge is a highly reactive and dynamic non-thermal plasma. It has been used in many applications, including environmental remediation, medicine, and material processing. Although the physics of streamer discharges in gaseous media is well understood, its interaction with a solid and liquid dielectric surface remains under investigation, in particular when quantitative data are searched for. Here, we investigate the propagation of pulsed discharge at the surface of distilled water, in pin-to-plate geometry and under various experimental conditions of gap distance and applied voltage. The former has been adjusted between 10 and 1000 µm, while the latter was adjusted from 8 to 20 kV; the pulse width was 100 ns. The discharge was characterized electrically, using high voltage and current probes, and optically, using time resolved imaging technique (ICCD camera with temporal resolution of 1 ns). The results have showed that the discharge is ignited at the anode tip and propagates towards the water surface. Initially, it has a disk-like shape that evolves (after a few nanoseconds) to a ring. Another few nanoseconds later, the ring breaks into dots that propagate on the water surface. Because of its stochastic nature, a large number of discharges was performed to address the influence of the applied voltage and the gap distance on the number of plasma dots produced, as well on the injected charge. As expected, for a given applied voltage, the breakdown voltage is found to increase with the gap distance. Moreover, the total injected charge decays linearly with a rate of ~8-9 nC by 200 µm of gap distance increase, while the number of dots decreases linearly with the gap distance at the rate of ~1 dot by 200 µm of gap distance increase. Based on the measurement of the propagation velocity of the plasma dots and on the estimation of the electric field in the medium, an average mobility of plasma dots of ~1.5 cm2/Vs is evaluated. From both, this value and the instantaneous measured propagation velocity, the temporal evolution of the charge per dot is determined. The observations reported here are of interest for fundamental studies as well as for applications where well-controlled charge transfer to surfaces is crucial.

[3389] (G*) Plasma activated water treatment in hydroponic culture: from seedling to mature growth (14:30, 15 minutes)

Presenter: WATSON, Sean (Polytechnique Montreal)

Rupture of the supply chain caused by the COVID-19 pandemic highlighted the need for increased local food production. Coupled with population increase, there is steadily increasing demand for fresh local produce. While hydroponic growth allows year-long environmentally controlled production, its humid environment brings undesirable side effects like the proliferation of fungi. For example, Pythium and Phytophtora fungi lower the yield of Boston lettuce production; to combat these pathogens we envisage water treatment with non-thermal air plasma, a method where chlorination and ozone have failed. This enables other beneficial reactions, nitrogen fixation, which help reduce the need for commercial fertilizers. Before tackling the larger-scale use of plasma in Quebec-based green houses, our team is first conducting the following laboratory-scale investigation. We study the evolution of lactua savita var. capitata in a batch type hydroponics system, from seedling to a fully mature growth. A comparison is conducted between plasma treated and untreated contaminated water, with or without added nutrient, and positive (tap water + nutrients) and negative controls (tap water only), to assess the impact of plasma treatment on plant growth and possible phytotoxicity. Plant growth indicators such as root length and foliage size are investigated; evolution of the water and its nutrient content are monitored with pH, conductivity and colorimetric essays for both NO_2^- and H_2 O_2 with Griess reagent and titanium sulfate stabilized with sodium azide. Electrical parameters for plasma generation are correlated to those resulting chemical moieties in the water.

T3-8 Precision Techniques in Spectroscopy (DAMOPC) | Techniques de précision en spectroscopie (DPAMPC) - MDCL 1016 (13:15 - 14:45)

-Conveners: Jens Lassen

time	[id] title	presenter
13:15	Detailed program to come (1h 30m)	

T3-7 Fluctuations and Disorder in Condensed Matter (DCMMP) | Fluctuations et désordre en matière condensée (DPMCM) - MDCL 1309 (13:15 - 14:45)

-Conveners: Lee, Sung-Sik (McMaster University)

[3413] (I) Understanding the role of entropy in disordered crystalline materials (13:15, 30 minutes)

Presenter: Prof. HALLAS, Alannah (University of British Columbia)

High entropy oxides (HEOs) are a new class of disordered materials that exhibit great promise for a range of applications due to their enhanced structural stability. The “entropy” in an HEO originates from the random mixture of five or more metal ions sharing a single crystal lattice. These phases can only form at high temperatures, when configurational entropy can overwhelm the enthalpy of formation for a conventional ordered phase. However, the actual degree of configurational disorder, its role in stabilizing the HEO phase, and its effect on other physical properties such as magnetism all remain open questions. To shed light on these questions, we have selected the spinel HEO (Mn,Fe,Cr,Co,Ni)3O4 as our model system. This material possesses two unique advantages over other HEOs: (i) the spinel structure has two distinct metal sites in its lattice, allowing us to directly probe entropic forces vs. site selectivity and (ii) all five metal ions are magnetic, meaning that we can independently study the effect of disorder and magnetic dilution. Our study makes use of experimental probes with sensitivities that extend over many orders of magnitude in length scale, which is important for characterizing the true degree of randomness. In my talk, I will present our findings on the nature of the role of entropy in determining the structure of the spinel HEO and the relationship between configurational disorder and magnetism.

[3414] (I) Disordered Phases in quasi-1D models of Kitaev Materials (13:45, 30 minutes)

Presenter: SORENSEN, Erik (McMaster University)

Most of us are familiar with ferromagnetic and antiferromagnetic materials. Although in some cases quantum fluctuations can be strong in such systems we would usually say that the ground state is ordered and described by a non-zero local order parameter. In such systems, the interaction between the quantum spins do not depend on the bond direction. Today, there is a growing class of magnetic materials where it is believed that the interactions indeed are bond-dependent in a way first imagined by Alexei Kitaev thereby opening a way for realizing so called topological phases. Bond-dependent interactions are strongly frustrating for the system and hinders conventional ordering. However, in these Kitaev materials other interactions are also often present, among them the well known Heisenberg coupling and also off-diagonal Gamma (Γ) terms giving rise to an unusally rich phase diagram. Even for the simplest models of Kitaev materials it is extremely difficult to arrive at a precise understanding of this complex phase-diagram. Hence, in order to obtain accurate results it is often useful to restrict the analysis to low-dimensions and here we mainly discuss chains and two-leg ladders. Using advanced numerical techniques, it is possible for such models to determine the phase-diagram with very high precision, including the effects of an applied magnetic field. An astonishing abundance of phases arises from the combination of frustration and applied field. In this talk I will focus on some of these phases that appear disordered, without any conventional local magnetic ordering, but where a hidden string-order can be identified. Surprisingly, such string-order was first suggested in the context of surface roughening.

[3415] (I) Nuclear Magnetic Resonance as a Local Probe of the Disordered Ground State of Proximate Quantum Spin Liquid Materials (14:15, 30 minutes)

Presenter: IMAI, Takashi (McMaster University)

Understanding the nature of the quantum spin liquids (QSL) is the holy grail of quantum condensed matter physics with a broad range of implications to other research fields. Many materials, such as the kagome lattice Heisenberg antiferromagnet (KLHA) consisting of Cu^{2+} ions with spin S=1/2 arranged in a corner sharing triangle geometry, have been proposed as the model system for the QSL. However, they all suffer from various complications, such as the phase transition into the long-range ordered ground state (which should not take place in the real QSL). The few materials that do not undergo a long-range order tend to have structural disorder. Recent research indicated that structural disorder often affects the properties of the proximate QSL materials in a profound manner, making the interpretation of the experimental findings non-trivial. Nuclear magnetic resonance is a local probe, and in principle suited for characterizing the disorder effects in materials. In practice, the distribution of the NMR spin-lattice relaxation rate $1/T_1$ induced by disorder prevented proper data interpretation for decades. In this talk, we will explain how one can deduce the **distribution function** $P(1/T_1)$ of $1/T_1$ based on inverse Laplace transform (ILT) of the nuclear magnetization recovery [1]. $P(1/T_1)$ provides rich information, such as the fraction of spin singlets in the KLHA [2]. [1] P.M. Singer et al., Phys. Rev. B 101, 174508 (2020). [2] J. Wang, W. Yuan et al., Nature Physics 17, 1109-1113 (2021). DOI: 10.1038/s41567-021-01310-3

T3-6 Physics at the EIC Symposium: Theoretical Physics at the EIC (DNP) | Symposium sur la physique à l'EIC: physique théorique à l'EIC (DPN) - MDCL 1008 (13:15 - 14:45)

-Conveners: Stephen Kay

[3459] (I) Theoretical Opportunities at the EIC (13:15, 30 minutes)

Presenter: RADICI, Marco

I will give an overview of selected topics where the EIC could give a substantial improvement to our current understanding of hadron structure.

[3323] (I) Canadian Theory Community and the Electron-Ion Collider (13:45, 30 minutes)

Presenter: Dr BARKANOVA, Svetlana (Grenfell Campus, Memorial University of Newfoundland)

The Electron-Ion Collider (EIC) will uniquely address questions about the origin on nucleon mass and spin, properties of dense systems of gluons, as well as opportunities to connect to neutrino physics, astrophysics, and fundamental symmetries at higher energies. Canadian theorists are valued collaborators complementing the experiment efforts worldwide, and they are currently taking roles in EIC working groups and committees and offer a broad range of contributions such as e+A gluon saturation, GPDs and TMDs, radiative corrections and Lattice QCD. The talk will briefly outline related efforts and expertise of Canadian theory groups, and how Canadian subatomic physics community gathers to outline its vision for the next five years and beyond, placing Canadian contributions within a long-term international context.

[3319] Predicting pion and kaon EM form factors with spin-improved holographic light-front wavefunctions. (14:15, 15 minutes)

Presenter: AHMADY, Mohammad

Holographic light-front wave functions augmented with a dynamical spin structure are used to predict the electromagnetic form factors as well as the decay constant and charge radius for pion and kaon.

T3-5 Private Sector Physicists (CAP-DAPI) | Physicien(ne)s dans le secteur privé (ACP-DPAI) - MDCL 1009 (13:15 - 14:45)

-Conveners: Cluff, Daniel (University of Exeter)

[3504] Energy Management and Mine Cooling via Cryogenics (13:15, 30 minutes)

Presenters: CLUFF, Daniel (University of Exeter), SENGUPTA, Sujit

Mining is at the fundamental base of the technologies needed to manage Climate Change; Canada has recently recognised the importance of implementing a critical metals strategy to secure the future. As we search for more metals we are going deeper, at depths of 2000 m or more the current chilling systems are no longer efficient or even capable of providing the needed chilling. Cryogenic liquids are an energy storage vector that can convert the heat of the mine to electricity and has the unique feature of being a pumped liquid; therefore, chilling can be delivered to the zone where it is needed without having to chill the entire mine air supply. We will present results from our latest test in a real mine setting, which elevates the TRL level from 5 to 7, and outline plans for a large scale test in the next phase of development on the pathway to commercialisation. The presentation will outline the physical mechanisms of cryogenic chilling and energy storage, provide results of measurements during the real time test and include a short video of duration 4:20.

[3505] Panel Session (13:45, 1 hour)

Presenter: D'SOUZA, Ian

T3-4 Hot Topics From Theory Made Accessible (DTP) | Sujets chauds de la théorie rendus accessibles (DPT) - MDCL 1102 (13:15 - 14:45)

-Conveners: Robert Petry

[3386] (I) Entering a new, data-driven era for precision cosmology: opportunities and challenges for machine learning. (13:15, 30 minutes)

Presenter: PERREAULT LEVASSEUR, Laurence

In the past decades, the standard model of cosmology, the inflationary lambda CDM model, has had remarkable success at predicting the observed structure of the universe over many scales of space and time. However, to this day, very little is known about the fundamental nature of its principal constituents: the inflationary field(s), dark matter, and dark energy. In the coming decade, new surveys and telescopes will provide an opportunity to probe these unknown components. These surveys will produce unprecedented volumes of data, the analysis of which can shed light on the equation of state of dark energy, the particle nature of dark matter, and the nature of the inflaton field. The analysis of this data using traditional methods, however, will be entirely impractical. In this talk, I will share recent advances in cosmological data analysis, specifically focusing on the development and the application of machine learning methods. I will show how these methods can allow us to overcome some of the most important computational challenges for the data analysis of the next generation of sky surveys and open a new window of discoveries for cosmology.

[3069] (I) Formation and dynamics of extreme mass ratio inspirals with environmental effects (13:45, 30 minutes)

Presenter: YANG, Huan

In this talk I will discuss relevant environment effects (i.e., accretion disk, tidal gravitational field from close objects) that influence the formation and dynamics of extreme-mass-ratio inspirals (EMRIs), which are important sources for space borne gravitational wave detectors such as LISA. I will show that disk-assisted EMRIs may be more commonly seen by LISA. They can be distinguished from EMRIs formed through cluster multibody scattering by eccentricity measurements. The disk force and tidal gravitational field from nearby objects may also leave observable imprints on the gravitational waveform of the EMRIs. With environmental effects properly accounted for, multi-messenger observations of EMRIs provide new opportunities in probing dark matter, primordial black holes and accretion flows at galactic centers.

[3040] (I) Planets Big and Small (14:15, 30 minutes)

Presenter: Prof. LEE, Eve

Planets in our solar system can be divided into rocky terrestrials as large as the Earth vs. gassy giants as small as Neptune. Planets outside of our solar system, on the other hand, look nothing like our own, with most of these detected exoplanets falling right in between the size of the Earth and Neptune. I will describe the underlying physics that drives the huge diversity in the observed exoplanetary population and discuss how future missions will help us better understand the formation and evolution of solar and extrasolar planets.

Health Break (with exhibitors) | Pause santé (avec exposants) - MDCL Hallways (14:45 - 15:15)

T4-4 Hot Topics From Theory Made Accessible (DTP) | Sujets chauds de la théorie rendus accessibles (DPT) - MDCL 1102 (15:15 - 17:15)

-Conveners: Scandolo, Carlo Maria (University of Calgary)

[3099] (I) Hyperbolic Band Theory (15:15, 30 minutes)

Presenter: Prof. MACIEJKO, Joseph (University of Alberta)

Hyperbolic lattices are a new form of synthetic quantum matter in which particles effectively hop on a discrete tiling of two-dimensional hyperbolic space, a non-Euclidean space of negative curvature. Hyperbolic tilings were studied by the British-Canadian geometer H.S.M. Coxeter and popularized through art by M.C. Escher. Recent experiments in circuit quantum electrodynamics and electric circuit networks have demonstrated the coherent propagation of wave-like excitations on hyperbolic lattices. While the familiar band theory of solids adequately describes wave propagation through periodic media in Euclidean space, it is not clear how concepts like crystal momentum and Bloch waves can be extended to hyperbolic space. In this talk, I will discuss a generalization of Bloch band theory for hyperbolic lattices and stress the intriguing connections it establishes between condensed matter physics, high-energy physics, number theory, and algebraic geometry.

[3006] (I) Electron Hydrodynamics (15:45, 30 minutes)

Presenter: SCAFFIDI, Thomas

Wolfgang Pauli called solid-state physics "the physics of dirt effects", and this name might appear well-deserved at first sight since transport properties are more often than not set by extrinsic properties, like impurities. In this talk, I will present solid-state systems in which electrons behave like a hydrodynamic fluid, and for which transport properties are instead set by intrinsic properties, like the viscosity. This new regime of transport opens the way for a “viscous electronics”, and provides a new angle to study how quantum mechanics can constrain and/or enrich hydrodynamics.

[3113] (I) The physics of aging: embracing complexity (16:15, 30 minutes)

Presenter: RUTENBERG, Andrew

As living organisms age, they stochastically move through high-dimensional "health-space". Developing simple and predictive models that captures aging dynamics is challenging because the organism is not homogenous: there are many thousands of distinct physiological attributes that could be measured. We pursue three strategies to simplify aging while embracing its complexity. First we develop simple one-dimensional summary measures of health. These predict mortality surprisingly well, but not health-trajectories. Second we develop minimal models of networked health that still capture the heterogeneity of the data. These "generic network models" allow us to model how the heterogeneity of health affects aging, but also the effects of disease. Finally, we use machine-learning to identify natural coordinates for describing aging, and to identify simple interactions between health attributes.

time	[id] title	presenter
15:15	Break for DNP John D'Auria Memorial Talk (30 minutes)	

T4-3 New Directions in Accelerator-Based Experiments: Future Experiments - From Collider to neutrinos (PPD) | Nouvelles voies fondées sur des accélérateurs: expériences futures - de collisionneur à neutrinos (PPD) - MDCL 1105 (15:15 - 17:15)

-Conveners: David, Claire (York University (CA))

[3439] (I) The MOLLER experiment (15:15, 25 minutes)

Presenter: Prof. ARMSTRONG, David (William & Mary)

The upcoming MOLLER (Measurement Of a Lepton Lepton Electroweak Reaction) experiment at Jefferson Lab will provide a precision measurement of the parity-violating asymmetry in polarized electron-electron scattering. This should yield the most precise measurement of the weak mixing angle at low energy, and would be sensitive to new physics contributions in the interference between the neutral current and electromagnetic amplitudes as small as 0.1% of the Fermi constant. This would provide discovery reach for new physics in flavor and CP-conserving processes at the multi-TeV scale.

[3220] (I) Proton Driven Plasma Wakefield Acceleration Experiment at CERN (15:40, 25 minutes)

Presenter: VERZILOV, Victor (TRIUMF (CA))

Acceleration of particle beams by induced wakefield in plasmas is a possible solution on a path to push the energy frontier of experimental high energy physics by constructing compact machines with acceleration rates in excess of GV/m. The Advanced Wakefield Experiment (AWAKE), a plasma wakefield acceleration experiment, driven by the 400 GeV proton beam from the CERN SPS synchrotron is unique among plasma wakefield acceleration projects in its selection of protons as the driving particles. The efficiency and reach of energy transfer from 400 GeV protons to electrons confer a clear advantage over electron or laser driven alternatives. The AWAKE collaboration, including a team from Canada, was formed in 2013 as a proof-of-principle experiment and has already produced a wealth of results. The Run 1 of the experiment yielded the discovery of Self-Modulation of the SPS proton bunch in plasmas and acceleration of externally injected electrons to the GeV energy level. Starting in 2021 the experiment has proceeded with a decade-long Run 2 program. The goals for the Run 2 are the stable acceleration of a quality electron beam with high gradients over long distances and proof of scalability of the design principles to very high beam energies. This will allow the AWAKE collaboration to contemplate first applications of the experimental scheme to high-energy physics.

[3454] (I) DUNE and PIP-II (16:05, 25 minutes)

Presenter: MERMINGA, Lia (TRIUMF)

Abstract to come

[3217] (I) Neutrino Physics and Beyond at T2K and Hyper-Kamiokande (16:30, 25 minutes)

Presenter: HARTZ, Mark Patrick (TRIUMF & Kavli IPMU, University of Tokyo)

The Kamiokande, Super-Kamiokande (Super-K) and SNO+ experiments have established large-scale water Cherenkov detectors as powerful tools for the study of neutrinos and the search for new physics processes. Operating since 2009, the T2K experiment has used an accelerator source of neutrinos to study neutrino oscillations with the Super-K detector. In 2020, the successor to T2K and Super-K, Hyper-Kamiokande (Hyper-K), was approved in Japan. Hyper-K will have a sensitive mass 8 times larger than Super-K, and receive a neutrino beam with 2.5 times the intensity of T2K. The unprecedented statistics collected at Hyper-K will allow for precision measurements of neutrino oscillations, including the most sensitive search for CP violation. Hyper-K will also have significantly improved sensitivity for nucleon decay searches, burst and diffuse supernova neutrino detection and dark matter searches, amongst a broad physics program. In this talk, I will review the status of the T2K experiment and the status and plans for the construction of the Hyper-K detector and experiment. I will highlight the Canadian contributions to the Hyper-K project, including contributions to the Intermediate Water Cherenkov Detector, photosensors, calibration systems, and data analysis techniques using machine learning.

[3267] (I) Photogrammetry Calibration of the Super-Kamiokande and Hyper-Kamiokande Detectors (16:55, 15 minutes)

Presenter: GAUR, Rhea

Why there exists an asymmetry between matter and antimatter is one of the great mysteries in understanding the evolution of the universe. The discovery of neutrino oscillations by the SNO and Super-Kamiokande experiments opened up an avenue to explore the differences between neutrinos and antineutrinos, potentially shedding light on the mystery. Teasing out this small difference and understanding complicated neutrino interactions will require unprecedented levels of precision provided by a succeeding, next-generation water Cherenkov experiment called Hyper-Kamiokande. To achieve this, I will present the R&D and implementation of a cross-disciplinary approach known as photogrammetry. This talk focuses on the hardware design for Hyper-Kamiokande and analysis pipeline currently being applied to the Super-Kamiokande detector. Through this, we are able to take images of the detectors and aim to pinpoint the positions of their features to the sub-cm level, effectively reducing systematic uncertainties in the modeling of the detectors due to geometrical distortions.

T4-1 Advances in Physics in Biology and Medicine Symp.: Novel diagnosis and therapy (DPMB) | Symposium sur les progrès en physique dans la biologie et la médecine: nouveaux diagnostics et thérapies (DPMB) - MDCL 1110 (15:15 - 17:15)

-Conveners: Valerie Booth

[3436] (I) Stemless Plastic Scintillation Detectors - A Novel Radiation Dosimeter with a Bright Future (15:15, 30 minutes)

Presenter: HUPMAN, Allan

Approximately half of all cancer patients require radiation therapy at some point during the management of their disease. Radiation detectors are tools for the quantitative characterization of fields of ionizing radiation used for radiation therapy and are essential for their safe and effective use. The goal of dosimetry measurements is to quantify the amount of energy deposited in the body (dose). Therefore, a perfect detector would respond to radiation the same way as human tissue. However, most radiation detectors are not tissue equivalent, which poses a major challenge. Organic electronics are attractive candidates for radiation detectors due to their ability to have highly customizable configurations, can be made flexible, and can be fabricated with a wide selection of materials (i.e. tissue equivalent). In this talk I will present our investigation of a novel detector, the stemless plastic scintillation detector (SPSD), which couples an organic photodiode to a plastic scintillator. Plastic scintillation detectors (PSDs) offer properties that are ideal for the measurement of small fields (high spatial resolution, tissue equivalence, real-time measurements, etc.). However, a limitation of PSDs is Cerenkov radiation (created in the optical fiber), which contaminates the signal and requires a correction. The SPSD detector eliminates the need for an optical fiber to carry the signal, which could allow it to have the benefits of a PSD, while removing the main drawback. The development of this detector will be presented in 4 steps. First, an organic photodiode was operated as a direct radiation detector, exhibiting linearity with dose rate and output factors which agreed with commercial detectors. Second a novel method for the correction of extraneous signal (Compton current) in the organic photodiode will be described. Third, an organic photodiode was coupled to an organic scintillator, creating a single-element SPSD. Several radiation dependencies of the SPSD were measured, which included: linearity with dose, instantaneous dose rate, energy dependence, and directional dependence. The dependencies measured were promising for employment as a radiation detector. Lastly, the culmination of this work was the fabrication of a 1D SPSD array. The array accurately measured small field profiles and output factors.

[3311] (U*) Retinal Image quality decreases in those with diabetes with increasing duration of disease and inversely with the level of disease control (15:45, 15 minutes)

Presenter: Mr DHALLA, Rahim (Physics and Astronomy, University of Waterloo)

Introduction: The eye's optics change in those with type 1 diabetes mellitus. Known optical changes could impact both vision and imaging of diabetes-related changes to blood vessels, which are sight threatening. Here we investigate retinal image quality in those with diabetes and healthy controls. Methods: Using novel methods, retinal image quality was derived for 1200 healthy eyes and 46 participants with type I diabetes mellitus with 47 age-matched controls. For each eye, a phase plate, generated from previously measured Zernike polynomials, was placed in an eye model in CODEV. Individual point spread functions (PSFs) and modulation transfer functions (MTFs) were generated. Image quality metrics were determined from PSFs: their diameter at 50% Encircled Energy (EE), Strehl Ratio (SR), and FWHM depth resolution and from MTFs: area under the Hopkins ratio (AHR). Results: Expected decreased image quality with age was seen in the larger healthy dataset but not in the age-matched healthy controls. Lens thickness increased significantly with age with an additional effect of diabetes duration, in age-matched controls and those with diabetes. In those with diabetes, for at least one metric, image quality worsened with an increase in lens thickness and with variables related to diabetes: lack of diabetes control (glycated hemoglobin, HbA1c) and diabetes duration. A semi-log fit to lens thickness and HbA1c gave the best multiple variable fit of SR and AHR, global metrics of image quality, and good fits of depth and lateral resolution (EE and FWHM). Multiple variable linear fits of metrics of lateral and depth resolution (EE and FWHM) to HbA1c and diabetes duration gave the best fits. Conclusions: Compared to healthy control eyes, image quality in eyes of those with diabetes worsens with increasing lens thickness, diabetes duration and lack of diabetes control (HbA1c). The lens thickness increases with diabetes duration. Reduced image quality may explain poorer vision in those with diabetes and may affect the sensitivity of retinal screening for sight threatening conditions. Extending this work could yield improved imaging instruments.

[3105] (G*) Dosimetric characterization of modified radiochromic materials: Comparison of photon to proton beam irradiation (16:00, 15 minutes)

Presenter: KAIYUM, Rohith (York University, University Health Network)

A quantitative real-time in vivo evaluation of ionizing radiation delivered to patients during a radiotherapy procedure is critical to assure patients receive treatments with rigorous quality control. Current dosimeters are not well suited for simple and direct measurements due to atomic composition, requiring correction to dose distribution, and probe size limitations. We are developing a fibre optic probe dosimeter based on a radiochromic sensor for real-time in vivo dosimetry. The calibrated change in optical density of the radiochromic sensor is used to quantify the absorbed ionizing radiation. The radiation sensitive material is composed of lithium-10,12-pentacosa diynoate (LiPCDA), which polymerizes upon exposure resulting in an increased optical density. We have observed that monomers of LiPCDA have two distinct dose-sensitive crystalline forms with distinct polymerized optical absorption maxima at 635 nm (635-LiPCDA) and 674 nm (674-LiPCDA). We have characterized and compared the dose sensitivity and dose rate response of the two crystal morphologies produced by adjusting the Li+ concentration using a linear accelerator (LINAC). Alternatively, in dense tumours near sensitive organs, direct ionization through charged particles (Hadrontherapy) may be used as an effective treatment. We investigate here the dose response of both radiochromic LiPCDA crystal forms comparing dose response behaviour to X-ray vs. proton ionizing irradiation. This enables our dosimeter to expand its application to a broader variety of new radiotherapy methods. Radiochromic crystals were fabricated to produce both 635 nm and 674 nm forms by adjusting the ratiometric concentration of Li+ to active material and exposed to 50-7000 cGy using a clinical LINAC with either a 6 MV X-ray beam (University Health Network) or a cyclotron producing a tunable 74 MeV proton beam (TRIUMF). Preliminary results from photon and proton irradiation show that 674-LiPCDA crystals are significantly less sensitive to dose but have a broader dynamic range. In conclusion, we demonstrate that radiochromic LiPCDA crystals can be preferentially grown to exhibit differing dose response based on their crystal structure under photon irradiation, and this dosimeter can be generalized to proton therapies (including FLASH).

[3115] Optical Coherence Tomography as a Screening Tool for Oral Cancers (16:15, 15 minutes)

Presenter: Dr SCHRUDER, Christopher (York University, Department of Physics and Astronomy)

Structural optical imaging within tissues is potentially useful for medical screening of various diseases, and particularly suitable for superficial and easily accessible oral cancers. Optical coherence tomography (OCT) is a non-invasive, low coherence imaging technique that allows micron-scale resolution for structural determinations within tissues. Intensity data from OCT images can be used to determine the optical properties of samples, such as the attenuation coefficient. While a highly promising technique, the imaging depth of OCT is limited to only several millimetres in most light diffusing tissues. In order to overcome this limitation, we have examined the use of optical clearing agents with chemical penetration enhancing techniques to increase the axial depth of resolution at which signals can be obtained. We examined the use of penetration enhancers on porcine tongue tissue based on the time-dependent effects of the clearing effect and depth for which 50% signal intensity is lost through the tissue. We have collected OCT data from a prospective study on lesions obtained from recently excised human oral tissues biopsied for histopathology analysis, as well as archived tissue samples embedded in paraffin. By modeling the OCT data using a form of the Beer-Lambert Law, 2D attenuation coefficient maps were computed. We have studied the attenuation coefficients obtained from the intensity decay data of 250 excised human tissue samples from our prospective study, diagnosed as non-cancerous (i.e. hyperkeratosis) and squamous cell carcinoma through histopathological analysis. The calculated attenuation coefficients were then correlated to the histopathological diagnoses (from hyperplasia to cancer). Our results suggest it may be possible to use OCT as a fast and non-invasive oral cancer screening tool.

[3280] Iron Microparticle Cluster Quantification In Vitro Using Pure Phase Encoding Magnetic Resonance Imaging (16:30, 15 minutes)

Presenter: BAZZI, Layale (University of Windsor)

Magnetic Resonance Imaging (MRI) is a non-invasive medical imaging modality that provides excellent soft tissue contrast and resolution. MRI cell tracking effectively monitors cell migration in various immunotherapies where cells are labelled with high susceptibility iron oxide particles to create a negative contrast in the image. However, it is not possible to quantify the number of cells as the number of particles within each cell can vary significantly. Quantitative analysis of the cell migration requires evaluating the number of particles within a cluster. Iron oxide microparticles are also explored in hyperthermic treatments of cancer, where the thermal dose is defined by the particle quantity. The microparticle quantity correlates with the magnetic field distortions. Severe field distortion leads to image artifacts in conventional MRI. It is therefore very challenging to quantify the particles with such methods.

Image artifact can be effectively removed by reducing the signal evolution time in the pure phase encoding (PPE) MRI. The technique can accurately measure the magnetic field distortion around the particle cluster and quantify the particle. PPE methods were successfully employed to correlate iron microparticle cluster mass with magnetic field distribution in vitro using a 1 T small animal scanner. Excellent linearity and theoretical agreement were observed.

T4-2 Plasma Physics Symposium VI : Networking (DPP) | Symposium de physique des plasmas VI: Réseautage (DPP) - MDCL 1010 (15:15 - 17:15)

-Conveners: Reuter, Stephan (Polytechnique Montreal); Ahmad Hamdan

T4-8 Precision Techniques in Spectroscopy (DAMOPC) | Techniques de précision en spectroscopie (DPAMPC) - MDCL 1016 (15:15 - 17:15)

-Conveners: Jens Lassen

time	[id] title	presenter
15:15	Detailed program to come (2 hours)	

T4-5 Private Sector Physicists (CAP-DAPI) | Physicien(ne)s dans le secteur privé (ACP-DPAI) - MDCL 1009 (15:15 - 17:15)

-Conveners: Cluff, Daniel (University of Exeter)

[3537] (I) Transitioning Quantum Technologies to a Business (15:15, 30 minutes)

Presenter: JENNEWEIN, Thomas (University of Waterloo)

For many years of working in quantum optics research I have always had an interest in the applications of quantum technologies, and in particular in their transition to the commercial domain. I will discuss my two endeavours into two business that I co-founded, Universal Quantum Devices and QEYNEt. I will try to illustrate how keeping an open mind in the research laboratory can help identify business opportunities.

[3507] Professional Development / P Phys (15:45, 30 minutes)

Presenter: CLUFF, Daniel (University of Exeter)

A short presentation of the proposed changes to the professional physicist designation. Physicists are abundantly qualified for many jobs that are secured by an act of parliament that prevents them from attaining these high paying jobs. Particularly physicists are working as engineers in increasing numbers. An outline of how these proposed changes will provide an increased level of credibility to the P.Phys. and a plan to provide a pathway to the P. Phys, for students starting after the completion of the second year of an approved program. This presentation/discussion is of particular interest to students and early career physicists or established physicists considering acquiring a P.Phys. or a career change.

T4-7 Fluctuations and Disorder in Condensed Matter (DCMMP) | Fluctuations et désordre en matière condensée (DPMCM) - MDCL 1309 (15:15 - 17:15)

-Conveners: Sorensen, Erik (McMaster University)

[3416] (I) The quest for quantum spin liquids in frustrated rare-earth pyrochlores (15:15, 30 minutes)

Presenter: Dr GAUTHIER, Nicolas (Universite de Sherbrooke)

Geometrically frustrated magnets form a broad class of materials where competing interactions lead to the partial or complete suppression of classical magnetic order. While short-range magnetic correlations exist in the absence of long-range order, these systems remain disordered and fluctuating, exploring a largely degenerate and complex energy landscape. Such state is commonly named a spin liquid, as the magnetic moments behavior is analogous to the one of particles in a liquid. Classical spin liquids are driven by thermal fluctuations and exhibit slow dynamics at low temperatures. In contrast, quantum fluctuations can generate long-range entanglement of the magnetic moments, a state of matter called quantum spin liquid. The fundamentally quantum nature of this state attracts great interest, in particular because it is a playground to study emergent gauge theories with fractionalized excitations and of its potential relevance in quantum computing. Proving experimentally the existence of this quantum state however remains challenging. Rare-earth based pyrochlore magnets form a large family of geometrically frustrated magnets that exhibit analogous effects to the proton disorder in water ice. I will discuss our experimental work on two quantum spin liquid candidates on this pyrochlore lattice. Using a combination of experimental techniques, and in particular neutron scattering, we evidenced that Pr$_2$Hf$_2$O$_7$ and Ce$_2$Sn$_2$O$_7$ exhibit many key features expected from a quantum spin liquid state. Interestingly, both systems are fundamentally different at the microscopic level. In Pr$_2$Hf$_2$O$_7$, while the magnetic dipoles are correlated, the quantum fluctuations are driven by interactions between the electric quadrupoles. In contrast, in Ce$_2$Sn$_2$O$_7$ it is the interactions between the magnetic dipoles that generate quantum fluctuations while the magnetic octupoles are entangled. These two examples illustrate that multipolar degrees of freedom provide novel routes to quantum fluctuations and quantum spin liquids.

[3417] (I) Disorder and spin fluctuations: the case of electron-doped cuprates (15:45, 30 minutes)

Presenter: GAUVIN-NDIAYE, Chloé (Université de Sherbrooke)

In conventional metals like aluminum or copper, the behaviour of electrons is well described by traditional methods of solid state physics. However, these methods cannot be used to study strongly correlated materials in which the interactions between electrons are significant. It instead becomes important to take into account large classical and quantum fluctuations. This is the case in the electron-doped cuprates, in which electron-electron interactions lead to significant antiferromagnetic spin fluctuations. In this talk, I will explain the role spin fluctuations play on the physical properties of the electron-doped cuprates. I will then discuss our recent work on the interplay of spin fluctuations and disorder in a theoretical model of electrons on a two-dimensional lattice where the temperature, the interaction strength the number of electrons can be varied. More specifically, we apply this model to the study of the electron-doped cuprates and show that disorder suppresses spin fluctuations.

[3418] (I) Emergence of discrete relative ordering in coupled XY models (16:15, 30 minutes)

Presenter: DROUIN-TOUCHETTE, Victor (Rutgers University)

Many two-dimensional physical systems, ranging from atomic-molecular condensates to low-dimensional superconductors and liquid crystal films, are described by coupled XY models. The interplay of topology and competing interactions in these XY systems drives new kinds of emergent behavior relevant in both quantum and classical settings. Such coupled U(1) systems further introduce rich physics, bringing topology into contact with fractionalization and deconfinement. In this talk, I will focus on the realization of these systems in a liquid crystal setting, where the theoretical description of 2D crystallization involves the binding of topological defects, accompanied by smooth thermodynamic transitions. However, the isotropic liquid crystal 54COOBC thin films are found to solidify via an intermediate “mystery” phase associated with a sharp specific-heat anomaly. I will show that this hidden-order phase can be understood as the relative ordering of the nematic and hexatic molecular degrees of freedom. This insight comes from the finite-temperature phase diagram of a minimalist hexatic-nematic XY model obtained through extensive large-scale Monte-Carlo simulations. A small region of composite three-state Potts order above the vortex binding transition is identified; this phase is characterized by relative hexatic-nematic ordering though both variables are disordered. I will show that the Potts order results from a confinement of fractional vortices into extended nematic defects and discuss the broader implications of fractional vortices and composite ordering in the wider class of coupled XY condensates, relevant to both soft and hard condensed matter fields.

T4-6 Physics at the EIC Symposium: Experimental Opportunities at the EIC (DNP) | Symposium sur la physique à l'EIC: opportunités expérimentales à l'EIC (DPN) - MDCL 1008 (15:15 - 17:15)

-Conveners: Zisis Papandreou

[3464] (I) AI-assisted design of the EIC Detector (15:15, 30 minutes)

Presenter: FANELLI, Cristiano (Massachusetts Institute of Technology)

The Electron-Ion Collider (EIC) is a cutting-edge accelerator experiment proposed to study the origin of mass and the nature of the "glue" that binds the building blocks of the visible matter in the universe. The proposed experiment will be realized at Brookhaven National Laboratory in approximately 10 years from now, with the detector design and R&D currently ongoing. Notably EIC can be one of the first facilities to leverage on Artificial Intelligence (AI) during the design phase. Optimizing the design of its tracker is of crucial importance for the EIC Comprehensive Chromodynamics Experiment (ECCE), which proposed a detector design based on a 1.5T solenoid. The optimization is an essential part of the R&D process and ECCE includes in its structure a working group dedicated to AI-based applications for the EIC detector. In this talk I describe the implementation of an AI-assisted detector design using full simulations based on Geant4. Our approach deals with a complex optimization in a multidimensional design space driven by multiple objectives that encode the detector performance, while satisfying several mechanical constraints. We describe our strategy for optimisation, discuss the exploration of different AI-based approaches, and illustrate the set of tools developed to "navigate" interactively the obtained Pareto front. We finally show the results of the AI-assisted tracking system in ECCE.

[3129] (I) Pion and Kaon Form Factor Measurements at the EIC (15:45, 30 minutes)

Presenter: Dr KAY, Stephen (University of Regina)

One of the most puzzling aspects of the standard model is that the overwhelming majority of the mass of hadronic systems arises from massless and nearly massless objects. How this occurs is poorly understood, and remains a major open question of the standard model. Developing our understanding of hadronic mass generation mechanisms is one of the three key physics questions for the upcoming Electron-Ion Collider (EIC). From the little that we do understand, we know that mass generation is intricately connected to the internal structure of hadronic systems. Somewhat counter intuitively, it is some of the lightest hadronic objects, the charged pion and kaon, that may be able to fill in the missing piece of the puzzle. Advancing our understanding of the internal structure of these objects is crucial if we are to begin to untangle how this structure emerges from the dynamical nature of the interactions that govern it. One potential window into the internal structure of the charged pion and kaon is their elastic electromagnetic form factors, $F_{\pi}(Q^{2})$ and $F_{K}(Q^{2})$. Electromagnetic form factors are fundamental quantities which describe the spatial distribution of partons within a hadron. Determining these form factors, as well as how they vary with Q^{2}, is an important step on our road to understanding the internal structure of these objects. The EIC opens up the possibility of studying $F_{\pi}(Q^{2})$ and $F_{K}(Q^{2})$ to very high Q^{2}. The Q^{2} reach of these measurements is deep into unexplored territory, these cutting edge measurements could help disentangle the mass generation puzzle of QCD. In this talk, I will outline the opportunities and challenges of pion and kaon form factor measurements at the EIC. I will also present the latest projections for these measurements, which are based upon recent detector simulations.

[3474] (G*) AI-Assisted Design of the ECCE Tracking System at the Electron Ion Collider (16:15, 15 minutes)

Presenter: Mr SURESH, Karthik

The Electron-Ion Collider (EIC) is a future facility, which will be uniquely poised to address questions related to the origin of mass and spin of the nucleon and the emergent properties of dense systems of gluons. EIC Comprehensive Chromodynamics Experiment (ECCE) will be building the detector for EIC based on a 1.5T solenoidal magnet. During its proposal, ECCE leveraged on Artificial Intelligence (AI) to design the tracking detector subsystem. ECCE was one of the first-large scale experiment to use AI during its design phase. In this talk, the ECCE tracking system will be presented, as well as the AI-assisted optimization process employed to optimize the dimensions and locations of the inner tracker elements. Details related to Multi-Objective Optimization (MOO) using an AI-based evolutionary algorithm will be shown. Finally we present the results of the various optimization phases for the tracker in ECCE-EIC.

NOTE re Poster session programming: The 2 min time allotted to each poster is SIMPLY used to have each poster display more conveniently in the schedule. There is NO specific presentation time for posters. All presenters should be at their posters for the duration of the poster session. (17:15 - 17:30)

DPP Poster Session & Student Poster Competition (5) | Session d'affiches DPP et concours d'affiches étudiantes (5) - MUSC Marketplace (17:30 - 19:00)

[3229] (POS-22) 2D fluid modelling of a magnetron discharge (17:30, 2 minutes)

Presenter: Mr MUN, Jong Hern (University of Saskatchewan, Aix-Marseille University)

Recently, it was observed that under moderate pressure (p > 10Pa), nanoparticles can be created using sputtering magnetron discharges [1]. Although such plasma source has been widely studied at low gas pressure (p < 0.1Pa) in the context of industrial application such as thin film coating, there are only few plasma models at the fairly high-pressure range where collisions between sputtered species and the background neutral particles favor the growth of nanoparticles. Such small "dust particles" were also observed in tokamaks of graphite wall [2]. Magnetron discharges in which the plasma density may reach 10^18 m-3 in the cathode region could help us to understand their formation in the coldest plasma region of tokamaks. Experimental studies are in progress at PIIM laboratory in Marseille where magnetically confined plasmas are generated using sputtering magnetron discharge. The feed gas is argon at 30 Pa and the magnetron cathode is in tungsten. In that context a new and reliable numerical model is currently under development in order to investigate the transport of sputtered tungsten atoms in the discharge. Usually, cold plasma discharges are simulated using PIC-MC or kinetic models [3], but in this presentation, we present a 2D axisymmetric fluid model. In particular, as to resolve the sheaths, we developed a non quasineutral drift-diffusion model of two fluids – ions and electrons. First two moments of the Boltzmann equation are solved for both with the energy equation only solved for the electrons. Second order finite difference and a fourth order Runge-Kutta method are used for the spatial and temporal discretization. Poisson equation completes the model, and we use kinetic boundary conditions based on a shifted and truncated velocity distribution functions [4]. Some results including plasma potential and density profiles of different species from the first numerical simulations are shown. References [1] L. Couëdel et al., AIP

Conf. Proc., Proceedings of the 8th ICPDP, Prague, (2017). [2] C. Arnas et al., Plasma Phys. Control. Fusion 52, 124007 (2010) [3] G. J. M. Hagelaar et al., Journal of Applied Physics 93, 67 (2003) [4] R. Sahu et al., Phys. Plasmas 27, 113505 (2020)

[3523] (POS-66) Experimental investigation of 1 inch End-Hall Ion Source for surface processing applications (17:32, 2 minutes)

Presenter: OUDINI, Noureddine (Plasmionique Inc, 1650 Lionel-Boulet, Varennes, J3X 1P7, QC, Canada)

End-Hall Ion Source (EHIS) is a gridless device that combines a magnetic field **B** with an electric field **E**, in a **E** x **B** configuration, to generate and sustain a high-density plasma and to extract and accelerate a broad ion beam. The source can operate in a wide range of discharge voltage, such as 50 – 500 V, for a discharge current in the 1 A magnitude order. In this work, we presents an experimental investigation of a 1 inch EHIS produced by Plasmionique Inc. This source can operate in two different modes, namely: i) low voltage – high current mode, typically 50 V – 1 A, suitable for Ion Beam Cleaning applications and ii) moderate to high voltages – high current mode, typically [100, 500] V – 1 A, suitable for Ion Beam Assisted Deposition and Ion Beam Sputtering applications. The experimental investigation focuses on source’s current-voltage characteristics, ion energy distribution function, beam divergence and beam total current.

[3512] (POS-67) Disinfection of Bacteria Contaminated Water Using Plasma Jet of Argon and Oxygen (17:34, 2 minutes)

Presenter: BOUSBA, Houssem Eddine (Laboratory of Microsystems and Instrumentation (LMI), Electronic department, Faculty of Technology Sciences, Frères Mentouri Constantine 1 University, Constantine, Algeria)

The aim of this work is to investigate the effectiveness of one of the novel disinfection methods that is based on cold plasma treatment. A particular plasma setup was adapted for the treatment of aqueous solutions and has been employed for the purification of water contaminated with bacterial strains. The treated samples were prepared by adding Staphylococcus aureus bacteria to distillated water, and then the treatment was carried out by submerging the aforementioned plasma jet in the suspension volume. The plasma discharge in our setup was ignited using a controlled mixture of argon and oxygen. Results of this study showed that full water decontamination can be attained after about 12 minutes of treatment under 1.5 slpm of Argon gas flow containing 2.5±0.2% of oxygen. In addition, it is found that the oxygen ratio in the mixture is key parameter for the maintaining of the decontamination potential; exceeding 130 ml/min of oxygen flow rate resulted in the reproduction of the bacterial activity. Adding oxygen gas to argon leads to the creation in water of highly reactive oxygen based species (ROS), these species react with the microorganisms cells and lead to their destruction and to stop their reproduction. This study helped setting the ideal margins for the key parameters that should be taken into account while igniting the plasma in order to attain a full disinfection of water contaminated with harmful bacterial cells.

[3357] (G*) (POS-68) Pulsed spark discharges in deionized water: influence of the magnetic field (17:36, 2 minutes)

Presenter: GÉRAUD, Korentin

Electrical discharges in dielectric liquids are considered as an efficient technique for nanoparticle synthesis and machining via controlled erosion of the electrodes. Recently, magnetic field assisted method has shown great potential for enhancing the plasma-electrode interactions. Investigating the influence of the magnetic field, intensity and orientation, on the behavior of spark discharges are needed to understand the interactions, with the aim to improve the processes. In this study, spark discharges are produced in pin-to-plate configuration using a nanosecond pulsed power supply in deionized water. The magnetic field is generated with permanent magnet NdFeB. A statistical study of the electrical characteristics (voltage, current) of discharges with and without magnetic field was conducted with W and Ni electrodes and with various inter-electrode distances. The data is processed to report the evolution of some characteristics of the discharges, such as breakdown voltage, current peak, discharge delay, injected charge. Also, the pin erosion rate and the distribution of the impacts on the plate electrode are determined.

DAPI Poster Session & Student Poster Competition (4) | Session d'affiches DPIA et concours d'affiches étudiantes (4) - MUSC Marketplace (17:30 - 19:00)

[3178] (POS-17) PET Image Denoising and Enhancement Based on Partial Differential Equation (17:30, 2 minutes)

Presenter: Ms WANG, Xue (Anhui University)

Positron emission tomography (PET) is an excellent medical imaging technique in clinical applications such as brain disease detection and tumor diagnosis. To reflect the level of brain molecular metabolism accurately, larger amounts of radio tracers are sometimes needed, which can be problematic for radiation dose. Improving the quality of the PET image using smaller amounts of radiotracers can be beneficial. In the paper, we propose a denoising and enhancement method for the low-dose PET images. Specifically, we use partial differential equations (PDE) to denoise images and apply the limited-contrast adaptive histogram equalization method to enhance images. We designed the diffusion coefficient of the anisotropic diffusion model by adding variance and bilateral filtering, which can better preserve details. In addition, we introduce the adaptive threshold method to adjust the diffusion coefficient and apply the regularization terms for further protecting the original details of the image. During the process of enhancement, we fine-tuned the denoised image using a limited-contrast adaptive histogram equalization method and adjusting the image contrast. Experiments show that our algorithm can remove much noise as well as maintain both the global structure and the fine textures of the PET image. On diverse datasets, the proposed method outperforms other methods in terms of qualitative and quantitative compared results.
Keywords: Positron emission tomography, PET, PDE, denoising, enhancement

[3444] (G*) (POS-18) Dynamic Mechanical Analysis with Portable NMR (17:32, 2 minutes)

Presenter: SELBY, Will (University of New Brunswick)

Dynamic mechanical analysis (DMA) is an umbrella term for a variety of rheological experiments in which the response of a sample subjected to an oscillatory force is measured to characterize its dynamic properties. In this work, we present a method for DMA that employs simple magnetic resonance techniques and a small unilateral three magnet array with an extended constant gradient to measure the velocity of a vibrating sample. By orienting the vibrations in the direction of the gradient, we use the motion-sensitized phase accumulation to determine the velocity. By implementing delays into the pulse sequence, we measure the phase at evenly spaced points in the vibration cycle, allowing for the acquisition of a complete velocity waveform. Using velocity waveforms, samples are characterized through differences in amplitude and phase, providing information on the magnitude of the dynamic modulus and loss-angle, respectively.

[3494] (POS-19) Evaluating high-velocity particle motion with dynamic magnetic resonance scattering (17:34, 2 minutes)

Presenter: OSMOND, Duncan (University of New Brunswick)

Structure functions are employed in many optical scattering experiments for the determination of size distributions in small particles. Recently a similar method for magnetic resonance (MR) has been proposed, Dynamic Magnetic Resonance Scattering (DMRS) [1], which constructs structure functions from MR signal time series data. DMRS is useful in the characterization of sample dynamics, where it can be used to measure velocity of moving particles (coherent motion) or the diffusion coefficient of particles in a medium (random behaviour). DMRS has a number of potential advantages from an MR perspective: it examines particles below the minimum spatial resolution of instruments, and it largely cancels static signal contributions that occur in many samples. The method can be employed using a constant magnetic gradient, and the data can be acquired via basic MR sequences. Additionally, DMRS should be well-suited to studies of opaque media where optical methods, such as light scattering, fail. The original paper, though robust in characterising applicability, does not explore extreme cases for coherent motion such as high particle velocity. In this work, we explore the case of dispersed media (sprays) with velocities several orders of magnitude higher than the original paper, and we discuss fundamental restrictions of the method in terms of instrument parameters. The simulated structure function behaviour of expected velocities agrees with experimental data for velocities ~100 times faster than the original publication. Estimates of other variables of interest are discussed, as well as considerations for applicability to low-field and unilateral NMR instruments. ---------- [1] Herold, Volker, Thomas Kampf, and Peter Michael Jakob. "Dynamic magnetic resonance scattering." *Communications Physics* 2.1 (2019): 1-10.

[3511] (G*) (POS-65) A Monte Carlo simulation of the feasibility of detecting bone tungsten using X-ray fluorescence (17:36, 2 minutes)

Presenter: Mr MCHEIK, Sajed (Ryerson University)

Title: A Monte Carlo simulation of the feasibility of detecting bone tungsten using X-ray fluorescence Authors: Sajed Mcheik(1,*) and Ana Pejovic-Milic(1,) Affiliations: Department of Physics, Ryerson University, Toronto, ON, Canada, M5B 2K3; E-mail address of the corresponding author: smcheik@ryerson.ca An increased number of studies are introducing use of tungsten in medicine in the form of sodium tungstate as an antidiabetic medicine t[1], and tungsten nanoparticles as a contrast agent for CT scanning [2] or enhancers of cancer therapy [3]. On the other side, human exposure to tungsten could lead to adverse health effects, including tumour promotion, pulmonary dysfunction, or immune dysfunction [4]. Therefore, it is timely to develop a diagnostic tool to monitor medical exposure to tungsten. To address this need, we propose developing a robust non-invasive technique to detect bone tungsten in-vivo based on the x-ray fluorescence (XRF). A HPGe detector along with homogenous bone phantoms were modeled using Monte Carlo software

TOPAS, 3.3 version. A cylindrical shape bone phantom constituted of percent mass as Ca10(PO4)6(OH)2 [5] (2.7 cm diameter and 8 cm height) were modeled simulating human tibia measurements. The simulation model generated XRF spectra using 109 particles, which were then analyzed to decide on the best excitation source and geometry to optimize the detection limit The TOPAS simulation showed that Cd-109 is a potential excitation source to detect tungsten in tibia with a minimum detection limit equal to 0.3 ppm W/Ca for 180-degree geometry. Reference: [1] Bertinat, R., Westermeier, F., Gatica, R., & Nualart, F. (2019;2018;). Sodium tungstate: Is it a safe option for a chronic disease setting, such as diabetes? Journal of Cellular Physiology, 234(1), 51-60. [2] Jakhmola, A., Anton, N., Anton, H., Messaddeq, N., Hallouard, F., Klymchenko, A., Mely, Y., & Vandamme, T. F. (2013;2014;). Poly- ε -caprolactone tungsten oxide nanoparticles as a contrast agent for X-ray computed tomography. Biomaterials, 35(9), 2981-2986 [3] Wang, R., Cao, Z., Wei, L., Bai, L., Wang, H., Zhou, S.. Ma, Q. (2020). Barium tungstate nanoparticles to enhance radiation therapy against cancer. Nanomedicine, 28, 102230-102230. [4] Bolt, A. M., & Mann, K. K. (2016). Tungsten: An emerging toxicant, alone or in combination. Current Environmental Health Reports, 3(4), 405-415. [5] Da Silva E, Kirkham B, Heyd D V and Pejovi´c-Mili´c A.(2013) Pure hydroxyapatite phantoms for the calibration of in vivo x-ray fluorescence systems of bone lead and strontium quantification Anal. Chem. 85 9189–95

DCMMP Poster Session & Student Poster Competition (8) | Session d'affiches DPMCM et concours d'affiches étudiantes (8) - MUSC Marketplace (17:30 - 19:00)

[3445] (G*) (POS-10) Angle-Resolved Photoemission (ARPES) on the Current-Induced Metallic State of Ca2RuO4 (17:30, 2 minutes)

Presenter: SUEN, Cissy (University of British Columbia (Quantum Matter Institute), Max Planck Institute for Solid State Research, Advanced Light Source (Lawrence Berkeley National Laboratory))

The quasi-2D Mott insulator Ca2RuO4 has a metal-to-insulator transition (MIT) controllable through temperature, pressure, epitaxial strain, and curiously -- electrical current. However, the mechanism by which the current induces the MIT has yet to be understood. We use angle-resolved photoemisson spectroscopy (ARPES) with nanometer scale resolution to compare the electronic band structures in equilibrium and in non-equilibrium, or with and without current respectively. Preliminary results show a clear closure of the band gap and a more equal distribution in photoemission intensities.

[3022] (POS-11) Spin Ice Spectrum with Finite Temperature in Pyrochlores (17:32, 2 minutes)

Presenter: WEI, Chen

spin ice material has many interesting properties such as geometrical frustration, non-zero magnetic moment and magnetic monopoles, the spin ice especially the quantum spin ice material was an active research areas. When temperature is low enough, the quantum fluctuation in spin ice material can lead to a liquid like material known as quantum spin liquid. In this paper, we use group theory to block diagonalize the Hamiltonian of 16 site Pyrochlore system and find the spin ice states. We start with the pure spin ice Hamiltonian and slowly turn the Hamiltonian to quantum spin ice by adding exchange constants as perturbation. Finally, we plot the spin ice spectrum with different exchange constants in finite temperature.

[3200] (G*) (POS-12) The Piezoelectric Contribution in the Catalytic Activities of BaTiO3 Nanoparticles (17:34, 2 minutes)

Presenter: KALHORI, Hossein

It is an increasingly urgent to protect the environment from the different kinds of pollutants, in particular industrial pollutants. Wastewater treatment is one example of these efforts that are necessary for mankind to enjoy a sustainable future. Recently, the use of piezoelectric nanomaterials as catalyst for water purification has been reported. It has been demonstrated that the piezoelectric properties of nanomaterials in solution, can be used for the degradation of organic pollutants, when activated by ultrasonic waves. When submitted to ultrasonic waves, however, other physical phenomena also contribute to the degradation of organic pollutants: Tribocatalytic activity comes from the frictions of the particles generating of transient charges that cause the degradation of organic compounds. Moreover, at higher ultrasonic energies, cavitation bubbles can occur, whose collapse creates localized pockets of high temperature in excess of 4000K and high pressure in excess of 1000 atm decomposing organic pollutants, a phenomenon called sonolysis. A general literature review shows not enough attention has been devoted so far to discriminate between these various effects, in particular when studying the pollutant degradation, using piezocatalyst materials such as BaTiO3 nanoparticles. In this study, we quantified the piezo-, tribo- and/or sonocatalytic activities of BaTiO3 nanoparticles, comparing their catalytic activities to that of non-piezoelectric TiO2 nanoparticles, which happen to have a similar surface termination. This comparison allows us to derive the contribution of the piezoelectric effect in the catalytic degradation reactions. BaTiO3 and TiO2 crystalline nanoparticles were characterized using X-ray diffraction and Raman spectroscopy. The degradation of methyl orange in water has then been measured using either BaTiO3 or TiO2 as catalysts. Comparing the results for BaTiO3 and TiO2 allows us to experimentally quantify the portion of the piezoelectric effect in the catalytic activity of BaTiO3 nanoparticles.

[3457] (POS-13) Ultrasound and Transport Measurements in the Weyl Semimetal NbP (17:36, 2 minutes)

Presenter: WARD, Marianne (Université de Sherbrooke)

In recent years, physicists have discovered that the topological electronic structure of materials can have dramatic consequences on their properties. In a new variety of topological materials called Weyl semimetals, electrons behave as massless relativistic particles. These materials are in some sense a 3-dimensional equivalent to graphene. Many interesting magneto-electric effects, that could possibly be applicable to quantum technologies, have been predicted in Weyl semimetals and are still studied today. Theoretical and preliminary experiments have demonstrated that it is possible to probe the topological nature of these materials by measuring the speed at which acoustic waves travel through the material. This research technique allows us to probe the volume of the sample and to avoid certain errors associated with electrical conductivity measurements. In this project, we explore experimentally how the application of a magnetic field modifies the speed and absorption of sound in the Weyl semimetal NbP. We will show how applied magnetic fields have an anisotropic effect on the sound velocity and compare with previous results on the isostructural material TaAs. The sound velocity measurements also exhibit quantum oscillations that allow us to characterize the Fermi surface of the material. We have also carried out transport measurements on the same material NbP as a complementary measurement of quantum oscillations.

[3259] (G*) (POS-14) Triangular Pair-Density Wave in Confined Superfluid 3-He (17:38, 2 minutes)

Presenter: Mr SENARATH YAPA, Pramodh (University of Alberta)

Recent advances in experiment and theory suggest that superfluid ^{3}He under planar confinement may form a pair-density wave (PDW) whereby superfluid and crystalline orders coexist. While a natural candidate for this phase is a unidirectional stripe phase predicted by Vorontsov and Sauls in 2007, recent nuclear magnetic resonance measurements of the superfluid order parameter rather suggest a two-dimensional PDW with noncollinear wavevectors, of possibly square or hexagonal symmetry. In this work, we present a general mechanism by which a PDW with the symmetry of a triangular lattice can be stabilized, based on a superfluid generalization of Landau's theory of the liquid-solid transition. A soft-mode instability at finite wavevector within the translationally invariant planar-distorted B phase triggers a transition from uniform superfluid to PDW that is first order due to a cubic term generally present in the PDW free-energy functional. This cubic term also lifts the degeneracy of possible PDW states in favor of those for which wavevectors add to zero in triangles, which in two dimensions uniquely selects the triangular lattice. *P.S.Y. was supported by the Alberta Innovates Graduate Student Scholarship Program. R.B. was supported by Département de physique, Université de Montréal. J.M. was supported by NSERC Discovery Grants Nos. RGPIN-2014-4608, RGPIN-2020-06999, RGPAS-2020-00064; the CRC Program; CIFAR; a Government of Alberta MIF Grant; a Tri-Agency NFRF Grant (Exploration Stream); and the PIMS CRG program.

[3181] (POS-15) 19F NMR investigation of barlowite kagome lattice Heisenberg antiferromagnet Zn1-xCu3+x(OD)6FBr (x ~ 0.05, 0.5, and 1) (17:40, 2 minutes)

Presenter: Dr YUAN, Weishi (McMaster University)

The Quantum Spin Liquid is a novel magnetic ground state, characterized by quantum entanglement without long range magnetic order. Kagome lattice Heisenberg antiferromagnet is a prime candidate of quantum spin liquid owing to highly frustrated spin ½'s arranged on a corner sharing triangle geometry. We report 19F NMR investigation of a series of "barlowite" kagome material Zn1-xCu3+x(OD)6FBr with x ~ 0.05, 0.5, and 1 based on the inverse Laplace transform analysis on the spin-lattice relaxation rate 1/T1.

[3486] (POS-16) Lattice Dynamical Study of High-Entropy Oxides (17:42, 2 minutes)

Presenter: WILSON, Connor

High-entropy oxides (HEOs) comprise an equimolar mixing of metal cations combined into a single-phase crystal structure. First synthesized in 2015 [1], HEOs have garnered much attention as candidates for high-efficiency batteries and heat shields [2, 3]. HEOs composed of four and five binary oxides have been previously investigated by infrared [4] and Raman spectroscopy [5] and lattice dynamical simulations. The IR spectra consist of a strong, reststrahlen mode at $350~\textrm{cm}^{-1}$ and a much weaker mode at $150~\textrm{cm}^{-1}$ not predicted by group theory. The absence of spin-phonon splitting in the reststrahlen band below the Neel temperature (T_N), despite appearing in the parent oxides CoO and NiO, has been attributed to a high rate of static disorder scattering. The Raman spectra are composed of five peaks which have been assigned to $TO, LO, LO+TO, 2LO$ modes, as well as a two-magnon mode. Fits of the spectra to the Lorentz oscillator model revealed a temperature-dependent damping parameter which was ascribed to anharmonic effects. The phonon density of states will be simulated using GULP [6] in order to understand the IR and Raman spectra. [1] Christina Rost et al. "Entropy-stabilized oxides". In: Nature Communica- tions 6 (Sept. 2015), p. 8485. doi:

10.1038/ncomms9485. [2] Abhishek Sarkar et al. “High Entropy Oxides for Reversible Energy Stor- age”. In: Nature Communications 9 (Aug. 2018). doi: 10.1038/s41467- 018-05774-5. [3] Joshua Gild et al. “High-entropy fluorite oxides”. In: Journal of the Euro- pean Ceramic Society 38.10 (2018), pp. 3578–3584. issn: 0955-2219. doi: https://doi.org/10.1016/j.jeurceramsoc.2018.04.010. url: https: //www.sciencedirect.com/science/article/pii/S0955221918302115. [4] Tahereh Afsharvosoughi and D. A. Crandles. “An infrared study of antifer- romagnetic medium and high entropy rocksalt structure oxides”. In: Jour- nal of Applied Physics 130.18 (2021), p. 184103. doi: 10.1063/5.0070994. eprint: https://doi.org/10.1063/5.0070994. url: https://doi.org/ 10.1063/5.0070994. [5] Tahereh Afsharvosoughi. “Structural, Magnetic and Vibrational Studies of Entropy Stabilized Oxides”. Brock University, 2021. [6] Julian D. Gale. “GULP: A computer program for the symmetry-adapted simulation of solids”. In: J. Chem. Soc., Faraday Trans. 93 (4 1997), pp. 629–637. doi: 10 . 1039 / A606455H. url: http : / / dx . doi . org / 10 . 1039 / A606455H.

[3518] (POS-64) Revival of Neutron Scattering Capabilities at the McMaster Nuclear Reactor (17:44, 2 minutes)

Presenter: Dr BEARE, James (McMaster University)

Neutron scattering is an invaluable tool for studying the bulk characteristics of condensed matter systems. With the shutdown of the National Research Universal (NRU) reactor at Chalk River in 2018, Canada lost its main source of neutrons for spectroscopy and diffraction experiments, forcing those working at Canadian institutions to look abroad. There is currently a national effort to rebuild and renew Canada’s neutron scattering capabilities, and the centrepiece of this effort is “Building a Future for Canadian Neutron Scattering”, a successful CFI project led by McMaster and a coalition of 17 Canadian universities. Over the next five years, this project will lead to a $24 million investment in neutron scattering facilities at the McMaster Nuclear Reactor (MNR) and the construction of three new beamlines: a high-resolution neutron powder diffractometer, a neutron reflectometer, and a neutron stress scanning diffractometer. A new small-angle neutron scattering facility (MacSANS) is also scheduled to begin operation in Summer 2022. In this poster, we will describe new instrument development projects on the McMaster Alignment Diffractometer (MAD), a general purpose triple-axis spectrometer. This includes the commissioning of new sample environments, such as a 4K-800K cryofurnace, and the relocation of the detector from the C2 neutron powder diffractometer at Chalk River. The C2 detector is a gas filled (BF3) multiwire detector, with an array of 800 vertical wires covering an angular range of 80 degrees with 0.1 degree angular resolution. This new equipment will introduce exciting capabilities for neutron powder diffraction, low temperature, and magnetic scattering experiments at the MNR.

DHP Poster Session & Student Poster Competition (0) | Session d'affiches DHP et concours d'affiches étudiantes (0) - MUSC Marketplace (17:30 - 19:00)

DAMOPC Poster Session & Student Poster Competition (9) | Session d'affiches DPAMPC et concours d'affiches étudiantes (9) - MUSC Marketplace (17:30 - 19:00)

[3101] (G*) (POS-1) Femtosecond Pulse Compression Using Liquid Alcohols (17:30, 2 minutes)

Presenter: STEPHEN, Jake

Ultrafast science is a branch of photonics with far reaching applications in and out- side the realm of physics. Ultrashort laser pulses on the order of femtoseconds (1 fs = 1 × $10^{−15}$ s) are widely used for ultrafast science. Many lasers can produce pulses on the order of 100 fs, with state of the art, high end lasers being capable of producing pulses around 30 fs. However, many experiments require pulses around 10 fs or shorter. Few-femtosecond pulses are typically generated using spectral broadening via self-phase modulation, followed by dispersion compensation. The most common spectral broadening technique exploits the nonlinear interaction of intense pulses focused into gas-filled hollow-core fibres. More recently, multiple crystal plates have been used to broaden the spectrum while using a self-focusing relay to maintain the beam quality. We have researched substituting solids and gases with liquid alcohols. By using a series of 1 cm cuvettes filled with 1-decanol, we have compressed a pulse from 83.6 fs down to 31.3 fs with a spectrum capable of supporting 25 fs pulses, all whilst avoiding filamentation. Liquids have proven to be useful due to the ease in which they can be set up and achieve broad spectra as well as their ability to remain intact when exposed to high intensities. In contrast with gases, alcohols provide an inexpensive material for spectral broadening, providing a compact and easy to use setup unhindered by the length of hollow-core fibres. We have shown that alcohols provide a compact, inexpensive alternative to solids and gases for pulse compression that is not susceptible to permanent damage.

[3150] (G*) (POS-2) High-Harmonic Sidebands for Time-Resolved Spectroscopy (17:32, 2 minutes)

Presenter: DROUILLARD, Nathan (University of Windsor)

High-Harmonic Sidebands for Time-Resolved Spectroscopy In the semi-classical picture of high-harmonic generation (HHG), a strong ($10^{18}-10^{20}W/m^2$) laser field is applied to an atom, repeatedly accelerating one of its valence electrons into the continuum and back to the parent atom. Upon recollision with the parent atom, the electron emits photons of odd-integer harmonics of the driving field [1]. When a second weaker field is applied to the system, the trajectory of the electron is perturbed, causing sidebands to occur in the harmonic spectrum that are characteristic of the perturbing field energy [2],[3]. Consequently, HHG can be used as a method of upconverting mid-infrared light for sensitive spectroscopy, as high-harmonics of infrared (IR) light lie in the visible regime and beyond. We perform numerical simulations of HHG in order to inform future experimental work that will use HHG cross-correlation to measure time-resolved fields in the mid-IR. HHG cross-correlation involves the mixing of the strong femtosecond driving field with a weak mid-IR field in a nonlinear material, leading to the sidebands that appear in the harmonic spectrum. The position of the sidebands in the spectrum indicates the frequency of the optical free-induction decay [2]. This is a particularly pragmatic approach to IR spectroscopy because it precludes the need for expensive detectors that need to be cooled. Furthermore, the emitted bursts of radiation are on the order of attoseconds (10-18s) in duration, opening the possibility of ultrafast spectroscopy extending into the mid-and far-IR. References [1] P. B. Corkum. Plasma perspective on strong field multiphoton ionization. Physical Review Letters 71, 1994–1997 American Physical Society (APS), 1993. [2] T.J. Hammond et al.. Femtosecond time-domain observation of atmospheric absorption in the near-infrared spectrum. Physical Review A (2016). [3] G. Vampa et al.. Linking high harmonics from gases and solids. Nature 522, 462–464 Springer Science and Business Media LLC, 2015.

[3261] (G*) (POS-3) Quantum catastrophes in a rotating Bose-Einstein condensate (17:34, 2 minutes)

Presenter: KAMP, Denise

We consider a dilute gas of bosons in a slowly rotating toroidal trap, focusing on the two-mode regime consisting of a non-rotating mode and a rotating mode corresponding to a single vortex. With the help of the single-particle density matrix we track the presence of Bose-condensates in this system which can occur in one mode, both modes or superpositions of the two. We also compare an enhanced mean-field theory which uses the truncated Wigner approximation comprising multiple classical trajectories with a fully quantum many-body description. Following a sudden quench, we find quasi-periodic dynamics where the condensates oscillate between the modes and identify cusp-shaped structures in the wavefunction as quantum versions of elementary catastrophes.

[3367] (G*) (POS-4) Wavelength-multiplexed entanglement-based quantum key distribution (17:36, 2 minutes)

Presenter: VINET, Stephane

Quantum Key Distribution (QKD) has reached a level of maturity sufficient for commercial implementation. However, to-date transmission distances remain curtailed due to absorption losses. Satellite links have been proposed as a solution to scale up the distances of quantum communication networks. By using orbiting satellites as nodes between ground stations, the signal-to-noise ratio is improved as most of the photons' propagation path is in empty space. Yet such satellite based quantum links currently suffer from low photon count rates, due to the atmospheric effects and the limitations of current entangled photon sources. Furthermore, while a practical quantum network necessitates connectability to multiple users, most QKD implementations so far are limited to two communicating parties. To address this issue, we investigate the use of a wavelength-multiplexing entangled photon source. In this work, we simulate the performance of such a multi-channel operation and show that by using multiple wavelength channels one can improve the secure key rate linearly up to several orders of magnitude whilst maintaining the same quantum bit error rate. Taking advantage of the inherent hyper-correlations produced by the entangled photon source, one can deterministically separate wavelength correlated photon pairs into different detection channels. Hence, every pair of frequency channels can be considered as an independent communication link. In doing so, we can not only circumvent the timing limitation of the photon detectors which leads to an intrisincally increased key rate while maintaining the same signal-to-noise ratio but also enable the interconnectability of a single satellite link with multiple user end-points on the ground. These results indicate the possibility of achieving a very high brightness photon pair generation rate, suitable for satellite-based QKD, without saturation in the detectors. Thus, this method proposes scaling potential to improve quantum communication distances and networkability.

[3378] (G*) (POS-5) Transmission of near-infrared time bin encoded entangled photons through a 3.5km telecom fiber (17:38, 2 minutes)

Presenter: VINET, Stephane

Integrating single photon sources to existing telecommunication (telecom) networks is an on-going challenge due to the wavelength mismatch between the photon sources and the telecom optical fibers. A solution is to develop frequency conversion devices that can convert the optical frequency of the photon sources to the appropriate telecom frequencies. However, these solutions are difficult to implement and can require a large overhead in equipment and expertise to operate. Here, we demonstrate the direct distribution of near-infrared time bin entangled photons along a telecom fiber for the purpose of quantum key distribution. The near-infrared entangled photon pairs of 785nm and 832nm wavelengths are generated by an entangled photon source. The 832nm photons are sent to a local polarization analyzer. The 785nm photons were coupled into a standard telecom single mode fiber with lengths up to

3.1km and measured using a field widened unbalanced Mach Zehnder interferometer. The results indicate that, despite the multi mode nature of the telecom fibers for the 785nm photons and the associated modal dispersion that the different modes experience when propagating through the fiber, strong quantum correlations can be recovered in both the zeroth order mode and the higher order modes. The direct use of near-infrared quantum sources with the already existing telecommunication infrastructure reduces the need for frequency conversion devices and is thus important for the development of the quantum internet.

[3393] (G*) (POS-6) Active Phase Compensation of Polarization Encoded Photons in Quantum Key Distribution (17:40, 2 minutes)

Presenters: WU, Wilson, MOHAMMADI, Kimia

As the demand for secure communication has grown in recent years, so has the need for robust implementations of quantum key distribution (QKD). Polarization encoding schemes suffer from phase drifts when encoded pulses pass through optical fibres, making the use of active phase compensation essential. These drifts arise due to ambient temperature changes and mechanical stresses on the fibre, which are unavoidable, especially in applications where part of the source is exposed to outdoor temperatures or is connected to moving platforms. We propose a method of active phase monitoring that can be used with a phase compensation system for the quantum optical ground station which is aimed to do free-space polarization-based QKD with quantum satellites, as a part of the Quantum Encryption and Science Satellite (QEYSSat) mission. Rather than performing a complete tomography of the polarization states, we propose monitoring the polarization encoded pulses using only one basis. Active phase corrections are applied using a PID control loop that takes as input the results of the measurement results of the characterization system. Not only does this approach ensure accurate transmission of the polarization encoded qubits, the approach also simplifies the requirements on optical equipment which results in reducing the net cost while maintaining the high performance.

[3456] (G*) (POS-7) Search for Light Bosons with King and Super-King Plots Optimized for Li$^+$. (17:42, 2 minutes)

Presenters: DHINDSA, Harvir, MARTON, Victor

The King plot technique widely used for isotopes of heavy atoms is extended to light heliumlike ions by taking second differences to eliminate large mass polarization corrections [1]. The effect of a hypothetical electron-neutron interaction propagated by light bosons is included and a comprehensive survey of all second-King plot transitions for all states of Li$^+$ up to $n = 10$ and $L = 7$ is presented in order to find the ones most sensitive to new physics due to light bosons. The sensitivity is found to be comparable to that for the recently studied case of Yb$^+$. [1] G.W.F. Drake, Harvir S. Dhindsa and Victor J. Marton, Phys. Rev. A 104, L060801 2021).

[3476] (G*) (POS-8) Quantum Control of Trapped Ions Using Krotov's Algorithm (17:44, 2 minutes)

Presenter: MANSON, Zachary

The optimization of quantum systems using Quantum Optimal Control Theory (QOCT) is very important in many fields such as quantum information, photocatalysis, and atomic and molecular physics. The goal of QOCT is to optimize an external field shape such that it drives a quantum system to a target state. When applied to the real world, QOCT can be used to develop quantum gates in quantum computing or to achieve a particular state in atomic and molecular physics. There are many numerical methods that exist in order to determine the optimal external field shape when controlling quantum systems, with one being Krotov's algorithm. Krotov's algorithm minimizes the optimization functional, which consists of the figure of merit and any constraints. In this research, I apply Krotov's algorithm to determine the optimal external field shape to achieve quantum control in a chain of trapped ions employing the Sørensen & Mølmer scheme. I numerically implement Krotov's algorithm and compare its performance to other methods.

[3521] (G*) (POS-9) Demonstrating Novel Quantum Control With Ultracold Atoms (17:46, 2 minutes)

Presenter: COOKE, Logan (University of Alberta)

Ultracold neutral atoms are an excellent test-bed for novel quantum control techniques due to their stability, and efficient coupling to fields in the radio, microwave, and optical regimes. Various control protocols which could be used in quantum information processing (QIP) may first be investigated in ultracold atoms to prove their efficacy before being generalized to other more established systems. In this spirit we present two different novel control protocols. First we demonstrate holonomic single-qubit gates, which are conventionally performed via the adiabatic evolution of a degenerate manifold of states through a path in parameter space; this yields a non-Abelian geometric phase which couples the states in a way that depends only on the path taken. In this study, we eliminate the explicit need for degeneracy through Floquet engineering, where the atomic spin Hamiltonian is periodically modulated in time. We characterize the non-Abelian character of the geometric phase through a gauge-invariant parameter, the Wilson loop. Next, we demonstrate a decomposition of SU(3) including a resonant dual-tone operator which synthesizes coupling between two disconnected qutrit levels. For many conventional systems where the third coupling is not possible this technique provides a potential workaround. A decomposition of SU(3) using this operator is tested against conventional methods by performing a Walsh-Hadamard gate and performing maximum likelihood tomography on the resulting states. In both protocols we demonstrate novel methods for precision quantum control essential in advancing QIP techniques which can be readily adapted to trapped ions, superconducting qubits, and other quantum computing platforms.

DGEP Poster Session & Student Poster Competition (0) | Session d'affiches DEGP et concours d'affiches étudiantes (0) - MUSC Marketplace (17:30 - 19:00)

DSS Poster Session & Student Poster Competition (0) | Session d'affiches DSS et concours d'affiches étudiantes (0) - MUSC Marketplace (17:30 - 19:00)

DNP Poster Session & Student Poster Competition (4) | Session d'affiches DPN et concours d'affiches étudiantes (4) - MUSC Marketplace (17:30 - 19:00)

[3260] (G*) (POS-20) High-precision experimental nuclear physics with the upgraded TITAN Penning trap (17:30, 2 minutes)

Presenter: Ms KAKKAR, S. (University of Manitoba, TRIUMF)

Nuclear-physics experiments probe nuclear structure, nucleosynthesis and fundamental interactions, for which high precision and accurate mass measurements are critical inputs. TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN) facility employs the Measurement Penning Trap (MPET) to measure masses of exotic nuclei to high precision and accuracy up to ~1e-10. To improve the resolving power and reduce statistical uncertainty in the mass measurement, a higher charge state of the ions can be used. This and other benefits of charge breeding radionuclides like improved beam purification can only be realized at TITAN as it alone in world combines radioactive ions, charge breeding, and a Penning trap. To fully leverage these advantages, MPET is undergoing an upgrade to a new cryogenic vacuum system compatible with ions in charge states over 20+. The status of the new cryogenic upgrade will be presented.

[3336] (POS-21) Development of an In-Gas Laser Ablation source (17:32, 2 minutes)

Presenter: GONZALEZ ESCUDERO, Laura

nEXO is a next generation detector to search for neutrinoless double-beta decay in Xe-136. This hypothetical decay violates lepton-number conservation, requiring the neutrino to be its own antiparticle and would imply the existence of physics beyond the Standard Model. As a potential upgrade to further improve nEXO's sensitivity, the Ba-tagging technique is being developed to eliminate nearly all background events. The Ba-tagging scheme being pursued by Canadian institutions involves an extraction of Ba-136 ions from candidate Xe-136 double-beta decay events within the detector in a gas phase, and an identification of Ba ions using laser and mass spectroscopy. To study and optimize the Ba-tagging extraction and identification process, a well-characterized in-gas ion source is needed. To this end, our group at McGill is developing an in-gas laser ablation source. Currently, ion production and transport efficiency in noble gas as a function of gas pressure is being studied. The setup, analysis, and future plans of the in-gas laser ablation source will be presented.

[3503] (G*) (POS-62) A comprehensive Monte Carlo simulation of the neutron response of multi-element microdosimetric detectors based on thick gas electron multiplier. (17:34, 2 minutes)

Presenter: SINGH, Rachna (McMaster University)

The neutron dose responses of the tissue equivalent multi-element Thick Gas Electron Multiplier (THGEM) microdosimetric detectors have been computed by Monte Carlo simulations. The absence of wire electrodes in THGEM has immensely simplified the construction of multi-element detectors. Three muti-element configurations of 7x3, 19x5, 37x7 were used as the representative detector geometries and the microdosimetric response of each configuration was computed by the MCNP 6.2. code. The dimensions of the three configurations were kept such that each configuration occupies a cylindrical volume of 5 cm diameter by 5 cm length. The incident neutron energy was varied from 10 keV to 2 MeV. The angular response was studied for incident neutron beam at angle 0^{0}, 30^{0}, 45^{0}, 60^{0}, and 90^{0}.The simulated response showed a good agreement with the evaluated fluence-to-kerma conversion coefficients in the neutron energy region 10 keV to 100 keV while discrepancies were observed in the region above 250 keV. It was identified that the discrepancy was caused by the non-tissue equivalent response of the THGEM. This under-response can be corrected by applying a correction factor. The angular response simulation result showed an excellent uniform response.

[3509] (G*) (POS-63) Optimization and Characterization of Bi-Detector Coincidence Beta-Ray Spectrometry System (17:36, 2 minutes)

Presenter: Mr SUN, Ruoyu (McMaster University)

We present optimization and characterization of a Si-plastic scintillator coincidence beta-ray spectrometer. Recent recommendation to lower the dose limit for the lens of the eye by International Commission on Radiological Protection posed new health physics requirement in the country. Beta-ray dosimetry is of great importance for nuclear industries, particularly during the maintenance periods. The beta-ray spectral data is most fundamental and vital information for accurate beta-ray dosimetry for mixed beta-gamma fields that are often encountered during the nuclear maintenance work. To this end, a Si-Plastic scintillator coincidence beta-ray spectrometer has been developed. The spectrometer can collect pure beta-ray spectra by rejecting the gamma-ray detection events through coincidence. The pulse height and arrival time of each detector signal was processed by a compact digital system and was collected in list mode. A recent upgrade in the digital processor enabled the spectrometer to cover the entire beta energy range of interest.The responses of the spectrometer to beta and gamma were characterized by experiments and Monte Carlo simulations. Spetrcal measurements under beta-gamma mixed fields with various beta and gamma count rates using 90Sr and 137Cs sources were executed as the evaluation of the system performance. The coincidence beta spectrum was quite stable and consistent in most energy region with the increase of the gamma count rate for a fixed beta field. Development of a real-time spectrum analysis method is currently underway.

DASP Poster Session & Student Poster Competition (0) | Session d'affiches DPAE et concours d'affiches étudiantes (0) - MUSC Marketplace (17:30 - 19:00)

DPE Poster Session & Student Poster Competition (0) | Session d'affiches DEP et concours d'affiches étudiantes (0) - MUSC Marketplace (17:30 - 19:00)

DPMB Poster Session & Student Poster Competition (16) | Session d'affiches DPMB et concours d'affiches étudiantes (16) - MUSC Marketplace (17:30 - 19:00)

[3044] (U*) (POS-45) Measuring Axon Diameters in Mice Using Oscillating Gradient Spin Echo MRI Sequences (17:32, 2 minutes)

Presenter: CHISHOLM, Madison (Neuroscience, The University of Winnipeg)

Schizophrenia is a neurological disease that affects 20 million people world-wide. Previous research has linked Schizophrenia post-mortem to abnormalities in axon distribution and integrity within the corpus callosum. Therefore, it is of high interest to investigate methods that will eventually be able to measure axon diameters in areas such as the corpus callosum in live brains. This would create new clinical applications such as earlier diagnosis, and allow for the development of new treatments. Diffusion MRI is a method with potential to infer microstructure in live brains using temporal diffusion spectroscopy (TDS). TDS, when used with certain pulse sequences, such as Oscillating Gradient Spin Echo (OGSE), can be used to infer micron-scale axon diameters. To calibrate TDS with OGSE, ex vivo mouse brains were imaged and analyzed in this project. The images were collected using a 7T Bruker AvanceIII NMR system with Paravision 5.0 and were processed and analyzed using MATLAB. The method was able to infer axon diameters on the order of a few microns in size from some of the image sets. Electron microscopy measurements to confirm the MRI findings are planned. Further work is being done to improve image quality and optimize MRI parameters for more precise measurements. The authors wish to acknowledge Rhonda Kelley for her help with animal care and imaging. The authors acknowledge funding from NSERC and Mitacs.

[3060] (G*) (POS-46) Inferring axon diameters in white matter tracts of the live mouse brain (17:34, 2 minutes)

Presenter: ANDERSON, Melissa (Biomedical Engineering, University of Manitoba)

Tissue microstructure, such as axon diameters, can be inferred from MRI diffusion measurements either through relating models of the geometry of the tissue and MR parameters, or through directly relating MR measurements to tissue parameters. Some have implemented geometric models to infer axon diameters using temporal diffusion spectroscopy. In order to target smaller diameter axons, we have replaced the pulsed gradient spin echo pulse sequence used in most temporal diffusion spectroscopy measurements with oscillating gradient spin echo sequence (OGSE). Here we use OGSE temporal diffusion spectroscopy to infer axon diameters is white matter tracts of the live mouse brain. Axon diameters in the live mouse brain were inferred using oscillating gradient spin echo temporal diffusion spectroscopy. Two sets of five images were collected in less than 11 minutes from which the measurements were made. Diameters ranged from 4 to 12 μm in various white matter regions including the optic tract, corpus callosum, external capsule, dorsal hippocampal commissure and fasciculus retroflexus. Confirmation of axon diameters using electron microscopy is planned and the collection of more MRI data is planned. The short imaging time suggests this is the first step toward a feasible imaging method for live animals and eventually for clinical applications. The authors wish to acknowledge Rhonda Kelley for her help with animal care and imaging. The authors acknowledge funding from NSERC and Mitacs.

[3100] (POS-48) Developments in the Rapid Diagnosis of Bacterial Pathogens Using Laser-Induced Breakdown Spectroscopy (17:36, 2 minutes)

Presenter: BLANCHETTE, Emma (University of Windsor)

Our lab has been investigating the use of laser-induced breakdown spectroscopy (LIBS) for the rapid detection and diagnosis of bacterial pathogens. LIBS is a spectrochemical technique that utilizes a laser to produce a near instantaneous elemental assay of a substance. The laser interacts with the substance to produce a high-temperature microplasma. As the plasma cools it emits light, which is collected by an Echelle spectrometer to give a high-resolution time-resolved spectrum. Currently we prepare bacteria samples by depositing them on a nitrocellulose filter through a custom fabricated centrifuge device and custom fabricated cone. The resulting thin film of bacteria is ablated in our LIBS apparatus. Using this sample preparation method, we have collected several hundred spectra of five species of bacteria: *Staphylococcus epidermidis*, *Escherichia coli*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, and *Enterobacter cloacae*. We have also analyzed the spectra of control specimens, including blank nitrocellulose filters and sterile water deposited on those filters. Detection and diagnosis of bacterial specimens based on a spectrochemical signal relies on the use of chemometric algorithms. Our work uses discriminant function analysis (DFA), partial least-squares discriminant analysis (PLSDA), and we are investigating the use of artificial neural networks (ANN). In the past, we have achieved reliably high discrimination accuracy with pelletized bacterial targets containing high numbers of cells. However, detection and diagnosis of bacteria becomes increasingly more difficult as bacterial suspension concentrations decrease. In this poster we present ways to achieve reliable detection and diagnosis with lower and more clinically relevant concentrations of cells. One such method is increasing the intensity of plasma emission by co-ablating silver with the cells. We investigated the deposition of silver with two methods including the use of microparticles as well as laser-sputtered thin films. Sensitivities and specificities achieved with methods focusing on optimizing discrimination will be reported for both the detection of cells in sterile fluids using PLSDA and the discrimination between bacterial species using DFA. Lastly, the use of an ANN algorithm trained using a large set of pseudodata created to resemble the bacteria spectral data will be discussed.

[3109] (G*) (POS-49) Segmentation in Quantitative Dynamic Nuclear Medicine: The Insufficiency of the TG-211 of the AAPM (17:38, 2 minutes)

Presenter: LAPORTE, Philippe

Purpose : The Task Group 211 report of the American Association of Medical Physicists (AAPM) made a literature review of various segmentation techniques for nuclear medicine. These methods are valid and strong in the context of static images; when faced with dynamic images, many challenges arise, and the user-dependency becomes problematic. Material : Many dynamic TEP acquisitions had been made on small animals and other acquisitions have been made on a custom-designed dynamic phantom. The injected medical compound was either FDG or another radiopharmaceutical. The acquisitions lasted between 40 and 60 minutes. Methods : For the analysis, three different classes of segmentation techniques have been used, according to TG-211: a gradient-based, statistics-based, and filling algorithms. The segmentations were performed on a specific reference timeframe and were static, i.e. the segmentation was not varying from one timeframe to the other. To compare the results, the discrepancies between the segmentations were evaluated with various metrics, among which the Sørensen-Dice coefficient. Furthermore, since the segmentations are useful for pharmacokinetic analyses, the variations in the segmented volumes were assessed based on the quantitative impacts upon the time-activity curves (TACs). Results : Concerning the segmentations themselves, the choice of timeframe upon which to base the algorithms has a great impact on the segmented volume. In the case of the small animals, this represents a large fraction of the total region of interest. In the case of the phantom, since the movement can be controlled and is known, the discrepancies are much less severe. Concerning the TACs themselves, they are not as affected as had been expected: this could partially be explained by the fact that part of the voxels that are either present or not between segmentations are not the most active and, thus, have a lower impact on the statistics pertaining to the segmented region. Conclusion : The TG-211 is a robust reference for static segmentations in nuclear medicine, but it is not trivial to apply its methods in a dynamic context. We conclude that the methods can be used, but it needs to be done carefully, as to be aware of the possible pitfalls pertaining to the transition from static to dynamic imaging.

[3128] (U*) (POS-50) Laser-Induced Breakdown Spectroscopy Emission Enhancement from Bacteria on a Silver Thin Film (17:40, 2 minutes)

Presenter: TRACEY, Emily (University of Windsor)

Laser induced breakdown spectroscopy (LIBS) is a technique whereby time-resolved optical emission spectroscopy is performed on high-temperature laser-induced plasmas to determine the elemental composition of the target. This lab uses LIBS to identify and classify bacterial pathogens based on differences in the concentrations of inorganic elements in the membrane of bacterial cells. This rapid classification will be used for diagnosing pathogenic bacteria in clinical specimens. Preliminary work using silver microparticles deposited on a nitrocellulose filter underneath the bacterial cells showed promising enhancement of the bacteria's LIBS emission spectra. This motivated work to increase the uniformity of deposited silver for an improved ablation surface and to prevent the silver deposition from being disrupted by the laser shots. A 60 mJ 1064 nm pulsed laser focused onto a rotating silver foil target in a 10 mTorr evacuated environment sputtered a highly uniform silver thin film onto a nitrocellulose filter. Experiments were performed to locate the filter in a position to sputter the most uniform film across the 9 mm filter diameter. Sputtering times from 1 minute to 20 minutes were investigated. Uniformity was determined with LIBS and scanning electron microscopy. The silver filters were removed from the vacuum sputtering chamber and ablated in an atmospheric pressure argon environment to acquire LIBS spectra. Analysis of the LIBS spectra exhibited decreased shot-to-shot variation in the silver LIBS intensity between subsequent laser pulses when compared to previous experiments on microparticle covered filters. Bacteria specimens were deposited on a silver filter using a centrifugation concentration device. Analysis of the LIBS spectra from bacteria deposited on filters created with a sputtering time of greater then 15 minutes showed a 50-100% increase in the magnesium and calcium ion emission intensity, while neutral element emission intensity decreased, indicating an increase in plasma temperature. While overall LIBS emission enhancement was observed for a *S. aureus* sample deposited on a silver filter compared to an empty filter, no statistically significant increase in the signal to noise ratio was found. Work is ongoing to investigate other silver deposition methods including pulsed laser deposition in a non-vacuum environment to create nanoparticles.

[3130] (G*) (POS-51) Achieving robust perfect adaptation while suppressing stochastic fluctuations in biochemical reaction networks (17:42, 2 minutes)

Presenter: KELL, Brayden

Chemical reaction networks allow cells to sense and adapt to sustained environmental perturbations. Due to inherent stochasticity and low copy numbers, biochemical regulatory modules must achieve adaptation despite significant fluctuations, limiting the applicability of classical control theory to understand and rationally design such modules. Recent theoretical work has established the class of molecular control modules capable of achieving robust perfect adaptation (RPA) for average abundances in stochastic reaction networks. RPA ensures the controlled signal perfectly adapts to disturbances, despite parameter variations and unknown details in the controlled network. All molecular control modules exhibiting this property are an extension of the antithetic integral feedback (AIF) motif, whose adaptation property has been demonstrated experimentally. It has been suggested that increased fluctuations about the average controlled species abundance is the price to pay for RPA in these systems. We present evidence that this apparent noise penalty may indeed be unavoidable in generalized AIF topologies studied in the literature. However, we show different couplings between the controller and the controlled system avoid this penalty and even permit reduced fluctuations relative to an open-loop control strategy. Additionally, we quantify trade-offs amongst sensitivity, settling time, energetic cost, and fluctuations in several generalized AIF topologies in the presence of inevitable intracellular dilution effects, which results in imperfect adaptation. These results clarify our understanding of noise in biochemical adaptation and suggest design considerations for achieving RPA while suppressing stochastic fluctuations in biochemical networks.

[3183] (G*) (POS-52) Atomic Force Microscopy and Molecular Dynamics to Study the Structure of Nanodomains of Model Lipid Membranes in Relation to Alzheimer's Disease. (17:44, 2 minutes)

Presenter: MEI, Nanqin

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that causes loss of memory. In AD neuronal cell dysfunction and death are caused by amyloid aggregates which are toxic to the cellular membrane and cause membrane damage. The cellular membrane is a complex non-homogeneous bilayer and plays an important role in the amyloid toxicity. We previously showed that model lipid membranes mimicking healthy neurons and AD are different in their interactions with amyloid [1]. In this work, we studied the structure of membrane nano-domains in model membranes composed of DPPC, POPC, cholesterol, SM and GM1 mimicking healthy neuronal membrane and that at an early stage of AD using Atomic force microscopy (AFM) and Molecular Dynamics (MD) simulations. AFM was used to image the morphology of the membrane nanoscale domains and MD provided details on the domain structure and lipid composition that results in the formation of domains in each model membrane. We found that GM1 lipids preferably cluster with GM1, DPPC and cholesterol, while SM does not show a great preference for clustering. These findings help to understand how changes in lipid composition may alter the domain structure in model lipid membranes, and serve to understand their role in amyloid toxicity in AD. Reference: [1] Drolle, E., A. Negoda, K. Hammond, E. Pavlov, and Z. Leonenko, "Changes in lipid membranes may trigger amyloid toxicity in Alzheimer's disease", PLoS ONE, vol. 12, issue 8, pp. e0182194, 08/2017.

[3205] (G*) (POS-53) Protective Effect of Trehalose Sugar Against Amyloid β Toxicity in Model Lipid Membranes (17:46, 2 minutes)

Presenter: XU, Yue

The amyloid-β peptide (Aβ1-42) is regarded as a major pathogenic factor in Alzheimer's disease—a debilitating neurodegenerative disorder that causes memory loss and neuronal damage in elderly patients. Aβ forms toxic oligomers capable of binding to neuronal membranes and inducing damage through their insertion and subsequent formation of ion channels or pores in these membranes (Drolle et al, J. Drug Metabolism Research, 2014). Trehalose, a disaccharide, has been shown to protect plant cellular membranes in extreme conditions and modify protein misfolding processes, including those seen in Aβ. We hypothesize that trehalose can protect the neuronal membrane from amyloid toxicity. In this work we studied the protective effect of trehalose against Aβ-induced damage in model lipid membranes (DPPC/POPC/Cholesterol in mass ratio of 4:4:2), which are used to mimic neuronal membranes. We used Black Lipid Membrane (BLM) technique to detect the changes in membrane permeability by measuring ion currents through suspended model lipid bilayers upon addition of Aβ and trehalose. Atomic Force Microscopy (AFM) was used to visualize the 3D surface topography of model lipid membranes as well as the changes under the incubation of Aβ and trehalose by measuring the atomic force between sample surface and scanning probes. Our results demonstrate that Aβ binds to membranes and leads to ionic current leakage across membrane due to channel incorporation and membrane damage. The presence of trehalose reduces the ion current caused by Aβ peptides' destructive insertion to lipid membranes. This may indicate potential protective effects of trehalose against Aβ toxicity in model membranes. AFM images are in a good agreement with BLM data and support the protective hypothesis of trehalose in model membranes.

[3287] (G*) (POS-54) The Feasibility of the Xenon Ventilatory ADC Approach Using 129Xe MRI (17:48, 2 minutes)

Presenter: PARNIYANY, Elnaz

Hyperpolarized 129Xe lung MRI(1,2) is an efficient technique used to investigate and assess pulmonary diseases. The technique provides physiologically-relevant-biomarkers of obstructive lung-disease including emphysema, bronchopulmonary-dysplasia, congenital lobar emphysema and alpha-1-antitrypsin-deficiency.(3) However, the longitudinal observation of the emphysema progression using hyperpolarized-gas MRI-based Apparent-Diffusion-Coefficient (ADC) can be problematic, as the disease-progression can lead to increasing unventilated-lung-areas, which likely excludes the largest ADC estimates.(4) Five patients, underwent spirometry and 1H/129Xe (Static-Ventilation and ADC) MRI scans. 129Xe imaging was performed at 3.0T (MR750, GEHC, WI) using whole-body-gradients (5G/cm) and a commercial 129Xe quadrature-flex RF coil.(5) Hyperpolarized 129Xe gas (polarization=35%) was obtained from a turn-key, spin-exchange-polarizer-system (Polarean-9820 129Xe polarizer).(6) Calculated ADC values were normalized on the corresponding ventilation-defect-percent ((VDP), calculated as previously described(7) estimates to obtain vADC. The generated global-mean VDP estimates for the study-subjects were between 5% and 18%. The generated global-mean ADC/(vADC) estimates for the study-subjects were between 0.034s/cm2/(0.034s/cm2) and 0.048s/cm2/(0.048s/cm2). The 129Xe DW data reconstructed with the key-hole-technique had sufficient SNR to generate reliable ADC maps and reasonable matching with the Static-Ventilation data. For the first time the feasible of the vADC 129Xe MRI-based approach was demonstrated and shown that this method can be used to accurately evaluate the emphysema-progression in a small-group. The study results suggest that the diffusion data reconstructed with the key-hole-technique(8) had sufficient SNR to generate reliable ADC maps and showing reasonable matching with the static-ventilation-data. For future work, we plan rescan the study-participants in twelve-months and normalize the ADC by VDP for an accurate-assessment of the emphysema-progression over the year-interval. 1.Mugler, J.P., et al. JMRI,2013,37(2):313-31 5.Ouriadov et al. MRM,2020, 84:416-426. 2.Driehuys, et al., Radiol,2012,262(1):279-89 6.Kaushik, et al. MRM,2016,75(2):1434-1443 3.Young, H. M., Clinbiomech,2017:09.016 7.Kirby, M. et al. Radiol,2012.19(2):141-152 4.Westcott, A., et al. JMRI,2019,49(2):311-13 8. Barker, A. L. et al. ISMRM 19th,2019.

[3434] (U*) (POS-55) HEDGEHOG: a ridge filter design for FLASH proton therapy (17:50, 2 minutes)

Presenter: RODDY, David (TRIUMF, University of Edinburgh)

Damage to healthy tissue is a major concern in external beam radiation therapy. The risk of normal tissue complications from dose delivered outside the target reduces the effectiveness and safety of treatment. To mitigate this, research is oriented towards improving dose conformity to the target, and towards limiting damage inflicted by any wayward dose. Recent studies have reinforced older findings that increasing beam dose rates by around a thousand-fold offers superior sparing of normal tissue, known as the FLASH effect. This protective factor has been observed by several groups with various beam particles and targets, and the first patient was treated with electron FLASH in 2019. However, despite these promising results the underlying mechanism is not well understood. More research is needed to explore the FLASH effect and evaluate its clinical safety and effectiveness. TRIUMF has an experienced passive scattering proton therapy setup which treated patients for three decades and could be adjusted to conduct critical FLASH research. The modulator wheel currently used to create spread-out Bragg peaks does not spin fast enough to function properly at

FLASH dose rates. An alternative based on the static ridge filter was proposed in 2017 and adapting it for use at TRIUMF is underway. This adaptation is referred to as the Homogeneous Energy Distribution GEnerator for tHerapeutic prOton beam shapinG (HEDGEHOG), and the new design offers more versatile beam control, instant energy modulation and quick production through 3D printing. This project aims to develop a Python script which takes the target parameters as input and generates a HEDGEHOG geometry which will shape the beam as required. This geometry can be imported into Monte Carlo simulation packages FLUKA and GEANT4 for testing, and the same file can be prepared for 3D printing. This will maximise similarity between simulated and physical HEDGEHOGs allowing experiments to be planned accurately and efficiently. We will present the progress of this work including simulation results, comparisons between simulated and printed designs, and physical dose distributions measured at the TRIUMF Proton Therapy Research Centre.

[3264] (G*) (POS-56) Comparing perturbation responses of complex biological processes to their stochastic correlations (17:52, 2 minutes)

Presenter: IYENGAR, Seshu

Causal connections between biological molecules in reaction networks are often inferred by examining the correlation in the average levels of to component molecules across a range of drug perturbations to cells. At thermodynamic equilibrium, the fluctuation dissipation theorem relates a stochastic system's perturbation responses and correlations between variables in its spontaneous fluctuations. Since biochemical reaction networks do not operate at thermodynamic equilibrium, divergences from the fluctuation dissipation theorem may contain information about the underlying process. We analyzed how correlations in linearized biomolecular systems behave under random, unspecified perturbations to their kinetic parameters. We find that under certain situations the perturbation responses and spontaneous fluctuations share characteristics and that perturbation response correlations can be used to extract information about the parameter perturbations. We also identify the role of feedback in disrupting this correspondence between the two types of correlations. Our results suggest that combining perturbation response data with spontaneous stochastic fluctuations can be used with modern data collection to offer insights into the mechanisms of mammalian cell signalling and size control.

[3275] (POS-57) MSCDNet:A Multi-Scale and Cross-Dimension Feature Fusion Attention Network for Alzheimer's Disease Prediction With Structural MRI (17:54, 2 minutes)

Presenter: LIU, Fei (Anhui University)

Alzheimer's disease (AD) is a neurological degenerative disorder, clinically characterized as a cognitive impairment type of dementia. Structural magnetic resonance imaging (sMRI) is able to observe subtle structural alterations clearly in brain tissue and is widely used in the diagnosis of neurological disorders such as AD. However, the size distribution of the pathological area is more scattered due to the variations in the person's condition. Therefore, the key challenge for AD Prediction based on sMRI is how to identify discriminative features with different scales accurately. A multi-scale and cross-dimensional feature fusion attention network (MSCDNet) was proposed to identify AD and mild cognitive impairment (MCI) from normal controls (CN). MSCDNet consists of three parts: Firstly, to enhance the identification of pathological features of different sizes, the MSFA-Net subnetwork with a spatial attention perception layer extracts multi-scale features from the brain. Secondly, to obtain richer dimensional features, features were extracted simultaneously from sagittal, coronal, and axial cross sections by CDFA-Net subnetwork with dimensional mixed attention layers. Finally, a global attention classifier is used to obtain a weighted score of the features, thus balancing the contribution of the features to the classification results. We evaluated the performance of the proposed MSCDNet model on the baseline sMRI scans from two databases. Experimental results show that the proposed model is able to efficiently identify disease-related discriminative features with better classification performance in accuracy and generalization compared to multiple current best algorithms.

[2996] (POS-58) Needle Tip Identification in Clinical Power Doppler Ultrasound Using Induced Vibrations by an Innovative Mechanical Oscillator (17:56, 2 minutes)

Presenter: TESSIER, David

Brachytherapy is a type of cancer treatment that uses inserted needles that act as antennas to deliver radiation to the diseased tissue. A prototype medical device has been developed and built at Western University to provide an innovative technique to guide needle applicators in clinical ultrasound images. The device consists of a micromotor, battery, and contact shaft. The current standard of care is to use ultrasound to track the needle trajectory. Two-dimensional ultrasound is very limited in its ability to visualize the needle tip location due to image contrast, and the inherent flat nature. One method to help visualize the needle tip is through power Doppler (PD) ultrasound. Low amplitude vibrations produced along the needle, will show up on a power Doppler ultrasound, which greatly assists in locating the tip position. A transrectal 14 – 4 MHz ultrasound probe by BK Medical was used to collect image data on a tissue equivalent phantom. The needles were inserted in the phantom in a typical clinical pattern, mimicking the needle tip shadowing effect that makes some needle tips difficult to identify in a standard B-Mode image. Needle tips were identified in the three different setups: B-Mode, B-Mode with PD overlay, and PD without B-Mode. The results demonstrated similar tip error for well visible standard clinical needles, and superior tip error with the use of PD by more than a factor of two. The mean tip error for shadowed needles in B-Mode only images was found to be 0.80±1.70mm, and 0.34±0.47mm for B-Mode with PD enabled.

[3490] (U*) (POS-59) Using Ultrasound Imaging for Quantifying Kidney Fibrosis (17:58, 2 minutes)

Presenter: Ms MELINO, Helen (Ryerson University)

Chronic Kidney Disease (CKD) affects ~10% of the world population. There is no cure for CKD and kidney transplantation remains the only option. However, the donor pool is very small compared to the number of patients on the waiting list. This small donor pool consequentially leads to patients receiving older, less healthy kidneys with pre-existing fibrosis. Fibrosis is characterized by the accumulation of extracellular matrix proteins, which impairs kidney function. As tissue microstructures cannot be easily identified through non-invasive imaging tools, biopsies are considered the gold standard of assessment. This method however does have limitations as the small biopsy sections are not representative of the total fibrotic burden on the kidney. In this project, we are working towards exploring whether ultrasound (US) imaging can detect and quantify kidney fibrosis. US imaging is a non-invasive alternative to a renal biopsy, can assess the full kidney, and it is also widely accessible. Using signal analysis techniques on B-mode US images of murine kidneys, this work aims to find differences in US imaging for varying degrees of renal fibrosis with comparisons to acquired histological data. As there are 59 US frames in a single acquisition (5 Hz frame rate), the signal analysis technique employed compares the signal amplitude values for each pixel in the kidney ROI of the B-mode images for each frame relative to the first acquired frame. This method found that during 12 seconds of US acquisition, pixel signal amplitudes within the kidney fluctuate by amounts as large as 8500 (a.u.), especially in kidneys with fibrosis. Additionally, the deviation of pixel signal amplitude values from those in the first acquired frame increases as high as ±200 (a.u.) as imaging time progresses, especially for kidneys with fibrosis. These temporal changes in pixel signal amplitudes during US image acquisition suggest that this method could be the new standard for the non-invasive quantification of kidney fibrosis.

[3495] (U*) (POS-60) Sex Differences in Airway Metrics & Chronic Obstructive Pulmonary Disease (18:00, 2 minutes)

Presenter: Ms NASIR, Neha (Department of Physics, Ryerson University)

Introduction: Chronic obstructive pulmonary disease (COPD) is a complex disease defined by fixed airflow obstruction in the lungs, and is currently the 3rd leading cause of death globally. Female smokers are ~50% more likely than male smokers to develop COPD, yet, the reasons for females' higher susceptibility to COPD remains largely unknown. The objective of this study was to investigate the structural airway differences using computed tomography (CT) imaging between males and females from the Canadian Cohort of Obstructive Lung Disease (CanCOLD) study. **Methods:** Participants from the multicenter CanCOLD study with various smoking history (never vs current/ex-smoker) and CT images were evaluated. Airways were quantified on CT following segmentation and labelling using the VIDA Diagnostics software. CT measurements included emphysema quantified as a percentage of low-attenuation areas below −950 HU on inspiratory CT (LAA950) and measurements of airway wall thickness for a 10mm lumen perimeter (Pi10), the average airway lumen area (LA), and the total airway count (TAC) were measured. Multivariable linear regression models (MLR) were constructed for sex with these CT measurements, and adjusted for smoking status, age, CT total lung volume, CT air volume and CT display field of view. **Results:** A total of 1294 participants were evaluated: n=226 male and n=220 female never-smokers, and n=524 male and n=324 female ever-smokers. The MLR models found all four CT measurements to be significantly associated with sex. LAA was shown to be significantly different between males and females (estimate=0.73, p=0.03), indicating that males have greater emphysema than females. Further, the multivariable linear regression model found that females have significantly fewer airway counts (TAC: estimate=1.49, p=<0.001), thinner airway walls (Pi10: estimate=0.026, p=0.004) and lower LA than males (LA: estimate=0.907, p=0.026). **Conclusions:** Our study finds that females have fewer airways and thinner, narrower airway walls than males with COPD.

[3510] (G*) (POS-61) Drug design of small molecules implementing a deep learning model. (18:02, 2 minutes)

Presenter: Ms NAIR, Vrinda (Concordia University)

Antimicrobial resistance is a major global health threat, and it is on the rise. Roughly, 0.7 million people are dying of infections that in the past would have been cured by antibiotics. New techniques and approaches are therefore urgently needed. We are in a position to create new antibiotics and design new rules to combat Antimicrobial Resistance (AMR) by implementing deep learning, a technique that has already shown promise in the general area of small-molecule drug design. Deep learning is an artificial intelligence technique in which many layers of computational “neurons” are trained to solve a problem or recognize the underlying structure of the data. In particular, generative deep learning can create new data points “by analogy”, by generalizing from large quantities of provided data. We aim to identify potent small-molecule compounds and predict the properties of the fragments comprising them to find desirable traits in our molecules. We will implement a semi-supervised algorithm to learn from partially labelled data sets as we will be working largely with unlabelled data sets. The application of semi-supervised deep learning coupled with Fragment-Based Drug Design (FBDD) will enable us to combat AMR by identifying and optimizing desirable molecules. FBDD originated as an experimental approach in the pharmaceutical industry for reducing attrition and providing leads for previously intractable biological targets. FBDD identifies ~150 Da (low-molecular-weight ligands) that bind to biologically significant macromolecules and uses them as seeds for novel drug development. We propose to develop a similar approach computationally to identify novel building blocks, predict their properties, and use them to create a combinatorial search space. Using the semi-supervised deep learning infrastructure, we have built, we will study “design pathways”, by projecting existing expert trajectories for designing new drugs into the search space learned by the generator. The overarching goal of the project is to develop novel antibiotic hybrids (antibiotic hybrids are synthetic constructs of two molecules that are covalently linked) and new design rules for bypassing AMR and the creation of powerful antibiotics.

[3536] Effect of cuff-induced occlusion on muscle oxygenation (18:04, 2 minutes)

Presenter: BURTON, Timothy (Department of Biomedical Engineering, Toronto Metropolitan University, Canada)

Introduction: Quantification of oxygenation in a contactless manner is of interest in a variety of clinical scenarios, with diabetic wound management being one example. However, the development of such technology requires a reproducible and well-understood model of ischemia, including both inducement and measure effect using a reference standard, which is currently lacking. In our present work, we sought to advance the development of such a model with contact measurement of oxygenation using near-infrared (NIR) during occlusion of the arm. Material and methods: In this study, we have collected data from 28 healthy volunteers. The subject’s hands were placed on a table. One arm was occluded using a blood pressure cuff placed on the upper arm and inflated to 200mmHg for approximately two minutes. The muscle oxygenation signal (SmO2) was acquired using the NIR contact Moxy device (Fortiori Design LLC, Hutchinson, MN) placed on the arm distal to the occlusion. SmO2 was normalized, and the minimum value found, and the percent reduction from the initial to minimum value calculated. Results: Data collection was performed on 28 subjects in total, with each arm undergoing the ischemia protocol, for a total of 56 signals. 6 signals were excluded due to poor quality, leaving 50/56=89% of the signals, with all 28 subjects represented. The occlusion protocol resulted in an average relative reduction in SmO2 of -77±20%. Discussion: The SmO2 reduction varied significantly across the dataset, with the variation not explained by any collected metadata. We expect that the reduction would vary with respect to intrinsic physiological properties, as well confounding properties such as BMI. The variability in SmO2 reduction identifies the importance of collecting a broad group of metadata in when contactless technologies are validated against contact NIR during arm occlusion.

PPD Poster Session & Student Poster Competition (19) | Session d'affiches PPD et concours d'affiches étudiantes (19) - MUSC Marketplace (17:30 - 19:00)

[3058] (G*) (POS-27) The KDK Experiment: A Measurement of 40K Relevant for Rare-Event Searches (17:30, 2 minutes)

Presenters: HARIASZ, Lilianna (Queen's University, Kingston, ON), DI STEFANO, P.C.F. (Queen's University, Kingston, ON)

Potassium-40 (^{40}K) is a naturally-occurring, radioactive isotope of interest to rare-event searches as a challenging background. In particular, NaI scintillators contain ^{40}K contamination which produces an irreducible $\sim $3 keV signal originating from this isotope's electron capture (EC) decays. In geochronology, the $\mathcal{O}(\text{Gy})$ lifetime of ^{40}K is utilized in dating techniques. The direct-to-ground-state EC intensity (I_EC) of this radionuclide has never been measured, and theoretical predictions are highly variable ($I_\text{EC}\sim (0.064(19)–0.22(4))\%$). The poorly understood intensity of this branch may affect the interpretation or precision of experimental results, including those probing dark matter signals in the (2-6) keV region. The KDK (``potassium decay'') experiment is carrying out the first measurement of this I_EC branch, using a coincidence technique between a high-resolution silicon drift detector for $\mathcal{O}(\text{keV})$ X-rays and Augers, and a high-efficiency ($\sim 98\%$) Modular Total Absorption Spectrometer (Oak Ridge National Labs) for $\mathcal{O}(\text{MeV})$ gammas, to differentiate ground and excited state EC decays of ^{40}K. We report on the analysis of the main ^{40}K result, and on a measurement of ^{65}Zn decays used to test methods.

[3062] (POS-28) Systematic Investigation of the TRIUMF Electron Cyclotron Resonance Ion Source Charge State Booster (17:32, 2 minutes)

Presenter: Mr ADEGUN, Joseph

At the Isotope Separator and Accelerator (ISAC) facility of TRIUMF, an Electron Cyclotron Resonance Ion Source is used to charge breed radioactive ion beams before injection into the linear accelerator for post acceleration. The so-called Charge State Booster (CSB) has been used to charge breed radioactive isotopes ranging from potassium to erbium under the regime of single frequency heating since its commissioning in 2010. To improve the overall performance of the CSB, a research campaign has been launched since 2018 to conduct a systematic investigation of the source injection and extraction systems alongside the corresponding beamlines to further understand beam injection and formation from the booster. The well-known quadrupole scan technique was developed to measure the emittance of the beams from the CSB. To further improve the efficiency of the charge state booster, two-frequency heating is being implemented using a unique and unconventional method of the single waveguide. The results of the systematic investigation of the source extraction system, the efficiency of single charge states, the emittance of some selected charge states in comparison to the emittance of some selected background ion species will be presented and discussed.

[3435] (G*) (POS-29) Triggering on Atmospheric Muons in STRAW (17:34, 2 minutes)

Presenter: VEENSTRA, Braeden (University of Alberta)

The Pacific-Ocean Neutrino Explorer is a proposed multi-cubic kilometre neutrino telescope to be located off the coast of British Columbia, Canada. Two pathfinder missions, STRAW and STRAW-B, have been deployed to the Cascadian Basin site, which uses existing infrastructure maintained by Ocean Networks Canada (ONC). These missions were deployed in order to characterise the site. The first mission, STRings for Absorption Length in Water (STRAW) was deployed specifically to investigate the absorption and scattering length, and qualify the site. This original architecture was not designed to look for atmospheric muons, however their detection could be possible. My research focuses on configuring STRAW to trigger on atmospheric muons. This can serve as an experimental check on the muon rate 2.6 km underwater. In addition, it could potentially lay the groundwork for a full scale neutrino trigger in the future P-ONE detector.

[3324] (G*) (POS-30) Muon Veto System for Mini-HALO Neutrino Detector (17:36, 2 minutes)

Presenter: SAJID, Shayaan

The proposed neutrino detector HALO-1kT will be used to detect neutrinos from core-collapse supernova events and will contribute to our understanding of the stars' explosion mechanism. Its detection method is based on neutrinos interacting with lead nuclei which then emit neutrons that can be detected through helium counters. However, neutrino-lead cross sections at supernova energy scale are yet to be accurately measured. To help address this problem, a smaller scale prototype detector called Mini-HALO will be placed at Oak Ridge National Laboratory where a pulsed beam of neutrinos from the Spallation Neutron Source will interact with the lead in the detector producing neutrons. The measured cross-sections will then be used in HALO-1kT to constrain the number of neutrons we expect from a supernova signal. In order to obtain highly accurate measurements, a muon veto system will be installed on Mini-HALO to veto events induced by cosmic muons interacting in the detector that can be otherwise misidentified as signals from neutrino interactions. A suit of GEANT4 Monte Carlo simulations has been developed to study and build an optimized geometry of the muon veto system. These simulations consist of PVT polymer-based scintillator panels surrounding the detector which generate optical photons when traversed by high energy muons. Results from these simulations such as the energy deposited in the scintillator panels, the multiplicity of neutrons produced in muon-lead interactions in the detector, and detector dead-time will be addressed along with discussions on how these results can be used to veto the muon-induced signals in the detector.

[3187] (U*) (POS-31) Toward understanding the nuclear efficiency threshold of bubble chamber detectors (17:38, 2 minutes)

Presenter: LI, Xiang (University of Alberta)

A bubble chamber using fluorocarbons or liquid noble gases is a competitive technology to detect a low-energy nuclear recoil due to elastic scattering of weakly interacting massive particle (WIMP) dark matter. It consists of pressure and a temperature-controlled vessel filled with a liquid in the superheated state. Bubble nucleation from liquid to vapor phase can only occur if the energy deposition is above a certain energy threshold, described by the "heat-spike" Seitz Model. The nucleation efficiency of low-energy nuclear recoils in superheated liquids plays a crucial role in interpreting results from direct searches for WIMPs-dark matter. In this research, we used molecular dynamics simulation to study the bubble nucleation threshold, and we performed a Monte Carlo simulation using SRIM to obtain the nuclear recoil efficiency curve. The goal is to construct a physics model to explain the discrepancy observed between the experimental results and the current Seitz model. The preliminary results will be presented and compared with existing experimental data of bubble chamber detectors.

[3174] (G*) (POS-32) A mirror study in an ARICH detector for a hadron production experiment (17:40, 2 minutes)

Presenter: Mr FERRAZZI, Bruno (University of Regina)

A Ring Imaging Cherenkov (RICH) detector allows the identification of charged particles through the measurement of the emission angle of the Cherenkov light produced by the passage of particles with speeds greater than the speed of light in the detector medium. An Aerogel Ring Imaging Cherenkov (ARICH) device uses aerogel material as a radiator medium to achieve a desirable index of refraction. The EMPHATIC (Experiment to Measure the Production of Hadrons At a Test beam In Chicagoland) is a low-cost, table-top-sized, hadron-production experiment located at the Fermilab Test Beam Facility (FTBF) that will measure hadron scattering and production cross sections that are relevant for neutrino flux predictions such as those necessary for neutrino oscillation studies with the Hyper-K experiment. High statistics data will be collected using a minimum bias trigger, enabling measurements of all relevant cross sections. Particle identification will be done using silicon strip detectors, a time-of-flight (ToF) wall, and a lead glass calorimeter array in combination with the ARICH detector. The ARICH focuses on the kaons, pions and protons identification in a multitrack environment up to 8 GeV/c. In my presentation I will discuss the simulations and mechanical studies for the implementation of optical mirrors in the ARICH system to increase the angular acceptance of the detector as a low cost improvement.

[3172] (G*) (POS-33) Optical Calibration of the SNO+ Detector using Internal Backgrounds (17:42, 2 minutes)

Presenters: Dr RICCETTO, Serena (Queen's University), Ms DEHGHANI, Rayhaneh (Queen's University), ALLEGA, Anthony (Queen's University)

The SNO+ experiment is a multipurpose neutrino detector located 2 km underground at SNOLAB in Sudbury, Ontario. The primary goal of the experiment is to search for neutrinoless double beta $(0\nu\beta\beta)$ decay in liquid scintillator loaded with ^{130}Te in a low-background environment. An observation of a $0\nu\beta\beta$ decay signal would demonstrate the Majorana nature of neutrinos. In order to resolve such a rare decay process, a precise optical calibration of the SNO+ detector is critical. This work presents a sensitive method of investigating the attenuation parameters in liquid scintillator by modelling the simulated radial light yield profiles of various internal background sources. The scintillator materials utilized in the SNO+ Monte Carlo (MC) simulation framework have been fine-tuned based on *ex-situ* measurements of the light yield and comparison to detector data.

[3077] (POS-34) Optimizing IWCD's Outer Detector using optical simulations (17:44, 2 minutes)

Presenter: Dr TIWARI, Deepak (Hyper-K, University of Regina & TRIUMF)

Water Cherenkov (WC) neutrino detectors, such as Super-Kamiokande (Super-K), employ an outer detector (OD) volume to veto out cosmic muons and other types of background, and to provide passive shielding and identify events that are not contained in the inner detector (ID). The upcoming Hyper-Kamiokande (Hyper-K) experiment, a long-baseline neutrino facility to study oscillations and search for the CP violation in the lepton sector among other physics goals, will follow a similar OD and ID design for its far detector (FD) and for one of its planned near detectors - the Intermediate Water Cherenkov Detector (IWCD). The IWCD will be a sub-kiloton detector to be located at a distance of ~ 1 km from the J-PARC facility which will be upgraded to deliver a 1.3 MW beam. Due to its shallow depth and smaller size, along with its exposure to the intense neutrino beam, it is expected that background rates and pile-up events in the IWCD will be higher than in the Hyper-K FD. This demands a sophisticated OD veto system to reduce misidentified pile-up events and to improve the reconstruction efficiency for signal events. The IWCD OD walls will be covered with reflective Tyvek material to improve light collection, while a blacksheet layer will optically isolate it from the ID. Building an intelligent veto system would require, among other things, an understanding of the photon distribution in the OD region for different configurations of the reflective Tyvek and the blacksheet. For this purpose, a dedicated Geant4-based simulation was developed to perform a detailed optical simulation of the OD for different optical configurations in order to infer an optimal OD design, wherein we collect enough photon statistics to reconstruct the OD events and, at the same time, keep Cherenkov light localized to improve particle identification. The results of these optimization studies are presented here.

[3527] (U*) (POS-35) C14 in SNO+ (17:46, 2 minutes)

Presenter: PALESHI, Keegan

SNO+ is a multipurpose neutrino detector located 2km underground which detects events inside the active liquid organic scintillating (LAB) medium. It is important to understand the radio-active backgrounds in the detector in detail to interpret any potential physics signals. C14 is a source of background events in the SNO+ detector, and can be observed homogeneously throughout the LAB in the detector. The detector is now completely filled with scintillator and the wavelength shifter (PPO). By probing the detector threshold and evaluating the C14 rate we are able to investigate for any exotic physics interactions which may be present at low energy ranges.

[3134] (U*) (POS-36) Commissioning and Calibration of a High Purity Germanium (HPGe) Detector at SNOLAB (17:48, 2 minutes)

Presenter: SUBHI, Hassan

SNOLAB has a low background gamma ray counting facility to screen materials for use in the next generation of Neutrinoless Double Beta decay and Dark Matter experiments. The low background is achieved through a 2 km depth underground, gamma ray shielding from the lab environment, and Radon reduction with Nitrogen purge gas. SNOLAB has acquired a new detector in collaboration with the Health Canada, Comprehensive Nuclear Test Ban Treaty Monitoring Program. The detector will be used to further their high sensitivity monitoring program. We will present the results of the initial commissioning and calibration of this detector.

[3102] (G*) (POS-37) Toward a Veto Mechanism to Reduce Background for the Hyper-Kamiokande's Intermediate Water Cherenkov Detector (17:50, 2 minutes)

Presenter: KOERICH, Luan

Hyper-Kamiokande (HK) will be a next-generation neutrino detector. Following the successful T2K experiment, it will use a long-baseline neutrino beam to study neutrino oscillation and discover CP-phase violation in the lepton sector, among other goals. To characterize the unoscillated neutrino beam, the upcoming Intermediate Water-Cherenkov Detector (IWCD) will intercept the neutrino beam at different off-axis angles using a multi-Photomultiplier Tube (mPMT) system to detect Cherenkov light produced by charged particles resulting from neutrino interactions in the detector. However, the neutrino beam can also interact with the soil and water surrounding the IWCD, generating a background of penetrating particles, such as pions, photons, muons and electrons, that may interfere with the desirable neutrino-event detection. To reduce the effects of such background a veto mechanism is required. At the bottom of the mPMT module, a scintillator plate will generate a hit when traversed by a background particle, which, as part of a time-coincidence circuit with other detectors at the outer region of IWCD, will help us veto undesired particles. In this presentation, I will describe the conceptual considerations and experimental developments toward an optimal design for the mPMT's scintillator plates, and simulation efforts toward understanding its integration with the general IWCD's background-reducing mechanism.

[3067] (POS-38) Analysis on A Large HPGe PPC Detector with Machine Learning (17:52, 2 minutes)

Presenter: YE, Tianai (Queen's University)

High purity germanium (HPGe) p-type point contact (PPC) detectors are one of the ideal candidates for searching rare and low energy events, such as neutrinoless double beta decay and various dark matter candidates. We will report our studies on pulse shape characteristics and temperature dependency of a large segmented HPGe PPC detector. We will also discuss a machine learning algorithm in development to measure drift time of pulses and identify event positions. The determination of initial event position and optimized drift time measurement could be used for charge trapping correction, hence improving overall energy resolution of the final signals.

[3337] (U*) (POS-39) PMT Response Simulation and Long-Term Reliability Studies for nEXO's Muon Veto (17:54, 2 minutes)

Presenter: RETTY, Liam

nEXO is an experiment currently under design to search for neutrinoless double-beta decay using 5000 of enriched Xe-136. nEXO's sensitivity to the neutrinoless double beta decay halflife of 1.35×10^{28} yr at the 90% confidence level, under an ultra-low background environment. This will be accomplished partly by the implementation of an Outer Detector (OD) which serves to shield the liquid xenon time projection chamber from external radiation, as well as to veto backgrounds arising from the passage of nearby cosmogenic muons. Photomultiplier tubes (PMT) will be installed on the internal surfaces of the water tank to detect the Cherenkov light produced by those muons. The arrangement of the PMTs in the tank and their individual and collective performance directly impacts the muon tagging efficiency. This talk will outline the PMT response model, the effect of PMT failures on the muon tagging efficiency as well as risk mitigation procedures and strategies to ensure its stable and reliable long-term operation.

[3332] (U*) (POS-40) Cosmogenic Muon Background Characterization for nEXO (17:56, 2 minutes)

Presenter: ROSS, Regan

The nEXO experiment is being designed to search for neutrino-less double beta decay ($0\nu\beta\beta$) in a 5000 kg liquid xenon time projection chamber (TPC) enriched to the isotope xenon-136. nEXO's > 10^{28} year sensitivity reach to the $0\nu\beta\beta$ half-life requires extremely low backgrounds from external sources. Backgrounds are dealt with in part by surrounding the TPC with an outer detector (OD) in the form of a cylindrical water tank. The OD serves both to shield from incident particles like gamma and neutron radiation, as well as to veto cosmogenic backgrounds by detecting the Cherenkov light of passing muons using photomultiplier tubes (PMTs). In this talk, we discuss the simulation of incident cosmic muons and their respective event characterization. We examine the interrelatedness of muon path lengths, muon impact parameters, PMT geometries and the comparative detection efficiencies for the incident particles.

[3132] (G*) (POS-41) SNO+ backgrounds: Po210 on the acrylic vessel surface and Rn222 in cavity water (17:58, 2 minutes)

Presenter: YU, Shengzhao (Laurentian University)

SNO+ is a 780 tonnes of liquid scintillator neutrino detector located at Sudbury, ON in Vale's Creighton mine. 2km of rock above reduce cosmic radiation and enable rare even searches. However, radioactive material in the rock can decay and produce radiation in the region of interest of SNO+. This presentation will show the results for the daughter of U238 in the rock: Rn222, which is part of the external backgrounds that need to be monitored regularly. The water assay technique is used to find the Rn222 concentration in the cavity water surrounding the detector. In addition, the analysis of the SNO+ scintillator data during partial fill and the wavelength shifter addition period helps to understand the Po210 (Rn222 daughter) activity on the acrylic vessel surface of the detector. These results will also be presented.

[3104] (G*) (POS-42) Simulating nEXO's Outer Detector with Chroma (18:00, 2 minutes)

Presenter: AL KHARUSI, Soud

The nEXO experiment is a proposed neutrinoless double beta decay (0$\nu\beta\beta$) search in the isotope ^{136}Xe. Anticipated to be located at SNOLAB, nEXO aims to observe the Majorana nature of neutrinos with a sensitivity that will exclude up to a 1.35×10^{28} year half life (at 90% confidence level) and probe the entire inverted mass hierarchy parameter space for almost all nuclear matrix elements. nEXO's stringent low-background requirements necessitate a water shield in order to reduce contributions from external radiation. Photomultiplier tubes (PMTs) inside the water will measure Cherenkov light from passing muons which will allow the vetoing of cosmogenic backgrounds from the 0$\nu\beta\beta$ search; this active shield is referred to as the Outer Detector. This talk will present the status of GPU-accelerated Chroma simulations of Cherenkov photons in the water tank. Chroma allowed us to rapidly develop the instrumentation plan for the PMTs based on nEXO sensitivity requirements and assess the overall veto capabilities of the Outer Detector.

[3500] (G*) (POS-43) Searches for double beta decay of Xe-134 with EXO-200 (18:02, 2 minutes)

Presenter: PERNA, Allan (Carleton University)

The EXO-200 experiment uses a liquid xenon (LXe) time projection chamber to search for neutrinoless double beta decay ($0\nu\beta\beta$). The already observed two neutrino double beta decay ($2\nu\beta\beta$) mode, a second-order weak transition in which two neutrons simultaneously decay into two protons emitting two electrons and two antineutrinos, is a well-known process predicted by the Standard Model whereas the hypothetical neutrinoless double beta decay mode ($0\nu\beta\beta$), a spontaneous transition that emits only two electrons, has not been observed yet. The observation of $0\nu\beta\beta$ would help constrain the absolute mass scale of neutrinos and verify that they are their own anti-particle. Although focused on the study of ^{136}Xe, EXO-200's LXe enrichment of 80.7\% in the isotope ^{136}Xe and 19.1\% in the isotope ^{134}Xe allows to study the decay of both isotopes. The EXO-200 experiment collected data from 2011 to 2014 (Phase I) and from 2016 to 2018 (Phase II) at the Waste Isolation Pilot Plant in Carlsbad, New Mexico, USA. Using data from Phase I, EXO-200 obtained the most stringent lower limit for the half life of the two modes of double beta decay of ^{134}Xe, which is expected to be further improved using the complete data set. This poster presents the current efforts and results obtained by EXO-200 focusing on the analysis of the ^{134}Xe double-β decay modes.

[3526] (U*) (POS-44) Simulating an Active Target Time Projection Chamber (18:04, 2 minutes)

Presenter: POSTUMA, Alicia

The A2 Collaboration uses the Mainz Microtron to measure to conduct measurements probing hadron structure. An upcoming experiment will study Compton scattering off of helium-3 to obtain the polarizabilties of the neutron. To get a full picture of these events and reduce backgrounds, an active target is required. We intend to use a compact Time Projection Chamber (TPC) for this purpose, in combination with our existing CB-TAPS photon detector set-up. In preparation for this experiment, I have been simulating the TPC in Geant4, and implementing an event reconstruction framework in the A2 data analysis software. Various limitations in Geant4 have made this project more challenging than expected, but the resulting simulation will help design electronics for the detector and optimize experimental parameters, to make the best possible measurement of the neutron polarizabilities.

[3121] (POS-70) Upgrading the radiopurity.org materials database (18:06, 2 minutes)

Presenter: Dr SCORZA, Silvia

The radiopurity.org database has proven to be a valuable resource for the low background physics community as a tool to track and share assay results. This talk will describe recent collaborative efforts between the Pacific Northwest National Laboratory and SNOLAB to modernize the database for the community. Improvements to the search utility and data upload methods will be discussed. Installations to support individual physics collaborations and assay facilities will be described, as well as ongoing plans to develop and support the database.

DTP Poster Session & Student Poster Competition (4) | Session d'affiches DPT et concours d'affiches étudiantes (4) - MUSC Marketplace (17:30 - 19:00)

[3051] (G*) (POS-23) Logarithmic Wave Catastrophes: Hawking Radiation, Tidal Bores, and Radio Astronomy (17:30, 2 minutes)

Presenter: FARRELL, Liam

Caustics are regions of high intensity created generically by the natural focusing of waves. Some examples include optical rainbows, gravitational lensing, sonic booms, and even rouge waves. The intensity at a caustic is singular in the classical ray theory, but can be smoothed out by taking into account wave interference effects. Caustics are universally described by the mathematical theory of singularities known as catastrophe theory. Caustics can be categorized into classes of catastrophes, each class uniquely described by its own diffraction pattern. A more exotic form of wave singularity occurs near event horizons, which have analogues in classical hydrodynamics where the flow speed exceeds the speed of sound, and also in quantum fluids such as Bose-Einstein condensates (BEC), where Hawking radiation can be simulated. In particular, waves near event horizons display logarithmic phase singularities which cannot be described by the known catastrophe classifications. We introduce a new idea: a logarithmic catastrophe, which were first studied in the context of aeroacoustic flows from jet engines. We will discuss the basic idea behind these logged catastrophes and their relation to analogue Hawking radiation. Additionally we discuss two systems which appear to be categorized by logged catastrophes: undular tidal bores, and certain oscillatory integrals in radio astronomy.

[3197] (G*) (POS-24) Emergent cosmology from matrix theory (17:32, 2 minutes)

Presenter: LALIBERTÉ, Samuel (McGill University)

Despite its success in explaining the large-scale evolution of the universe, standard big bang cosmology has many unsolved problems. For example, it cannot explain why the universe is homogeneous and flat to the degree of precision we observe today. Moreover, as one goes back to the time of the big bang, the universe's energy density is expected to reach infinity, leading to an initial singularity. String theory is the leading candidate to resolve these problems, as it is expected to correctly describe gravity at high energies and unite all forces of nature under a single theory. Our poster presentation will describe ways that string theory can resolve the issues of standard big bang cosmology. We will explain a new and recently published string-inspired scenario (see arXiv:2107.11512) in which our universe emerges as a gas of strings described by a matrix model. In this model, the homogeneity problem is automatically resolved since the universe emerges in a thermal state, and the singularity problem is resolved by the non-commutative properties of the matrix model. In addition, we obtain an approximately scale-invariant spectrum of cosmological perturbations and a scale-invariant spectrum of gravitational waves, as one would expect from observations. Finally, we will go over other possible predictions of this new model which are currently the subject of our studies, namely that the dimensionality and flatness of our universe can be respectively explained by energy and entropy arguments.

[3483] (G*) (POS-25) Quantum signatures of black hole mass superpositions (17:34, 2 minutes)

Presenter: ARABACI, Cemile Senem

In his seminal work, Bekenstein conjectured that quantum-gravitational black holes possess a discrete mass spectrum, due to quantum fluctuations of the horizon area. The existence of black holes with quantized mass implies the possibility of considering superposition states of a black hole with different masses. Here we construct a spacetime generated by a BTZ black hole in a superposition of masses, using the notion of nonlocal correlations and automorphic fields in curved spacetime. This allows us to couple a particle detector to the black hole mass superposition. We show that the detector's dynamics exhibits signatures of quantum-gravitational effects arising from the black hole mass superposition in support of and in extension to Bekenstein's original conjecture.

[3502] (U*) (POS-26) Gravitational Stability of Black Hole Mimickers (17:36, 2 minutes)

Presenter: CADOGAN, Joshua

The classical black hole is one of the most extreme and scientifically rich products of classical general relativity. However, it has predictions which still leave some uncomfortable; these primarily being the nature of the event horizon and the mass singularity. This has led to the development of alternative black hole 'mimicking' models which correct for these singularities and retain the observed properties of black holes without requiring modifications to general relativity. One of these mimickers is the 'gravastar'; a dense spherical mass distribution constructed of a cold gravitational condensate, colloquially called dark matter, inside a thin perfect-fluid shell. The density of the gravastar varies and the sizes for which it exhibits black hole properties are unknown. It has also been shown that such a stellar configuration can exist in thermodynamic equilibrium while correcting the information paradox. However, to replace the classical black hole as the end-product of gravitational collapse, as is currently accepted, an analysis of its dynamical stability is required. By perturbing the shell from gravitational equilibrium – as also occurs during mass accretion, binary coalescence, and other black hole events – its dynamical stability can be discussed. If such a body could reach harmonic behaviour around equilibrium without collapsing to a classical black hole, or alternatively leading to stellar explosion, then it would suitably describe black hole behaviour while correcting for their singularities. In this work we sought exactly this. By thoroughly investigating the equations of motion of the thin shell, we determined the mass sequences for which a stable gravastar can exist as well as their dynamical stability to a first order perturbation theory. We found that although such a configuration does indeed have black hole mimicking equilibrium forms, they are dynamically unstable and thus not expected to exist in nature.

Departmental Leaders Meeting / Réunion des directeurs(directrices) de département - Off campus venue - McMaster Innovation Park (across main street) (19:00 - 22:00)

-Conveners: Rangan, Chitra (University of Windsor)

CJP Editorial Board Dinner | Souper du comité de rédaction de la RCP - Off campus venue (19:00 - 21:00)

-Conveners: Robert Mann

Wednesday, 8 June 2022

Congress Registration and Information (7h30 - 17h00) | Inscription au congrès et information (7h30 - 17h00) - MDCL Lobby (07:05 - 07:30)

NSERC Liaison Committee Meeting | Réunion du comité de liaison avec le CRSNG - MDCL 2230 (07:30 - 08:45)

-Conveners: Rituparna Kanungo

Exhibit Booths Open (08h30-16h00) | Salle d'exposition ouverte de 08h30 à 16h00 - MDCL Hallways (08:05 - 08:30)

W-PLEN1 Plenary Session | Session plénière - Shohini Ghose - MDCL 1305/07 (08:45 - 09:30)

-Conveners: Barbara Frisken

[3010] The NSERC Chairs for Women in Science and Engineering in Canada (08:45, 45 minutes)

Presenter: GHOSE, Shohini (Wilfrid Laurier University)

For over 25 years, NSERC has supported a national network of five women scientists holding the Chairs for Women in Science and Engineering. The goals of this program are to celebrate and support leading women scientists and increase the participation of women in science and engineering. What are the successes and challenges of the Chairs program? Find out in this talk.

W-PLEN2 Plenary Session | Session plénière - Chris Polly - MDCL 1305/07 (09:30 - 10:15)

-Conveners: Danninger, Matthias (Simon Fraser University (CA))

[3240] First Results from the Muon g-2 Experiment at Fermilab’s Muon Campus (09:30, 45 minutes)

Presenter: POLLY, Chris (Fermilab)

The much anticipated initial results from the Muon g-2 experiment at Fermilab’s Muon Campus were released last year. The new determination of the muon’s anomalous magnetic moment is in good agreement with the intriguing value obtained at Brookhaven National Laboratory 20 years ago. The Muon Campus at Fermilab is a new accelerator facility capable of delivering the intense beams of muons required for the Muon g-2 and Mu2e experiments. This talk will discuss the Muon Campus physics program with an emphasis on the recent Muon g-2 results.

Health Break with Exhibitors | Pause santé avec exposants - MDCL Hallways (10:15 - 10:45)

W1-10 Building Stronger Physics Departments (CAP) | Construire des départements de physique plus forts (ACP) - MDCL 1009 (10:45 - 12:15)

-Conveners: Rangan, Chitra (University of Windsor)

[2991] (I) The Ruination of a University: The Sad Tale of the Laurentian University Fiasco (10:45, 30 minutes)

Presenter: GALIANO, Eduardo

In a legally unprecedented and controversial action, administrators on behalf of Laurentian University in Sudbury, ON, filed for insolvency protection in Ontario Superior Court on Feb 1, 2021 [1,2]. It marked the first (and still only) time in the annals of Canadian Academia, that a publicly funded, non profit, post-secondary institution availed itself of the provisions of a federal legal mechanism designed to protect profit making corporations: the Companies' Creditors Arrangement Act (CCAA). The action resulted in part, due to successive chronic operating deficits effectively unknown to faculty, staff, students, alumni, benefactors, provincial authorities, or the public at large. On April 12, 2021 under court protection, the university eliminated 69 undergraduate and graduate programs, terminated 111 full-time faculty (of which approximately 87 were tenured), 41 unionized staff members, and 37 non-union positions [3,4,5]. In some extreme cases - entire academic units such as the Physics Department - were completely eliminated. As the last serving Chair at the time of elimination, in this talk I will offer my perspectives on the "whats", "whens", "whys", "whos", "hows", and "what nows" surrounding this episode. In particular, I will devote some attention to how I dealt with the assigned task of the orderly shutting down the Department in 18 days, which at the time had a proud and productive 60 year existence [37]. [1] "Laurentian

University, key school for northern Ontario, files for creditor protection"CBC News Sudbury. 2021-02-01. [2] "Laurentian University files for creditor protection; former Queen's Provost appointed as special advisor". YGK News. [3] Laurentian University (2021-04-12). "Laurentian University academic Senate votes to approve certain program closures". [4] Friesen, Joe (2021-04-11). "Laurentian professors in precarious spot as university navigates insolvency". Globe and Mail. [5] Ulrichsen, Heidi (2021-09-23). "Laurentian's first-day-of-class down almost 13% overall". Sudbury.com. [6] https://www.cbc.ca/news/canada/sudbury/radiation-therapy-laurentian-restructuring-physicists-training-1.6018454

[3496] (I) Effective Practices for Physics Programs (EP3) (11:15, 30 minutes)

Presenter: Dr CRAIG, David (Oregon University)

The EP3 program is led by the American Physical Society (APS), in collaboration with the American Association of Physics Teachers (AAPT). Dr. David Craig is Associate Head of the Department of Physics at Oregon State University. His research interests are in the foundations of quantum mechanics, quantum gravity, and quantum cosmology. Dr. Craig received his PhD in theoretical physics from the University of California, Santa Barbara, before becoming a National Research Fellow of the Canadian Institute for Theoretical Astrophysics. He has collaborated with physicists across the world, and enjoyed an appointment as a visiting scientist at the Perimeter Institute for Theoretical Physics. Dr. Craig conducted research and taught at the University of Minnesota, Morris, Hamilton College, and the State University of New York prior to joining the faculty at Le Moyne College in Syracuse, New York, where he was chair of the department of physics and director of engineering programs for twelve years. Dr. Craig served as a member of the APS Committee on Education and as a consultant to APS on the work which led to the formation of the EP3 Project before moving to Oregon State University where he is now serving as Associate Department Head.

time	[id] title	presenter
11:45	Discussion (30 minutes)	

W1-5 Advances in Instrument Design (DAPI) | Progrès dans la conception d'instruments (DPAI) - MDCL 1016 (10:45 - 12:15)

-Conveners: Silvia Scorza

[3328] A Parallel-Transmit Halbach Magnet TRASE MRI System (10:45, 15 minutes)

Presenter: Prof. SHARP, Jonathan (University of Alberta)

We have designed and constructed a low-field TRASE RF imaging system. In TRASE k-space encoding is achieved by refocusing with RF phase gradients. The system includes a motorized rotatable magnet, twin RF power amplifiers, two geometric decoupled truncated twisted solenoid RF transmit coils (1D radial TRASE encoding), and a multi-channel transmit software-defined-radio console. The magnet is a 2.85 MHz 8-ring Halbach design (25 kg). All components are custom made. An inherent axial gradient of the inhomogeneous magnet function as slice selection. The unique feature of this imaging configuration is the simplicity. Two RF channels and rotation provide multi-slice projection reconstruction imaging. **Magnet:** The constructed 66.7 mT magnet design with a measured homogeneity of 11,152 ppm in a 12.7 cm diameter, 1 cm long cylindrical region of interest. To rotate the Halbach magnet, we used a hybrid stepper motor and a 2-phase hybrid stepper servo driver. Angular precision is 0.04 deg. **RF Coils:** Coils are based on a geometrically decoupled nested twisted solenoid design. The RF coil set was a pair of truncated twisted solenoids (suitable for rotation experiments). In each case coils are geometrically decoupled (i.e. no PIN diode switching). Coil diameters were 100mm and 125mm with length 230mm. Imaging volume 80mm diam; 100mm length. Phase gradient strengths: 5.8deg/cm inner; 5.15 deg/cm outer coil. **NMR Console:** A new parallel transmit console (‘DNMR’) was designed and built for this project. The console is based around an AD9106 4-channel 12-bit DAC and waveform generator ADC chip (180 MSPS, 24-bit tuning word), and an ADC-SoC FPGA-CPU board (Terasic). **Results:** 1D TRASE profiles have been obtained at a series of angles. The main current limitation is that improved magnet homogeneity is required. Several shimming approaches being investigated will be discussed. **Conclusion:** The concept behind this design was to minimize the technology requirements for MRI. A new robust configuration for low-field 2D multislice MRI has been presented. The minimal requirement is a rotatable inhomogeneous low-field magnet with axial gradient; two RF transmit channels; two twisted solenoids Tx coils, moderately well geometrically decoupled (~ S12 -15 dB). J. C. Sharp, S.B. King, MRI using radiofrequency magnetic field phase gradients, Magn. Reson. in Med. 63 (2010) 151–161. doi:10.1002/mrm.22188.

[3009] Field Deployable Mass Spectrometer for Rapid Analysis of CBRNE Threats (11:00, 15 minutes)

Presenter: MACDONALD, Emma (Canadian Nuclear Laboratories, McMaster University)

Current mass spectrometry methods are typically not well suited to provide timely characterization of samples of interest in a threat investigation scenario. This limits their use by professional personnel to inform the best course of action in response to an event. A field-deployable, rapid, and accurate identification method for chemical, biological, radiological, nuclear and explosive (CBRNE) threats could enhance performances in response to these potentially life terrorizing situations. Such a system is under development at Canadian Nuclear Laboratories (CNL). There are two main technical requirements for a practical field-deployable mass spectrometer. The first requirement is that the spectrometer must possess sufficient resolution for isotopic identification. This is accomplished through the use of a commercial compact mass spectrometer which employs a multi-turn time of flight method capable of high mass resolution. The second requirement is that the mass spectrometer must have a simple sample introduction and ionization technique. This requirement will be met through the use of the original electron ionization (EI) source for gas analysis plus two additional ion sources. One is a CNL-developed compact laser ionization source which utilizes a focused, pulsed, high power laser beam for ablation and ionization of solid samples. The other is a matrix-assisted laser desorption ionization (MALDI) source which allows for the ionization of organic/biological samples. The ability to couple the EI source for gas analysis, the laser ionization source for solid analysis and the MALDI source for organic/biological analysis interchangeably with a mass spectrometer allows for analysis of the full spectrum of CBRNE threats. The current progress towards development of this field-deployable mass spectrometer will be presented including proof of concepts through experiments and an in-depth description of the physics behind the methods used. Future development plans will also be summarized. This work is funded under Atomic Energy of Canada Limited's Federal Nuclear Science and Technology Work Plan.

[3141] (G*) Characterization of Laser-Driven Photon Emission in Silicon Photomultipliers at TRIUMF (11:15, 15 minutes)

Presenter: MARTIN, Juliette (The University of Edinburgh, TRIUMF)

Silicon photomultipliers (SiPMs) are emerging as the technology of choice for single photon detection in large-area experiments used in rare-event physics searches. The SiPM consists of a 2-dimensional array of tightly-packed single photon avalanche diodes (SPADs) with quenching resistor, biased above breakdown. Upon absorption of an incident photon, this generates a self-sustaining charge avalanche. A regrettable consequence of the avalanche process is the production of secondary, or cross-talk photons. These can travel to neighbouring SPADs, where they can induce delayed or direct cross-talk avalanches, or exit the SiPM completely. In large-area experiments, cross-talk photons leaving the SiPM can trigger other SiPMs in their vicinity, contributing to detector background. While these effects can be partially addressed through isolation structures in SiPMs separating the SPADs (trenches), this does not eliminate the emission of secondary photons. As a consequence, it is vital to study this phenomenon as it has a systematic effect on detector performance. The SiPM MIcroscope for Excitation Luminescence Characterization (MIEL) was developed at TRIUMF to study the emission of cross-talk photons. This is an inverted microscope system used to observe SiPMs at a sub-SPAD level, permitting the capture of emission microscopy images (EMMIs), and spectroscopic characterization of light emitted as a result of secondary photon production. A previous study at TRIUMF has presented results for photon emission from avalanche pulses in dark conditions. Thanks to a recent cryogenic upgrade to the MIEL setup, dark noise can be reduced, permitting operation at lower overvoltages and operation of SiPMs at temperatures similar to the cryogenic conditions of a liquid xenon detector, such as the nEXO experiment, searching for neutrinoless double-beta decay. We can study secondary light production from avalanches stimulated by laser pulses centred on a SPAD, building on the previous work on avalanches in dark conditions. We will present results from this laser-stimulated emission, with SiPM EMMIs showing a geographical distribution of emitted light, alongside emission spectra near breakdown, and photon yield per avalanche for two photosensor candidates for nEXO.

[3075] (G*) Fluorescence of optical materials down to 4 K - acrylic, TPB, pyrene (11:30, 15 minutes)

Presenter: ELLINGWOOD, Emma

Many particle detectors that use liquid scintillators house it in an acrylic vessel. The acrylic may be coated by a wavelength shifter if the scintillation light produced from particle interactions is outside the wavelength range of the photodetectors. We have investigated the low-temperature properties of pyrene as an alternative to 1,1,4,4-tetraphenyl-1,3-butadiene (TPB) as pyrene has a much longer fluorescence time which could be useful for pathological background rejection in a detector. The fluorescence properties of pyrene-polystyrene coated acrylic were studied using samples with various concentrations and fluorescence grades of pyrene. In addition, we have studied the fluorescence of the acrylic itself, as it could form a background in rare-event searches and compared the relative light yield of pyrene to TPB at different temperatures. All these materials were excited with 285 nm UV light and studied at various temperatures between 4 K and 300 K to cover the operating temperatures of most particle detectors. We present the changes in the spectra and light yields of all these materials with temperature and discuss an additional analysis of the temperature dependence of the pyrene fluorescence time constants.

[3277] (G*) Single Photon Air Analyzer (11:45, 15 minutes)

Presenter: PATEL, Mayur

ne can go days without water and food but only a few minutes without air. Side effects of air pollutants have been well studied and documented. The results from these studies make it essential for us to monitor air quality. In this talk, we report the design of a small and low-cost yet efficient air quality monitor. The technique used is single-photon detection which is scattered off the particles. Silicon

Photomultiplier (SiPM) is being used as the detector, which is relatively new in the pollution monitoring system. Along with the challenge and results of the prototype, the future plan will be discussed.

W1-6 Nuclei and Neutrinos (DNP) | Noyaux et neutrinos (DPN) - MDCL 1116 (10:45 - 12:15)

-Conveners: Gericke, Michael (University of Manitoba)

[3466] (I) BSM neutrino physics in weak nuclear decay (10:45, 30 minutes)

Presenter: Prof. LEACH, Kyle (Colorado School of Mines)

Despite their relative complexity, unstable atomic nuclei are among the best physical systems to search for BSM neutrino physics. In particular, rare isotopes that undergo weak nuclear transitions such as β decay, $\beta\beta$ decay, or electron capture (EC) provide a sensitive probe of a wide range of topics including neutrino masses, Majorana nature of neutrinos, and lepton number violating processes. Several of these studies - particularly those on neutrino mass states (both light and heavy) - are able to be performed without any model dependencies in these systems. The experimental tools in these areas are broad, and leverage modern technological advancements in quantum sensing, atom/ion trapping, radioactive background control, and tonne-scale detectors. In this talk, I will describe the power of using weak nuclear decay for neutrino studies, and give examples of ongoing and future experiments that provide unprecedented sensitivity to various BSM physics scenarios.

[3322] Barium Tagging from Xe Gas as an Upgrade to the nEXO Experiment (11:15, 15 minutes)

Presenter: Dr CHAMBERS, Christopher

The proposed nEXO experiment will search for neutrinoless double beta decay (0νββ) of Xe-136 in a 5-tonne enriched liquid xenon TPC. If observed, 0νββ will reveal the Majorana nature of neutrinos and show that lepton number conservation is violated in weak decays. nEXO's sensitivity is projected to reach beyond 10^28 years (at 90% confidence level) probing for effective Majorana neutrino masses as low as 4.7 meV – 20.3 meV. Searches for such extremely rare events require excellent background suppression and rejection methods to achieve high sensitivities. The identification or "tagging" of the Xe-136 ββ decay daughter Ba-136 offers a very powerful discrimination technique in 0νββ searches and is being investigated as a potential upgrade for nEXO. Furthermore, a positive confirmation of a ββ event is provided by tagging the Ba daughter. By leveraging the 3D reconstruction of the time-projection chamber (TPC), a sample of xenon surrounding a candidate 0νββ event can be extracted to tag the Ba daughter, if present. To this end, an apparatus is being developed to take a gaseous sample from a liquid Xe environment and transport a Ba ion to high vacuum using an RF ion funnel. The ion is then trapped and identified via laser-fluorescence and mass spectroscopy. The status of the Ba-tagging effort in Canada is presented in this talk.

[3356] (G*) Ba-ion mobility simulations in LXe for Ba-tagging at TRIUMF (11:30, 15 minutes)

Presenter: CVITAN, Megan (McMaster University)

The proposed nEXO experiment is a tonne-scale liquid xenon (LXe) time projection chamber that aims to uncover properties of neutrinos via the neutrinoless double beta decays (0$\nu\beta\beta$) in the isotope Xe-136. The observation of 0$\nu\beta\beta$ would point to new physics beyond the Standard Model and imply lepton number violation, indicating that neutrinos are their own antiparticle. The nEXO detector is expected to be constructed at SNOLAB in Sudbury, Canada, with a projected half-life sensitivity of 1.35$\times$10^{28} years. The collaboration has been pursuing the development of new technologies to further improve upon the detection sensitivity of nEXO, such as Barium (Ba)-tagging. This extremely challenging technique aims to extract single Ba ions from a LXe volume. Ba-tagging would allow for an unambiguous identification of true $\beta\beta$ decay events, and if successful would result in an impactful improvement to the detection sensitivity. Innovative Ba-tagging studies aimed at determining the ion-extraction efficiency of Ba-ions from LXe will be performed at TRIUMF in the near future. Due to the slow rate of the 2$\nu\beta\beta$ decay of Xe-136, short-lived isotopes will be implanted into the LXe. These isotopes will subsequently decay to isotopes of Ba, which are then extracted from LXe and identified. In this contribution, I will introduce the Ba-tagging setup at TRIUMF and elaborate on ongoing simulations for future ion-mobility studies in LXe under the influence of an external field.

[3326] (G*) Commissioning of a linear Paul ion trap for Ba-tagging (11:45, 15 minutes)

Presenter: Mr RASIWALA, Hussain (McGill University)

nEXO is a proposed 5-tonne experiment that will search for neutrinoless double-beta decay (0νββ) in liquid xenon enriched in the isotope Xe-136. Detection of such an event would significantly improve our understanding of neutrinos and potentially explain the matter-antimatter asymmetry. An observation of 0νββ would indicate the violation of the lepton number, a conserved quantity in the Standard Model, as well as demonstrate the Majorana nature of neutrinos. The 3D event localization in a nEXO-type detector offers the potential to differentiate a double-beta decay event from environmental backgrounds by extracting some liquid xenon from the detector volume and identifying the Xe-136 double-beta decay daughter Ba-136. This is referred to as Ba-tagging, a technique being developed as a potential future upgrade to nEXO. As a part of the Canadian Ba-tagging effort, a linear Paul trap is being developed to filter, cool, and trap ions extracted from the detector volume. Ions first pass through a quadrupole mass filter, calibrated to selectively allow only ions with the correct mass-to-charge ratio. Filtered ions will be collisionally cooled using helium buffer gas and trapped in a buncher. At a later stage, barium ions will be identified using laser fluorescence spectroscopy. The quadrupole mass filter, as well as the linear Paul trap, are currently being commissioned at McGill University. Its design and results of initial testing will be presented.

[3305] (G*) Commissioning of a Multiple-Reflection Time-of-Flight Mass-Spectrometer for Barium-tagging (12:00, 15 minutes)

Presenter: MURRAY, Kevin

The proposed nEXO experiment aims to search for neutrinoless double beta decay (0$\nu\beta \beta$) in ^{136}Xe with a five-tonne enriched liquid Xe time-projection chamber. The addition of barium tagging will allow for the positive identification of a candidate 0$\nu\beta \beta$ event as a true $\beta \beta$ decay, by extracting and identifying the daughter Ba ion. The nEXO collaboration is pursuing various approaches to barium tagging for potential future upgrades to the detector. One approach, currently under development at multiple Canadian institutions, is to extract the decay daughter together with a small volume of liquid Xe at the location of a candidate event. Following a phase-change from liquid to gaseous Xe, the ion is separated from Xe with an RF funnel and transported and trapped in a linear Paul trap (LPT), where the Ba daughter will be tagged with laser fluorescence spectroscopy. Ions will then be ejected from the LPT to a multi-reflection time-of-flight mass-spectrometer (MRTOF) for mass identification. Beyond identification of the Ba isotope, the MRTOF is also essential for performing systematic studies of the ion extraction technique. A Laser Ablation Ion Source (LAS) is currently being used to commission the MRTOF. Progress on the commissioning of the MRTOF with the LAS will be presented and next steps will be discussed.

W1-1 Neutrino Experiments (PPD) | Expériences de neutrinos (PPD) - MDCL 1105 (10:45 - 12:15)

-Conveners: Hartz, Mark (TRIUMF & Kavli IPMU, University of Tokyo)

[3123] (I) Probing the hadronic Universe with high-energy neutrino observations: present and future (10:45, 30 minutes)

Presenter: PARK, Nahee

We have investigated the origin of high-energy cosmic rays since discovering these particles in 1912. Over more than one hundred years, our knowledge of cosmic rays has been improved immensely. However, as magnetic fields deflect the trajectories of cosmic rays, their sources remain elusive. Neutral particles generated from the interactions of cosmic rays, such as gamma rays and neutrinos, can be used to identify the sources as they preserve the directional information. Among these neutral particles, neutrino observations provide unique information as, unlike gamma rays, neutrinos are generated only by hadronic interactions. Also, as weakly interacting particles, neutrinos can probe obscure environments hidden from electromagnetic observations and travel much longer distances than gamma rays, allowing us to explore a larger part of the Universe. The detection of a diffuse neutrino flux by the IceCube neutrino observatory and the recent multi-messenger observations triggered by IceCube in the direction of the blazar TXS 0506+056 show the potential of this approach. High-energy neutrino observations also can be used to study the properties of neutrino interactions up to the PeV energy range. I will overview what we have learned from high-energy neutrino measurements by the IceCube Observatory and what we expect to learn in the future with the next-generation neutrino observatories, such as P-ONE, the future neutrino telescope that will be deployed within the Ocean Networks Canada (ONC) infrastructure in the Pacific.

[3059] Constraints on electron neutrino and antineutrino cross sections for the leptonic CP violation search at Hyper-Kamiokande (11:15, 15 minutes)

Presenter: Dr AKUTSU, Ryosuke (TRIUMF)

The Hyper-Kamiokande (HK) experiment will study long-baseline neutrino oscillations and search for the CP violation in the lepton sector, following the successful T2K experiment. An upgraded 1.3MW beam produced at J-PARC 30 GeV proton accelertor and a 184 kiloton of the far detector's fiducial mass will be used, resulting in about 20 times higher interaction rate than that of T2K. The CP violation search will be systematically limited predominantly due to the uncertainties on electron (anti) neutrino cross sections for water target. To control the uncertainties and make full use of the high data statistics, it is planned to build an intermediate water Cherenkov detector (IWCD) that will be a sub-kiloton scale detector to be located at about 1km from the neutrino source as one of the HK's near detectors. The detector is designed to be able to move vertically, in order to change the energies of the neutrinos impinging the detector. Collecting data at different vertical positions enables IWCD to study the relationship between the neutrino energies and the observables from neutrino interactions. This talk will detail the constraints on the electron (anti) neutrino cross-sections at IWCD, which have been developed specifically for the CP violation study.

[3070] (G*) Implementation of Cherenkov Physics in Chroma for nEXO's Muon Veto (11:30, 15 minutes)

Presenter: KLEMETS, Emma (McGill University, UBC)

nEXO is a proposed neutrinoless double beta decay ($0\nu\beta\beta$) experiment anticipated to be built 2 km underground at SNOLAB. nEXO is expected to reach a half-life sensitivity of 1.35×10^{28} years, which requires ultra-low background levels. To achieve this, a water-Cherenkov muon veto, also known as the Outer Detector (OD), surrounds the liquid xenon time projection chamber and the cryostat. This tank of ultra pure water shields the xenon from gamma and neutron radiation, and detects high energy cosmic muons passing through the water via their Cherenkov radiation. The Cherenkov photons are detected by photomultiplier tubes (PMTs) inside the OD and are used to tag the muons passing by, allowing for a veto against cosmogenic backgrounds in the $0\nu\beta\beta$ dataset. Before finalizing the design of the OD, simulations need to be run to optimize the placement of the PMTs. Last summer, the nEXO OD group adopted Chroma, a GPU-based ray tracing program, to simulate light propagation in the Outer Detector. Chroma, along with being easily editable for new detector set ups, is much faster (~100-1000x) than running comparable CPU-based ray tracing in Geant4 simulations. This talk discusses the implementation of the required physics to generate muon Cherenkov photons with the correct optical properties and distributions for Chroma photon propagation.

[3086] (G*) The SNO+ Scintillator Fill (11:45, 15 minutes)

Presenter: TAM, Benjamin (Queen's University)

The SNO+ Experiment is a versatile multipurpose neutrino detector situated at SNOLAB, with the primary goal of searching for neutrinoless double beta decay. After a successful operating phase as a water Cherenkov detector, the SNO+ target medium was switched to a liquid scintillator to increase the light yield of the detector, thereby enabling a much richer physics programme. The filling of the SNO+ detector with 780 tonnes of liquid scintillator was recently completed. As with all low-background detectors, minimizing contaminants within the detector medium was of the utmost importance. To ensure radiopurity and improve optical properties, all of components were extensively purified before it was used to fill the detector. The scintillator purification techniques and early measurements of the liquid scintillator deployed within SNO+ will be presented.

[3224] Measuring inelasticity distribution of neutrino interactions between E_ν 100 GeV and 1 TeV with IceCube DeepCore (12:00, 15 minutes)

Presenter: LIUBARSKA, Maria (University of Alberta)

There is currently a lack of experimental measurements supporting model predictions of neutrino-nucleon differential cross section in the energy range between ~300 GeV - 1 TeV. Here we seek to expand this knowledge by measuring the inelasticity of these interactions with IceCube DeepCore. DeepCore is a densely packed sub-array inside the IceCube detector, which allows us to detect and reconstruct neutrinos with tens of GeV with greater precision. IceCube has previously measured inelasticity distribution at 1 TeV-100 TeV and with this analysis we aim to extend this range to lower energies to fill in the gap with accelerator measurements. We use a low-background sample of fully contained muon-neutrino charged current events to fit the shape of flux-averaged inelasticity distribution. In this contribution we will present the methods and the status of the analysis.

W1-4 Nuclear Structure (DNP) | Structure nucléaire (DPN) - MDCL 1110 (10:45 - 12:15)

-Conveners: Starosta, Krzysztof (SFU)

[3473] (I) First Evidence of Axial Shape Asymmetry and Shape Coexistence in 74Zn: Suggestion for a Northern Extension of the N=40 Island of Inversion (10:45, 30 minutes)

Presenter: ROCCHINI, Marco (University of Guelph)

Understanding nuclear structure near ^{78}Ni is crucial to infer how chemical elements originate in the Universe. State-of-the-art shell model calculations agree with observations from recent experiments regarding the persistence of the N=50 shell closure in neutron-rich nuclei. However, how collectivity manifests and evolves in this region of the Segrè chart is still an open question, particularly concerning phenomena such as vibrational modes, triaxiality and shape coexistence. This is especially true in the Zn isotopic chain in the neutron-rich region beyond the valley of stability, in which even definitive spin assignments are unavailable except for the very low-lying states. In this talk, I will present the results of a recent experiment performed at the TRIUMF laboratory (Vancouver, Canada) using the GRIFFIN gamma-ray spectrometer. The excited states of ^{74}Zn were investigated via gamma-ray spectroscopy following ^{74}Cu beta decay. By exploiting gamma-gamma angular correlation analysis, the 2_2^+, 3_1^+, 0_2^+ and 2_3^+ states in ^{74}Zn were firmly established. The gamma-ray branching and E2/M1 mixing ratios for transitions de-exciting the 2_2^+, 3_1^+ and 2_3^+ states were measured, allowing for the extraction of relative B(E2) values. In particular, the $2_3^+ \to 0_2^+$ and $2_3^+ \to 4_1^+$ transitions were observed for the first time. The levels observed were organized into rotational-like bands and the results compared with large-scale shell-model calculations from which the shapes of individual states were determined. Enhanced axial shape asymmetry (triaxiality) is suggested to characterize ^{74}Zn in its ground state. Furthermore, an excited K=0 band with a different shape is identified. A shore of the N=40 island of inversion appears to manifest above Z=28, previously thought as its northern limit in the nuclide chart.

[3342] (G*) Investigation of States Populated in the 102Ru(p,t) Two Neutron Transfer Reaction (11:15, 15 minutes)

Presenter: BUCK, Samantha (University of Guelph)

One of the foremost goals of nuclear physics is to provide an understanding of how nuclei are assembled from the basic constituent building blocks of protons and neutrons. Previous studies have attempted to achieve this by observing the excitations of nuclei under fine tuned experimental conditions with the most advanced detectors available on the planet. Nevertheless, this initiative continues to present as an extraordinarily non-trivial system to investigate. The experiment under discussion herein focuses on the study of 100Ru via a two-neutron transfer reaction experiment that was performed using the Q3D magnetic spectrograph at the Maier-Leibnitz Laboratory, in Garching, Germany, in 2019. The experimental procedure employed the use of a target of 102Ru which was bombarded with protons that would effectively pick-up two neutrons from said target, resulting in the production of 100Ru. Removing a pair of particles from the system affords the study the neutron-pair properties of the states that were observed in the reaction, which in turn renders a more robust understanding of the structure of 100Ru. Results of the analysis of this experiment will be discussed and their future significance will be highlighted.

[2987] Electromagnetic Transition Rate Studies in 28Mg (11:30, 15 minutes)

Presenter: Dr STAROSTA, Krzysztof (SFU)

Neutron rich Mg isotopes far from stability belong to the island of inversion, a region where the configuration of single-particle nucleon states becomes inverted with respect to the predicted ordering of the spherical shell model. Nuclei in this region also exhibit collective behaviour in which multiple particle interactions play a significant role in nuclear wavefunctions and transitions. This can be observed through electromagnetic transition rate measurements. In-beam reaction experiments performed at TRIUMF, Canada's particle accelerator centre, allow for precision measurements of nuclei far from stability. Using the TRIUMF-ISAC Gamma-Ray Escape Suppressed Spectrometer (TIGRESS), an array of high purity germanium detectors, in conjunction with the TIGRESS Integrated Plunger for charged particle detection, electromagnetic transition rates in nuclei far from stability can be precisely measured. This allows for the use of the well-understood electromagnetic interaction to probe nuclear wavefunctions and test theoretical models of the nuclear interaction. In this talk, I will discuss a fusion-evaporation experiment performed using TIGRESS and the TIGRESS Integrated Plunger to measure the lifetime of the first excited state in 28Mg. This experiment utilized both the Doppler Shift Attenuation Method and the Recoil Distance Method, which exploit the Doppler shift of gamma rays emitted in flight, in order to be sensitive to both short- and long-lived states in the nucleus. The current state of data analysis and the impacts on nuclear physics will be discussed.

[3028] (G*) Direct Population and Lifetime Measurement of the 2^+_1 State in ^{40}Ca via an Alpha-transfer Reaction (11:45, 15 minutes)

Presenter: WU, Frank (Tongan) (Simon Fraser University)

At TRIUMF, Canada’s particle accelerator centre, the TIGRESS Integrated Plunger (TIP) and its configurable detector systems have been used for charged-particle tagging and light-ion identification in Doppler-shift lifetime measurements using gamma-ray spectroscopy with the TIGRESS array of HPGe detectors. An experiment using these devices to measure the lifetime of the 2^+_1 state of ^{40}Ca has been performed by projecting an ^{36}Ar beam onto a $^\text{nat.}$C target. Analysis of the experimental gamma-ray spectra confirmed the direct population of the 2^+_1 state. Kinematics of the reaction mechanism was identified using Monte-Carlo simulations, which also enabled the use of charged-particle correlations to select reactions that populated a specific excited state in the ^{40}Ca immediately after its production. Selection of the 2^+_1 state with this additional sensitivity further eliminated feeding cascades, and therefore restricted the decay kinetics predominantly to first order. The current work is on expanding the simulation to incorporate the stopping of the ^{40}Ca and enabling the emission of gamma rays to provide a Doppler Shift Attenuation Method measurement of the lifetime of the 2^+_1 state in ^{40}Ca. Results of analysis of the experimental data and simulations will be presented and discussed.

[3221] (G*) Beam Development and Composition at TRIUMF with the TITAN MR-TOF Mass Spectrometer (12:00, 15 minutes)

Presenter: Mr WALLS, Coulter (TRIUMF, University of Manitoba)

For many rare isotope experiments it is important to know what isotopic species are being produced and their relative abundances. To this end, TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN) was used in the commissioning of a new proton-to-neutron (P2N) converter target at TRIUMF. To determine relative rates of species in the produced rare isotope beam the TITAN multi-reflection time-of-flight (MR-TOF) mass spectrometer was employed. The TITAN MR-TOF provided ratios of isobaric beam components at several target temperatures and proton intensities. Key to the success of this program is the excellent mass accuracy $(\frac{\delta m}{m}\sim 10^{-7})$, sensitivity and dynamic range (10^4-10^8) of the TITAN MR-TOF. The short measurement time of the TITAN MR-TOF for mass determination also allowed for several first time isotopic mass measurements. The TITAN MR-TOF has also been used for identifying and measuring rates of species in beam for an implantation experiment in collaboration with Lawerence Livermore National Lab (LLNL). This experiment aims to determine the half-life of the isotopic chronometer ^{146}Sm. TITAN was employed to measure and identify contaminants in the beam throughout the implantation, in the hopes of making an unambiguous measurement of the ^{146}Sm half-life and resolve experimental discrepancies in previous measurements.

W1-7 Non-Thermal Plasmas (DPP) | Plasmas non thermiques (DPP) - MDCL 1115 (10:45 - 12:15)

-Conveners: Reuter, Stephan (Polytechnique Montreal); Ahmad Hamdan

[3107] (I) Plasma assisted oxidation of H_2 mixtures: from physics to chemistry (10:45, 30 minutes)

Presenter: Dr SNOECKX, Ramses (King Abdullah University of Science and Technology (KAUST))

For the past decades, plasma technology has been widely investigated to advance energy and environmental applications. The main focus of this research revolves either around developing new or enhancing existing reforming, combustion, and remediation processes. Nevertheless, due to the complex physicochemical nature of non-thermal plasma's, most of the experimental findings still await a full understanding. Here, we present our recent progress in developing and validating a temperature dependent plasma-chemical kinetic model for H/O/N systems. Our aim is to establish a foundation for low-temperature plasma assisted ignition as well as high-temperature plasma catalysis and reforming processes. We performed an experimental and numerical study for the plasma assisted low-temperature oxidation of H_2 for undiluted H_2/O_2 mixtures. We employed a temperature controlled dielectric barrier discharge reactor and developed a reaction mechanism as well as a zero-dimensional plasma-chemical kinetic model (KAUSTKin). Through systematically varying the gas temperature and discharge power, we found non-linear oxidation behavior highlighting a Negative Temperature Coefficient (NTC)-like trend in the temperature range of $600 \leq T_g \leq 750$ K. The simulations could successfully attribute these observations to a combination of physical and chemical effects. The unexpected non-linear change in the breakdown voltage and subsequent reduced field (*E/N*) with varying temperature was the dominant contributor for the nonlinear oxidation characteristics; at the same time, both the O_3 and HO_2 chemistry played a key role. Our findings show the importance of both the plasma-physical characteristics and the subsequent plasma-chemical kinetics to properly predict plasma processes. Furthermore, the distinct effects of *E/N* and T_g on the chemistry highlight how electrical discharges provide two ways of controlling the plasma reactions; by affecting the electron induced chemistry (governed by the physical properties of the discharge) and the thermally induced chemistry, respectively. The outcome of this work will serve as a basic building block for future oxidation and reforming studies of CH_4 and higher hydrocarbons.

[3381] (I) Advanced plasma deposition of organosilicon thin films at atmospheric pressure for innovative eco-friendly devices: tuning the physical mode for different applications (11:15, 30 minutes)

Presenter: Dr PROFILI, Jacopo (Université Laval)

Today, many scientific studies made with eco-friendly composites have highlighted the potential to use cellulose- and bio-based materials in different advanced applications. Although these materials could replace oil-based flexible substrates in the next few years, their surface often need to be modified for stability/efficiency or tuning the final properties for a specific purpose. Among the different techniques, plasma processes at atmospheric pressure offers an eco-friendlier, more efficient, and scalable alternative to replace and/or complete classical wet-chemical methods often used in the industry. In this context, several research teams have already studied during the last 50 years plasma-surface interactions as well as the effect of different physical modes occurring at atmospheric pressure (i.e., Filamentary, Townsend, Glow-like, Streamer) on the growth mode and the proprieties of the plasma-treated surfaces. In this study, we report the fragmentation of organosilicon molecules by plasma at atmospheric pressure for different applications. By comparing the physical regimes of the plasma and their relate mechanisms of breakdown, we highlight the possibility to modify the growth mode and the plasma-surface interactions. Similar chemical precursors have been studied to understand the fragmentation processes and affect the final proprieties of the thin plasma-membranes. The obtained results highlight that the physico-chemical processes can be tuned controlling the regime of the ionized gases at atmospheric pressure depending on the intended application (i.e., electrochemical, anti-fog, ice-phobic, barrier). The influence of the substrate's properties, such as the micro- and nano-porosity and the roughness, are studied by SEM to better understand the growth mode of the membrane and the plasma-interface interactions. Organicity levels of the plasma membrane created on the materials in analyzed by ATR-FTIR and XPS.

[3404] (G*) Charaterization of aerosol-assisted low pressure plasma deposition processes (11:45, 15 minutes)

Presenter: SIMONNET, Claire

Plasma-enhanced chemical vapor deposition is widely studied for deposition of functional thin films. For some applications, multifunctionality is a pre-requisite, and this can be achieved using a number of methods, among which is aerosol-assisted plasma deposition. Using a injector-reactor, stable but volatile liquids can be injected and pulsed into the discharge, resulting in a time-dependent plasma. The impact of pulsing argon into a low-pressure argon RF plasma was recently studied by optical emission spectroscopy with regards to the time-resolved electron number density and temperature. The present study builds on these results and characterizes the physics of a low-pressure capacitive RF plasma process assisted by pentane aerosols formed by pulsed liquid injection. In particular, time-resolved line emission intensities, pressure, and self-bias voltage of the plasma are measured. Low-pressure aerosols are injected either as mist (0.01-0.1 mL/min), mist plus droplets (0.1-1 mL/min), or only droplets (1-3 mL/min). Results show that increasing the amount of aerosol injected either by increasing the pulse frequency (while keeping the amount of liquid injected during a pulse fixed) or the amount of liquid injected during a pulse (while keeping the pulse frequency fixed) influence differently the pressure increase and self-bias voltage during each pulse. Over the range of experimental conditions investigated, the deposition rate of CxHy coatings rises with the liquid injection rate. However, by correlating plasma deposition rates with detailed aerosol characterization obtained by light scattering, it is found that droplet size play a significant role in the plasma deposition dynamics.

[3403] (G*) Impact of NH3 consumption in a low frequency Ar-NH3 atmospheric pressure DBD (12:00, 15 minutes)

Presenter: ROBERT, Raphael (Université de Montréal / université de Perpignan via Domitia)

In atmospheric-pressure dielectric barrier discharges, it is well known that 2 regimes of non-equilibrium discharge can be reached, a filamentary one and a homogeneous one. In nominally pure Argon at "low frequency" (below some hundreds of kHz), the discharge is filamentary. For specifics processes, filaments are unwanted. Such filaments can be suppressed by reducing the breakdown voltage through the use of Penning mixtures. Homogeneous discharge is reached by adding a molecular gas with an ionization energy lower that the one of metastable of the atomic gas, metastable atoms could then ionize molecular gas, and so lower the breakdown voltage. For example, in argon, some hundreds of ppm of NH3 are sufficient to bring the discharge to a homogeneous regime. In this context, we realize that NH3 quantity in the Penning mixture is a key parameter in the operation of the discharge. The aim of this study is therefore to characterize the impact of NH3 consumption over the flow on a low or radio frequency Ar-NH3 atmospheric pressure DBD. It is important to notice that the NH3 is dissociated into the discharge: in the direction of the flow, there is therefore less NH3 at the end of the discharge than at the beginning. Through spaced-resolved emission spectroscopy along the gas flow and 1D fluid modeling, it appears that the electronic temperature varies only slightly and the NH emissions decreases along the gas flow lines. This is a signature of the decrease of NH3 concentration and hence the statement that Penning mixtures discharges evolve depending on the distance to the discharge entrance.

W1-9 Quantum Magnetism (DCMMP) | Magnétisme quantique (DPMCM) - MDCL 1010 (10:45 - 12:15)

-Conveners: Imai, Takashi (McMaster University)

[3211] (G*) Inverse Laplace transform of NMR spin-lattice relaxation data (10:45, 15 minutes)

Presenter: WANG, Jiaming

Traditional NMR data analysis techniques, such as the stretched exponential fit, are used to determine the sample-averaged nuclear spin-lattice relaxation rate $1/T_1$. However, they face difficulty when dealing with heterogeneous materials with NMR signals coming from distinct local environments, especially those with large, overlapping distributions of their Knight shifts and $1/T_1$. To overcome this, we perform inverse Laplace transform (ILT) to obtain the histogram $P(1/T_1)$ of the $1/T_1$ distribution from the nuclear spin recovery curve $M(t)$. We apply this technique to ^{63}Cu and ^{79}Br NQR data of kagome lattice materials herbertsmithite (ZnCu$_{3}$(OD)$_{6}$Cl$_2$) and Zn-barlowite (ZnCu$_{3}$(OD)$_{6}$FBr) as well as ^{19}F NMR data of the latter. From the ^{63}Cu data, we were able to use ILT to observe the gradual emergence of spin singlets with spatially varying excitation gaps below $\sim$30~K in both materials. We also performed ILT across the ^{19}F NMR spectrum to obtain 3-dimensional ILT-resolved NMR lineshapes, which allowed us to separate the signals coming from two distinct, overlapping sites. [1] J. Wang *et al.*, *Nat. Phys.* **17,** 1109–1113 (2021) [2] J. Wang, W Yuan *et al.*, *Phys. Rev. Lett.* (in press)

[3111] (G*) Dynamic and frozen quantum magnetism in the ground states of triangular lattice magnets YbMgGaO4, ErMgGaO4 and YbCoGaO4 from inelastic neutron scattering (11:00, 15 minutes)

Presenter: Ms HUANG, Symphony (Hsiao-Yuan) (McMaster University)

The putative quantum spin liquid (QSL) state exhibited by YbMgGaO$_4$ is largely ascribed to the quasi-2D triangular lattice which the magnetic Yb^{3+} moments decorate in concert with anisotropic exchange and disorder in neighbouring disordered Mg^{2+}/Ga^{3+} bilayers [1,2,3]. We present new inelastic neutron scattering (INS) measurements on YbMgGaO$_4$ as well as its isostructural sister compounds: ErMgGaO$_4$ and YbCoGaO$_4$. Each material was synthesized as a phase-pure powder and INS measurements were performed on IN6-Sharp with E$_i$ = 3.1 meV at the Institut Laue-Langevin. We discuss the observed hallmarks of a QSL in YbMgGaO$_4$ and contrast these with signatures of frozen spin correlations in each of ErMgGaO$_4$ and YbCoGaO$_4$ in the INS measurements. The case of YbCoGaO$_4$ is an interesting one as it displays the interplay between a QSL-like state associated with the Yb^{3+} magnetism, interleaved with a two-dimensional spin glass state originating from the disordered Co^{2+} magnetism. [1] Paddison, J., Daum, M., Mourigal, M. et al. Nature Phys 13, 117–122 (2017) [2] Li, Y., Adroja, D., Zhang, Q. et al. Phys. Rev. Lett. 118, 107202 (2017) [3] Zhu, Z., Maksimov, P. A., Chernyshev, A. L. et al. Phys. Rev. Lett. 119, 157201 (2017)

[3175] (G*) The case for a U(1)π Quantum Spin Liquid Ground State in the Dipole-Octupole Pyrochlore Ce2Zr2O7 (11:15, 15 minutes)

Presenter: SMITH, Evan (Department of Physics and Astronomy, McMaster University)

The Ce3+ pseudospin-½ degrees of freedom in the pyrochlore magnet Ce2Zr2O7 are known to possess dipole-octupole character, making it a candidate for novel quantum spin liquid ground states at low temperatures. We've measured the heat capacity of Ce2Zr2O7 and fit the result to a quantum numerical linked cluster (NLC) calculation that allows estimates for the terms in the near-neighbour XYZ Hamiltonian expected for such dipole-octupole pyrochlore systems. Fits of the same theory to the temperature dependence of the magnetic susceptibility and unpolarized neutron scattering complement this analysis to produce robust estimates of the near-neighbour exchange parameters. A comparison between the resulting best fit NLC calculation and new polarized neutron diffraction results shows agreement, as well as discrepancies which are attributed to interactions beyond near-neighbours, such as zone-boundary diffuse scattering in the non-spin flip channel. We conclude that Ce2Zr2O7 realizes a U(1)π quantum spin liquid state at low temperatures, and one that resides near the boundary between dipolar and octupolar character.

[3228] (G*) IDMRG study of the J-Gamma Ladder: Shy of a Bakers Dozen (11:30, 15 minutes)

Presenter: AVAKIAN, Sebastien (McMaster University)

Quantum spin liquids (QSLs) may roughly be defined as states possessing sufficiently high quantum fluctuations that they impede long range magnetic order. Various electron interactions are currently being studied in order to physically realize such states in condensed matter systems since they can host fractionalized excitations. The purpose of our study is to examine two interactions established as important in the literature while not having been paired together. We consider a bond-dependant J-Γ ladder, comprised of an alternating symmetric exchange of spin components, mediated by Γ, along with a Heisenberg interaction controlled by J. By parameterizing these couplings by an angle ϕ, we produce a phase diagram of the system using the Infinite Density Matrix Renormalization Group (IDMRG) numerical technique. In order to classify the phases, we search for discontinuities in the entanglement spectrum for bonds along one of the legs and the rungs of the ladder while also looking at divergences in the susceptibility of the energy. These criteria reveal 11 phases hosted by the system, with 9 of them showing some form of magnetic ordering seen directly from the spin correlations and by applying magnetic fields in appropriate directions. Moreover, known points in the phase diagram can be adiabatically connected to other points within the same phase by tuning J or Γ. The remaining two phases however show no obvious long-range magnetic order while also having large contributions to the entanglement spectrum. Such phases, showing interesting initial signs, are discussed further in our study.

[3194] (U*) Electrical Control of Magnetism in Kitaev Materials (11:45, 15 minutes)

Presenter: Mr HOWSON, Griffin (University of Windsor)

A fascinating class of frustrated magnetic systems are the so-called Kitaev materials, typically composed of heavy transition metals, that realize Kitaev's honeycomb model and its variants — exactly solvable models with quantum spin liquid ground states. Finding ways to control the competition between the spin liquid phase and the nearby magnetic phases is crucial in advancing our understanding of this exotic phase of matter. We explore the effect of strong magnetoelectric coupling exhibited by Kitaev materials on their magnetic phases. Using a classical approach, we map out the phase diagram as a function of combined electric and magnetic fields, through a combination of numerical algorithms and analytical techniques. For large, but finite systems, iterative minimization and simulated annealing algorithms are effective in obtaining the ground states. . Using these methods, we confirm that the classical Kitaev model spin liquid phase persists over a finite range of the magnetic field before entering the polarized phase. Conversely, applied electric fields immediately induce ordered ‘stripy’ states for generic field directions. To explore the possibility of incommensurate states, we employ the Luttinger-Tisza method and a single Q-ansatz. Results of the magnetic phase diagram under applied electric and magnetic fields, obtained via the above described methods, will be presented.

W1-8 Condensed Matter Theory I (DCMMP/DTP) | Théorie de la matière condensée I (DPMCM/DPT) - MDCL 1309 (10:45 - 12:15)

-Conveners: Di Matteo, Olivia (The University of British Columbia)

[3085] Eigenstate entanglement in integrable collective spin models (10:45, 15 minutes)

Presenter: Dr KUMARI, Meenu (Perimeter Institute for Theoretical Physics)

The characterization of integrability and chaos in quantum mechanics is a long-standing open problem. Entanglement is a strong candidate for this characterization but exactly how remains debatable. The average entanglement entropy (EE) of the energy eigenstates in non-vanishing partitions has been recently proposed as a diagnostic of integrability in quantum many-body systems. For it to be a faithful characterization of quantum integrability, it should distinguish quantum systems with a well-defined classical limit in the same way as the unequivocal classical integrability criteria. We examine the proposed diagnostic in the class of collective spin models characterized by permutation symmetry in the spins. The well-known Lipkin-Meshov-Glick (LMG) model is a paradigmatic integrable system in this class with a well-defined classical limit. Thus, this model is an excellent testbed for examining quantum integrability diagnostics. First, we calculate analytically the average EE of the Dicke basis in any non-vanishing bipartition, and show that in the thermodynamic limit, it converges to 1/2 of the maximal EE in the corresponding bipartition. Using finite-size scaling, we numerically demonstrate that the aforementioned average EE in the thermodynamic limit is universal for all parameter values of the LMG model. Our analysis illustrates how the value of the average EE in the thermodynamic limit may be a robust criteria for identifying integrability.

[3106] Quantum computing fidelity susceptibility using automatic differentiation (11:00, 15 minutes)

Presenter: DI MATTEO, Olivia (The University of British Columbia)

Fidelity susceptibility is a physical quantity that can be used to study quantum phase transitions in a variety of condensed matter models. The closed-form expression of this quantity requires knowledge of the energy spectrum of a Hamiltonian; however it has been previously shown that it can also be computed from second-order derivatives of overlaps involving the ground state wave function. We show how such a calculation can be performed using variational quantum algorithms and quantum differentiable programming. Automatic differentiation is leveraged to compute the required energy and overlap derivatives directly from the results of quantum circuits, running on simulators or hardware, that have been trained to prepare the ground state of the system. We study a small case, using the transverse-field Ising model, and outline the viability and challenges that arise when solving this problem on near-term quantum hardware.

[3114] Hyperbolic Matter in Electrical Circuits with Tunable Complex Phases (11:15, 15 minutes)

Presenter: Prof. BOETTCHER, Igor (University of Alberta)

We introduce the theory of hyperbolic matter, a novel paradigm for topological states made from particles moving in the infinite two-dimensional hyperbolic plane. Negative curvature of space is emulated through a hyperbolic lattice. Utilizing topoelectric circuit networks relying on a newly developed complex-phase circuit element, we experimentally realize hyperbolic graphene as an example of topologically nontrivial hyperbolic matter and compare measurements of Dirac particles and Berry curvature to hyperbolic band theory.

[3144] Computing excitations in a matrix product state with block Lanczos (11:30, 15 minutes)

Presenter: BAKER, Thomas

Matrix product state methods are known to be efficient for computing ground states of local, gapped Hamiltonians, particularly in one dimension. We introduce the multi-targeted method that acts on a bundled matrix product state, holding many excitations. The use of a block or banded Lanczos algorithm allows for the simultaneous, variational optimization of the bundle of excitations. The method is demonstrated on a Heisenberg model and other cases of interest. A large number of excitations can be obtained at a small bond dimension with highly reliable local observables throughout the chain. Applications to several models and other cases are also discussed.

[3007] (G*) Relaxation of non-integrable systems and correlation functions (11:45, 15 minutes)

Presenter: RIDDELL, Jonathon (McMaster University)

We investigate early-time equilibration rates of observables in closed many-body quantum systems and compare them to those of two correlation functions, first introduced by Kubo and Srednicki. We explore whether these different rates coincide at a universal value that sets the timescales of processes at a finite energy density. We find evidence for this coincidence when the initial conditions are sufficiently generic, or typical.

[3112] (G*) Atomic insights into the lattice dynamics driving the relaxation of charged defects (12:00, 15 minutes)

Presenter: YUAN, Shuaishuai (Division of Materials Engineering, Faculty of Engineering, McGill University)

Electron-driven lattice rearrangements commonly exist in phenomena such as electron/hole transfer, defect ionization, photoexcitation, and polaron formation. These phenomena are manifested in a variety of important technologies employing energy harvesting and conversion materials. Hence, lattice equilibration processes at the atomic scale need to be more deeply understood in order to tailor the physical properties of such materials. In this work [1], we adopt the F$^+$-center in NaCl as a model system and study its femtosecond-resolved lattice dynamics driven by charge localization changes. Our results reveal that the excess energy is imparted amongst the highest optical phonon modes with no clear localization preference. The overall phonon decay trends are found to be largely exponential in the temporal domain and the corresponding phonon lifetimes are shown to be temperature dependent. The lifetimes of the local kinetic energy (decaying near the defect in real space) have a different timescale and display less variation at non-cryogenic temperatures. Moreover, a phenomenological first-order analytical model based on Langevin dynamics is provided to interpret the exponential decay trend of the phonon modes in the temporal domain and a first-order quantum rate mode is applied to interpret the temperature dependency of the phonon lifetime. In addition, this work also provides technical contributions in terms of showing the limitations caused by supercell size effects and the challenge posed by the extensive statistical sampling needed to reach convergent trends in lattice dissipation calculations. The calculation procedure and analysis methods in this work are transferable to study such formation dynamics in defects from first-principles. In general, the findings demonstrate how the charged-center dynamics may play a crucial role in the performance of many energy materials. [1] Yuan, S., Kantorovich, L., Shluger, A. L. & Bevan, K. H. Atomistic insight into the formation dynamics of charged point defects: A classical molecular dynamics study of F$^+$-centers in NaCl. Phys. Rev. Mater. 6, 15404 (2022).

W1-2 Quantum Theory (DTP) | Théorie quantique (DPT) - MDCL 1008 (10:45 - 12:15)

-Conveners: Randy Lewis

[3118] (I) Quantum Foundations Meets Causal Inference (10:45, 30 minutes)

Presenter: SPEKKENS, Robert (Perimeter Institute for Theoretical Physics)

Can the effectiveness of a medical treatment be determined without the expense of a randomized controlled trial? Can the impact of a new policy be disentangled from other factors that happen to vary at the same time? Questions such as these are the purview of the field of causal inference, a general-purpose science of cause and effect, applicable in domains ranging from epidemiology to economics. Researchers in this field seek in particular to find techniques for extracting causal conclusions from statistical data. Meanwhile, one of the most significant results in the foundations of quantum theory—Bell's theorem—can also be understood as an attempt to disentangle correlation and causation. Recently, it has been recognized that Bell's 1964 result is an early foray into the field of causal inference and that the insights derived from almost 60 years of research on his theorem can supplement and improve upon state-of-the-art causal inference techniques. In the other direction, the conceptual framework developed by causal inference researchers provides a fruitful new perspective on what could possibly count as a satisfactory causal explanation of the quantum correlations observed in Bell experiments. Efforts to elaborate upon these connections have led to an exciting flow of techniques and insights across the disciplinary divide. This talk will explore what is happening at the intersection of these two fields.

[3226] (G*) Locality in quasi-Hermitian quantum theory (11:15, 15 minutes)

Presenter: BARNETT, Jacob

Quasi-Hermitian quantum theory generalizes quantum theory while preserving unitarity and the reality of expectation values. Unitarity is defined with respect to a new inner product, associated to a positive definite operator referred to as the metric. In general, the metric operator can be an entangled operator. Thus, it's natural to ask whether quasi-Hermitian systems with a notion of locality have nontrivial physics. Due to entanglement, quantum theories contain correlations not present in classical systems. The value of nonlocal games is used to quantify the strength of such correlations. As an example, the Bell inequality can be realized as the classical value of the CHSH game. We demonstrate quasi-Hermiticity can not increase the value of a nonlocal game.

[3303] (U*) Non-perturbative Extraction of Tripartite Vacuum Entanglement (11:30, 15 minutes)

Presenter: MENDEZ AVALOS, Diana

Entanglement harvesting – the process of entangling qubits by extracting vacuum entanglement from a quantum field – provides information about the structure of the quantum vacuum. While there has been much work done on harvesting bipartite entanglement, the multipartite structure of the vacuum has received virtually no attention. Here I report on the first results of an investigation of non-perturbative harvesting of tripartite entanglement. I consider a set of three 2-level Unruh-DeWitt detectors (qubits), each strongly interacting with a scalar field in (3+1)-dimensional Minkowski space-time for a short interval (modelled with Dirac delta-functions), and compute the reduced density matrix for this system after interaction. Placing the detectors in both triangular and linear configurations, the resulting entanglement is computed from the π-tangle for each. We find, for any configuration, that a substantial amount of entanglement can be harvested if each detector interacts just once. This stands in strong contrast to the bipartite case, where it is necessary for at least one detector to interact more than once. I discuss the implications of these results for how information is sent and received via quantum fields.

[3338] (G*) Channel capacity of relativistic quantum communication with rapid interaction (11:45, 15 minutes)

Presenter: GALLOCK YOSHIMURA, Kensuke

We study nonperturbatively the transmission of classical and quantum information in globally hyperbolic spacetimes, where the communication channel is between two qubit detectors interacting with a quantized massless scalar field via delta-coupling interaction. This interaction approximates very rapid detector-field interaction, effectively occurring at a single instant in time for each detector. We show that when both detectors interact via delta-coupling, one can arrange and tune the detectors so that the channel capacity is (at least) as good as the quantum channel constructed nonperturbatively using gapless detectors. Furthermore, we prove that this channel capacity is in fact optimal, i.e., both nonperturbative methods give essentially the same channel capacity, thus there is a sense in which the two methods can be regarded as equivalent as far as relativistic quantum communication is concerned.

[3314] (G*) Variationally Scheduled Quantum Simulation (12:00, 15 minutes)

Presenter: BUCK, Samantha (University of Guelph)

Eigenstate preparation is ubiquitous in quantum computing, and a standard approach for generating the lowest-energy states of a given system is by employing adiabatic state preparation (ASP). In the present work, we investigate a variational method for determining the optimal scheduling procedure within the context of ASP. In the absence of quantum error correction, running a quantum device for any meaningful amount of time causes a system to become susceptible to the loss of relevant information. Therefore, if accurate quantum states are to be successfully generated, it is crucial to find techniques that shorten the time of individual runs during iterations of annealing. We demonstrate our variational method toward this end by investigating the hydrogen and P4 molecules, as well as the Ising model problem on a two-dimensional triangular lattice. In both cases, the time required for one iteration to produce accurate results is reduced by several orders of magnitude in comparison to what is achievable via standard ASP. The significant shortening of the required time is achieved by using excited states partially during ASP. As a result, the required quantum coherence time to perform such a calculation on a quantum device becomes much less stringent with the implementation of this algorithm. In addition, our variational method is found to exhibit resilience against control errors, which are commonly encountered within the realm of quantum computing.

W1-3 Optical Tools (DAMOPC/DPMB) | Outils optiques (DAMOPC/DPMB) - MDCL 1102 (10:45 - 12:15)

-Conveners: Ozzy Mermut; Jens Lassen

[3377] (I) Monitoring Humulone Isomerization Using Raman Spectroscopy: A Bitter Problem in the Microbrewing Industry (10:45, 30 minutes)

Presenter: WHELAN, William M. (University of Prince Edward Island)

Raman Spectroscopy is being explored to improve the characterization of beer bitterness which is derived primarily from the addition of the annual flowers (cones) of the perennial climbing vine Humulus lupulus (common hops). The hops cones contain humulones which are thermally isomerized into isohumulones during the brewing process. The isohumulones are highly bitter and contribute to the beer's flavour profile. Despite significant contributions to beer flavour and quality, humulone isomerization is not typically monitored in microbreweries because of the associated high cost. Raman spectroscopy probes molecular vibrations and, as such, is a potential low-cost analytical tool for the identification and quantification of specific molecules of interest in plants and food. In this work, the humulone isomerization process was mimicked using mixtures of pure humulone and isohumulone extracts, from 0% isomerization (i.e. pure humulone) to 100% isomerization (i.e. pure isohumulone).The Raman spectroscopy system consisted of an 830 nm laser (B&W Tek) coupled to a filtered fiber-optic probe (InPhotonics) and a spectrometer (Andor Technology) coupled to a deep-depletion

CCD detector (Princeton Instruments). Two univariate methods for monitoring humulone isomerization were examined. In the first method, the integrated Raman peak intensity ratio 345-500cm-1/1668cm-1 decreased linearly with increased percent isomerization. In the second method, a continuous Raman peak shift from 624 cm-1 to 609 cm-1 was observed as the percent isomerization increased. Results are also compared to simulated Raman spectra for humulones and isohumulones obtained using density functional theory. The results demonstrate the ability of Raman spectroscopy to detect different concentrations of isohumulones in the presence of humulones under ideal conditions. The next step is to measure the thermal isomerization of humulone samples. The overall goal of this research is to develop a field-ready, cost-effective Raman spectroscopy technique for monitoring and optimizing beer flavour and quality.

[3078] (G*) Rapid Detection of Bacterial Pathogens in Water and Clinical Specimens Using Laser-Induced Breakdown Spectroscopy (11:15, 15 minutes)

Presenter: BLANCHETTE, Emma (University of Windsor)

Our lab is developing laser-induced breakdown spectroscopy (LIBS) as a method to rapidly diagnose bacterial infections. Rapid diagnosis of bacterial infections would improve clinical response times, reduce the overuse of broad-spectrum antibiotic drugs, and improve patient outcomes. LIBS is a spectrochemical technique that can rapidly identify the elemental composition of a specimen. The specimen is ablated with an intense laser pulse in order to create a micro plasma. Light is collected from the cooling plasma and dispersed by a high-resolution Echelle spectrometer to create a high signal-to-noise time-resolved optical emission spectrum. The optical emission spectrum from an ablated target which contains bacterial cells is dominated by emission lines from several inorganic elements including calcium, magnesium, phosphorus, and sodium. Currently, we deposit bacterial cells onto nitrocellulose filter media by centrifuging bacterial suspensions through a custom fabricated concentration device to achieve a thin film of bacteria. Using our method of deposition, spectra from five species of bacteria have been acquired: *Staphylococcus epidermidis*, *Escherichia coli*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, and *Enterobacter cloacae*. As well, spectra from the blank filter media, sterile water, and sterile clinical specimens including blood and urine have been collected. This presentation will detail our efforts to optimize chemometric algorithms, specifically partial least-squares discriminant analysis (PLSDA), to reliably detect the presence of bacterial pathogens in sterile fluids. Reliable and accurate discrimination has been achieved between bacteria and sterile water, and the sensitivity and specificity for this discrimination will be discussed. This presentation will also detail our efforts to characterize sterile clinical specimens such as blood and urine using LIBS and our efforts to detect bacteria in these sterile specimens. PLSDA is used to classify between sterile clinical specimens and those containing bacteria. The accuracy of bacterial detection in these sterile bodily fluids will be discussed.

[3351] (G*) A novel optical filter-based Raman system operating in strong ambient light for in vivo clinical applications (11:30, 15 minutes)

Presenter: Mr GUO, Hao (Dalhousie University)

A portable optical system and methods have been developed for real-time synchronous detection of vibration and rotation modes in biotic systems. It consists of a modulated light source, laser beam shaping and light collecting optics, optical detectors, appropriately selected optical filters, a laser beam modulator, current-to-voltage converters, and lock-in amplifiers. The weak signal of characteristic Raman scattering peaks of glycerides is identified using the sensitive lock-in amplification technique, which supersedes the state-of-the-art for other similar approaches and allows for the detection of weak Raman signals in ambient LED and luminescent light conditions. Parallel measurements of duck fat phantoms and duck liver samples using an FT-Raman spectrometer and our handheld probe indicate that our system can provide a quantitative result on the fat content quickly and accurately in lipid phantoms and liver samples, demonstrating a strong linear correlation ($r^{2} >0.97$) between intensities of output voltage signals, MRI readings, and fat contents in the clinically relevant range (20%-60%) with a sensitivity of 16.75μV / 1% change in fat content, though the handheld probe is 10-fold cheaper than an FT-Raman system. An accurate real-time assessment of donor liver fat contents is hopeful to be achieved during organ procurement surgeries, which is crucial in predicting liver graft post-transplant dysfunction risks. Features of this device now need to be further evaluated by studying ex-situ and in-situ human livers.

[3316] (G*) Using synchrotron radiation techniques as a tool in invertebrate paleontology (11:45, 15 minutes)

Presenter: Mr MITCHELL, Jerit (Physics Department, University of Regina.)

Over the past decade there has been a revolution in the methods that paleontologists use to analyze the remains of organisms that lived millions of years ago. Using the exceptional brightness of synchrotron light it is now possible to analyze bones and fossil insects in better detail than ever before, as well as provide new technical methods for research. While fossil vertebrates like dinosaurs can be studied famously from their skeletons, invertebrates and their preservation are an integral subset of paleontology. Insects are best preserved when they are trapped in sticky tree resin, which hardens and forms amber over millions of years. The insect is preserved in life-like 3-D position as the amber acts as a shield from outside environmental factors. Fossilization is a rare process. Rarer still are organic signatures that preserve past a million years. Organic material has the potential to reveal more than mineralized inorganic remnants alone. Findings can help paleontologists peer into the past and make inferences on not only the evolution of organisms, but the evolution of planet Earth itself. In this talk I will discuss some of the work I have done analyzing fossil insects included in amber. A focus will be on a leaf beetle from the Eocene epoch (~44 Mya) that appears to have preservation of the organic substance chitin, one of the main components of insect exoskeletons. Synchrotron-based techniques used in the investigation include imaging and chemical analysis: Computed Tomography (μ-CT), Fourier Transform Infrared Spectroscopy (FTIR), and X-Ray Fluorescence micro-probe (μ-XRF) mapping. I will explain the physical principles of these various methods and how they are used to extract paleontological information from fossil insects.

time	[id] title	presenter
12:00	discussion & speaker Q&A; (15 minutes)	

Student Lunch Session │ Dîner-rencontre des étudiants - MDCL 1305/07 (12:15 - 13:15)

Break for Lunch (12h15-13h15) | Pause pour dîner (12h15-13h15) - MDCL Hallways (12:15 - 13:15)

New Faculty Lunch Meeting with NSERC | Dîner rencontre des nouveaux professeurs avec le CRSNG - MDCL 2230 (12:15 - 13:15)

-Conveners: Rangan, Chitra (University of Windsor)

W2-6 Neutrino Experiment and Related Calibrations II (PPD) | Expériences de neutrinos et calibration reliée II (PPD) - MDCL 1105 (13:15 - 14:45)

-Conveners: Nahee Park

[3362] (G*) Spatially resolved laser scanning for the performance characterization of silicon photomultipliers (13:15, 15 minutes)

Presenter: GINGRAS, Chloe

The nEXO experiment is a planned tonne-scale search for neutrinoless double beta decay (0$\nu\beta\beta$) in ^{136}Xe. In a single-phase liquid xenon time-projection chamber, ionization electrons and scintillation light will be recorded to reconstruct, among other parameters, the deposited energy of an event. Silicon Photomultipliers (SiPMs) have been chosen by the nEXO collaboration to record the scintillation light. SiPMs will be assembled into larger modules of hundreds of cm^2 to cover a total of 4.5 m^2. Testing the large number of SiPM modules at operating temperatures of about -100°C will require an automated approach and high throughput of SiPMs to be done in a reasonable timescale for nEXO. A precision scanning mechanism has been developed to systematically scan a spatially resolved laser beam across the surface of a SiPM module at cryogenic temperature. This Optical Rail System (ORS) has been designed and constructed to move the laser beam in 2D in order to scan the SiPM modules and study their response. The status of the ORS and its capabilities, such as spatial resolution and beam position mapping, will be presented, and future plans will be discussed.

[3331] (G*) Characterization of VUV sensitive silicon photomultipliers (13:30, 15 minutes)

Presenter: CHANA, Bindiya

Silicon photomultipliers (SiPMs) are emerging as the photodetector technology to be used in upcoming noble liquid experiments. Features that make SiPMs an ideal candidate to detect light signals include their compact size, insensitivity to magnetic field, high gain, low operating voltage, low dark noise rate and sensitivity to single photon counting. Newly developed SiPMs sensitive to vacuum ultraviolet (VUV) light will be directly used for the readout of scintillation photons (λ = 175nm) from liquid xenon in future tonne-scale experiments such as nEXO searching for neutrinoless double beta decay in 136Xe. The primary goal of this research project is to characterize the VUV-SiPMs using current-voltage (IV) and pulse-level measurements. These data are analysed to extract the SiPM's features like breakdown voltage, gain, crosstalk, afterpulsing, dark noise rate and photon detection efficiency. In this talk, the results from IV curve-based and pulse-level characterisation of SiPMs from two different vendors over a range of temperatures will be presented.

[3236] (G*) Improving the Super-Kamiokande systematics uncertainties by characterizing single PMT response at the photosensor test facility (13:45, 15 minutes)

Presenter: GOUSY-LEBLANC, Vincent

The Super-Kamiokande (Super-K) is a neutrino detector in Japan that aims to study neutrino sources (atmospheric, solar, supernovae), search for proton decay, measure neutrino oscillation and accelerator neutrinos. It contains ~11,000 photomultiplier tubes (PMTs) surrounding a massive tank filled with 50 ktons of ultra-pure water. One of the limiting factors for more measurements of neutrino properties (such as δCP and the neutrino mass hierarchy) and for the sensitivity of higher statistics, larger experiments such as Hyper-Kamiokande are the systematic uncertainties of the detector which is currently around 3% for Super-K. One of the potential sources of systematic uncertainty is our understanding of the PMTs individual responses to external variables such as the magnetic field and the angle of the incident light . Hence, precise measurements and characterization of the PMTs are required to reduce the uncertainty. The photosensor test facility (PTF, at TRIUMF) was recommissioned and improved to measure very precisely the variations of the PMT response in respect to the magnetic field, the polarization, the incident angle, position and the photon energy, all variables that are mixed together in the experiment. These measurements can then be integrated into the Super-K large scale simulation to decrease their contribution to the systematic uncertainty. During this talk, I will present the work done to rebuild the facility, some of the improvements done on the software and hardware along with preliminary measurements and their application to simulations

[3116] (G*) Cryogenic Distillation for Xe Isotopic Enrichment (14:00, 15 minutes)

Presenter: EMARA, Abo-bakr

Neutrinoless double beta decay (NLDBD) is one of the most important searches in particle physics nowadays. If discovered, it may help to answer some of the unanswered questions in physics, shedding light on the neutrino masses and helping explain the origin of matter in the universe. One of the most promising isotopes to search for NLDBD is 136Xe. The only existing method in the market for enrichment of xenon is centrifugation. Cryogenic distillation is a proposed alternative that depends on the relative vapour pressure of the different xenon isotopes. This talk presents the first reliable measurement of the xenon vapour pressure differences performed with a 1.8-m tall distillation still at Carleton University, and the ongoing work with an eightfold taller still at SNOLAB in Sudbury, Ontario.

[3273] Measuring light distribution of LED sources for Hyper-Kamiokande detector calibration (14:30, 15 minutes)

Presenter: Mr BOOTH, Nicholas (TRIUMF)

The Hyper-Kamiokande experiment uses water-Cherenkov detectors to study neutrino oscillation and CP violation with high precision. To reduce systematic errors, multi-photomultiplier tube modules (mPMTs) that comprise the detectors will include LED light sources for calibration purposes. This talk describes how the LEDs are incorporated into mPMT design, how the distribution of LED light is measured, and discusses how the LEDs will be used for the experiment calibration upon detector completion.

W2-9 Fluids and Granular Matter (DCMMP) | Fluides et matière granulaire (DPMCM) - MDCL 1010 (13:15 - 14:45)

-Conveners: Denniston, Colin (University of Western Ontario)

[3421] (I) The hydrodynamics of active matter in inhomogeneous environments (13:15, 30 minutes)

Presenter: ELFRING, Gwynn (University of British Columbia)

Active matter is a term used to describe matter that is composed of a large number of self-propelled active 'particles' that individually convert stored or ambient energy into systematic motion. Examples include a flock of birds, a school of fish, or at smaller scales a suspension of bacteria or even the collective motion within a human cell. When viewed collectively, active matter is an out-of-equilibrium material. This talk focuses on active matter systems where the active particles are very small, for example bacteria or chemically active colloidal particles, such that the inertia of the particles and the fluid flows that they generate is negligible. The motion of small active particles in homogeneous Newtonian fluids has received considerable attention, with interest ranging from phoretic propulsion to biological locomotion, whereas studies on active bodies immersed in inhomogeneous fluids are comparatively scarce. In this talk I will show how the dynamics of active particles can be dramatically altered by the introduction of fluid inhomogeneity, and discuss the effects of spatial variations of fluid density, viscosity, and other fluid complexity in the context of biological locomotion. **Bio:** Gwynn Elfring is an Associate Professor in the Department of Mechanical Engineering and the Institute of Applied Mathematics at the University of British Columbia. His group at UBC conducts research on the fluid mechanics of soft matter systems, including cell locomotion, the mechanics of (active) suspensions, interfacial and membrane rheology, and non-Newtonian flow physics. Previously, he completed a Ph.D. at the University of California San Diego under the supervision of Eric Lauga and postdoctoral studies with L. Gary Leal and Todd M. Squires at the University of California Santa Barbara and was recently a Visiting Associate at the California Institute of Technology.

[3208] (G*) Colloidal suspensions near the fluid phase interface of coupled Lattice-Boltzmann and molecular-dynamics simulations (13:45, 15 minutes)

Presenter: CRESTA, Daniel

Lattice-Boltzmann (LB) simulations have been used extensively over the past several decades in the study of hydrodynamics. With computational power increasing, LB methods have been coupled with various molecular dynamics (MD) methods to better simulate complex fluids, phase transitions, and their behaviour at interfaces. Using a modified LB package from the Large-Scale Atomic/Molecular Massively Parallel Simulator (LAMMPS), we couple colloidal particles and the LB fluid mesh under critical conditions to investigate particle dynamics at and near the liquid-gas interface due to variable wetting potentials. This work is preliminary to studying interfacial behaviour of complex fluid suspensions in LAMMPS, such as that of a liquid crystal (LC) colloid suspension, where distinct defect patterns are known to emerge at the LC-gas interface at equilibrium. We expect these defects to disturb the uniformity of the colloidal suspension.

[3003] (G*) The Pendant Drop Experiment for Aggregates of Adhesive Granular Particles (14:00, 15 minutes)

Presenter: Mrs HESHMATZADEH, Yasaman (McMaster University)

There is interest in reproducing macroscopic continuous matter experiments with granular systems to predict their properties and explore the analogues between granular and continuum systems. The classic pendant drop experiment can be used to measure interfacial tension in liquids. Here we prepare a granular ‘liquid’, consisting of adhesive, frictionless, monodisperse oil droplets in an aqueous solution, and perform a pendant drop experiment to determine the effective surface tension of the granular liquid. We tune parameters such as the buoyancy and the adhesion between the granular particles and present a simple model to predict the ‘granular surface tension’.

[3018] (G*) Coiling and Buckling Instabilities in Moving Chains of Droplets (14:15, 15 minutes)

Presenter: LEE, Carmen

We produce a chain of microscopic monodisperse droplets in an aqueous bath, which rises due to the buoyancy of the droplets. There is an attractive interaction between the droplets and if the droplets are produced quickly, such that one droplet is produced and contacts the next, they adhere. Producing many droplets in this fashion allows us to create a chain of sticky droplets. Tuning the rate of droplet production results in coiling and buckling instabilities in the rising chain as it moves through the aqueous bath and eventually hits a static interface.

[3302] (G*) Dynamic properties of a 2D granular analogue of a liquid puddle predicted through a ‘granular capillary length’ (14:30, 15 minutes)

Presenter: HOGGARTH, Johnathan

The structure of an accumulation of granular material, such as a pile of sand, can be characterized by the angle of repose, which is dependent on the balance between gravity and inter-grain friction. In contrast, for the case of a continuum material like a simple liquid, the height of a puddle is dictated by the capillary length which balances gravity and surface tension. Here we present an experiment of a 2D pile of monodisperse microscopic oil droplets. The droplets are buoyant, adhesive, and friction is negligible. Oil droplets are deposited within a chamber and accumulate at a barrier under the influence of buoyancy. In our experiments, the structure of the pile determined by a balance between buoyant and adhesive forces, reminiscent of the spreading of a liquid puddle, even though the pile is granular and 2D in nature. We define a parameter that can describe the structure of the piles, the ‘granular capillary length’, analogous to the capillary length in liquids. Additionally, as droplets are being added to the pile, collapsing events occur which spread the material across the barrier. The frequency of the collapses is a function of the defined granular capillary length.

W2-8 Condensed matter theory II (DCMMP/DTP) | Théorie de la matière condensée II (DPMCM/DPT) - MDCL 1309 (13:15 - 14:45)

-Conveners: Tamar Pereg-Barnea

[3160] (G*) Artificial electric field and electron hydrodynamics (13:15, 15 minutes)

Presenter: TAVAKOL, Omid

In the electron dynamics in quantum matter, the Berry curvature of the electronic wave function provides the artificial magnetic field in momentum space, which leads to nontrivial contributions to transport coefficients. It is known that in the presence of electron-electron and/or electron-phonon interactions, there is an extra contribution to the electron dynamics due to the artificial electric field (AEF) in the momentum space. In this work, we construct hydrodynamic equations for the electrons in time-reversal invariant but inversion-breaking systems and find the novel hydrodynamic coefficients related to the AEF. Furthermore, we investigate the novel linear and nonlinear transport coefficients in the presence of the AEF.

[3339] Fractonic quantum phases in breathing pyrochlore lattice (13:30, 15 minutes)

Presenter: HAN, SangEun (University of Toronto)

Fractonic phases of matter are characterized as possessing unusual mobility restricted quasiparticle excitations, and a ground state degeneracy that is sub-extensive and geometry dependent. While there exist a number of exactly solvable models with interactions between multiple particles/spins, the realization of such models in real materials is extremely challenging. In this talk, we investigate a realistic novel fractonic phase of matter that arises from a quantum model of quadratic spin interaction on the breathing pyrochlore lattice. Using membrane operators, we demonstrate the existence of a sub-extensive ground state degeneracy explicitly depending on the lattice geometry. This work provides a natural and realistic scenario to realize such exotic phases of matter, and a promising foundation for future theoretical and experimental investigations. [arXiv:2109.03835]

[3057] Thermal Conductivity of Square Ice (13:45, 15 minutes)

Presenter: RAU, Jeffrey

We investigate thermal transport in square ice, a two-dimensional analogue of spin ice, exploring the role played by emergent magnetic monopoles in transporting energy. Using kinetic Monte Carlo simulations based on energy preserving extensions of single-spin-flip dynamics, we explicitly compute the (longitudinal) thermal conductivity, κ, over a broad range of temperatures. We use two methods to determine κ: a measurement of the energy current between thermal baths at the boundaries, and the Green-Kubo formula, yielding quantitatively consistent values for the thermal conductivity. We interpret these results in terms of transport of energy by diffusion of magnetic monopoles. We relate the thermal diffusivity, κ/C where C is the heat capacity, to the diffusion constant of an isolated monopole, showing that the subdiffusive monopole implies κ/C vanishes at zero temperature. Finally, we discuss the implications of these results for thermal transport in three-dimensional spin ice, in spin ice materials such as $Dy_2Ti_2O_7$ and $Ho_2Ti_2O_7$, and outline some open questions for thermal transport in highly frustrated magnets.

[3292] Self-consistent study of topological superconductivity in quasicrystals (14:00, 15 minutes)

Presenter: Prof. TANAKA, K. (University of Saskatchewan)

Quasicrystals are emerging topological materials which have aperiodic long-range order and higher-dimensional symmetry, with peculiar rotational symmetry that is forbidden by crystallography. Motivated by the recent discovery of superconductivity in a quasicrystal, we study topological superconductivity (TSC) with broken time-reversal symmetry in two-dimensional quasicrystals. By solving the Bogoliubov-de Gennes equations self-consistently, we show the stable occurrence of TSC in quasicrystals whose topological nature is signified by the Bott index. We confirm the appearance of Majorana zero modes in accordance with the bulk-edge correspondence when the Bott index is nonzero. Furthermore, the effects of self-similarity and fractal structure inherent in quasicrystals and their possible interplay with TSC are examined.

[3049] Magnetic-field Induced Topological Transitions and Thermal Conductivity in a Generalized Kitaev Model (14:15, 15 minutes)

Presenter: LI, Heqiu

Recent experiments on Kitaev spin liquid candidate materials reported non-monotonic behavior of thermal conductivity as a function of magnetic field, which lead to conflicting interpretations of its origin. Motivated by this development, we study the magnetic field dependence of thermal conductivity of a generalized Kitaev model, which allows the phase transitions between different flux sectors as a function of the magnetic field. The thermal conductivity due to Majorana fermions shows dip-bump structures as the magnetic field increases, which is caused by either the transitions between different flux sectors of Kitaev spin liquids or the topological transitions that change the Majorana Chern number within the same flux sector. It is shown that the change of Chern number is closely related to the four-Majorana-fermion interaction induced by the magnetic field. The non-monotonic behavior in thermal conductivity emerges at finite temperature, and it becomes weaker when temperature decreases towards zero. Our model provides a generic mechanism for the Kitaev spin liquids to develop non-monotonic magnetic-field dependence of thermal conductivity while the comparison to realistic materials remains an open question for future investigation.

W2-7 Plasma-Matter interactions (DPP) | Interactions plasma-matière (DPP) - MDCL 1115 (13:15 - 14:45)

-Conveners: Reuter, Stephan (Polytechnique Montreal); Ahmad Hamdan

[3450] (I) Plasma Immersion Ion Implantation: Physics & Applications (13:15, 30 minutes)

Presenter: BRADLEY, Michael

Many materials science applications require high fluence ion implantation. Plasma Immersion Ion Implantation (PIII) is a technique in which the target to be implanted is immersed in the plasma, and implanted using negative-polarity high-voltage pulses. PIII has many applications including advanced semiconductor processing [1], photonic devices [2-3], ion implantation of advanced materials such as graphene [4], corrosion inhibition of metals [5], and most recently, studies of ion bombardment of plasma-facing components for plasma fusion applications. PIII has the advantage that very high ion fluences can be implanted over large area targets, without the beam scanning and complicated target mounts required for conventional beamline ion implantation. The PIII process involves complex physics which requires detailed study as the technology is further developed as a materials processing tool. This talk will discuss the PIII method in detail and highlight some important aspects of the underlying physics. which are being further developed in the Bradley Lab at the University of Saskatchewan. References [1] S. Qin, M.I. Current, S.B. Felch, and N.W. Cheung, “Plasma immersion ion implantation (PIII)” in Ion Implantation Applications, Science and Technology (J. Ziegler, ed.), Ion Implantation Technology Co., Chester, MD, USA (2012). [2] S.K. Purdy, A.P. Knights, M.P. Bradley and G.S. Chang, “Light emitting diodes fabricated from carbon ions implanted into p-type silicon”, IEEE Trans. Elect Devices 62, 914-918 (2015). doi:10.1109/TED.2015.2395995 [3] M. Risch and M.P. Bradley, “Prospects for Band Gap Engineering by Plasma Ion Implantation”, physica status solidi (c) 6, S210-S213 (2009). [4] G.R.S. Iyer, J. Wang, G. Wells, M.P. Bradley, F. Borondics, “Nanoscale imaging of nitrogen-doped single layer graphene” Nanoscale 7, 2289-2294 (2015). doi:10.1039/c4nr05385k [5] E. Awoyele*, I.N.A. Oguocha, A. Odeshi, M.P. Bradley, “Effect of nitrogen ion implantation on the fatigue life of AISI 1018 and AISI 1045 carbon steels”. 31st Canadian Materials Science Conference, University of British Columbia, Vancouver, British Columbia, Canada, June 10 13, 2019.

[3196] (I) Homogeneous, Micron-scale High Energy Density Matter Generated by Relativistic Laser-solid Interactions (13:45, 30 minutes)

Presenter: BEIER, Nicholas (University of Alberta)

Short-pulse, laser-solid interactions provide a unique platform for studying complex high-energy-density (HED) matter. HED matter exists in extreme states of temperature and density, producing conditions comparable to those found within astrophysical environments. Elucidating the relationship between temperature, pressure, and density in HED environments is critical for understanding the physics of stellar interiors and the achievement of inertial confinement fusion. However, developing an accurate description of HED conditions in this regime remains an experimental and theoretical challenge rapidly evolving conditions and spatial inhomogeneities present in laboratory plasmas. In this talk, I will discuss our recent work performing high-resolution X-ray spectroscopy of copper K-shell emission from high-intensity (I □ 10^{21} W/cm^{2}) laser experiments using the ALEPH laser at Colorado State University. The fielding of two X-ray spectrometers, including a newly developed high-resolution hard X-ray spectrometer, enabled the study of K-shell absorption effects to determine the plasma heating profile. Numerical modeling using collisional-radiative and 3D particle-in-cell codes reveals that solid-density plasmas were produced with electron densities exceeding 10^{24} cm^{-3} and temperatures exceeding 3 keV. This micron-scale homogeneity, not observed when using the laser fundamental wavelength of 800 nm, is attributed to the trapping and refluxing of the few MeV electrons within the target sheath fields. The capability of generating such hot, homogeneous, solid-density plasmas over large length-scales using mid-scale, short-pulse laser facilities provides novel and highly accessible experimental platforms that may be used for a wide range of HED applications.

[3341] (G*) High-Fluence Plasma Immersion Ion Implantation (PIII) for Fusion PFC Materials Testing (14:15, 15 minutes)

Presenter: Ms YOUSAF, tahreem (University of Saskchewan)

Plasma fusion devices will require plasma-facing components (PFCs) which can withstand the extreme environment at the edge of a hot fusion plasma [1]. Studies of materials suitability for fusion PFCs require experiments that can simulate the ion bombardment associated with fusion edge plasmas [2-3]. High fluence ion implantation is one tool for this purpose. The Bradley group at the University of Saskatchewan has been developing Plasma Immersion Ion Implantation (PIII) as a tool for this and other materials science applications requiring high ion fluence. High fluence ion implantation for this work is being conducted in the custom USask PIII system developed by the Bradley group, consisting of an Inductively Coupled Plasma and a custom high-voltage modulator [4-6]. This talk will review the physics underlying high fluence ion implantation using PIII, as well as some recent applications including those related to fusion PFC materials testing. References [1] T. Hirai et al., “Use of tungsten material for the ITER divertor”, Nuclear

Materials and Energy 9, pp. 616-622 (2016). [2] M. J. Baldwin and R. P. Doerner, “Formation of helium induced nanostructure ‘fuzz’ on various tungsten grades,” J. Nucl. Mater. 404, no. 3, pp. 165–173 (2010). [3] K. Tokunaga et al., “Blister formation and deuterium retention on tungsten exposed to low energy and high flux deuterium plasma,” J. Nucl. Mater., 337–339, pp. 887–891 (2005). [4] M. Risch and M.P. Bradley, “Prospects for Band Gap Engineering by Plasma Ion Implantation”, physica status solidi (c) 6, S210-S213 (2009). [5] C.J.T. Steenkamp and M.P. Bradley, “Active Charge/Discharge IGBT Modulator for Marx Generator and Plasma Applications”, IEEE Trans. Plasma Sci. 35, 473-478 (2007). [6] J. Moreno, A. Khodaee, D. Okerstrom, M.P. Bradley, and L. Couëdel, “Time-resolved evolution of plasma parameters in a plasma immersion ion implantation source”, Physics of Plasmas 28, 123523 (2021).

[3042] (G*) Nanosecond Pulsed Discharge in Air with the Presence of Micrometre Particles: Investigation of the Electrical and Optical Properties (14:30, 15 minutes)

Presenter: DIAMOND, James

Dusty or complex plasmas is a branch of plasma physics that aims to investigate the interactions between a plasma and solid particles with a size ranging from nanometers to micrometers. Most of the available studies have addressed these interactions under low pressure conditions. Currently, there is a lot of interest to process micrometer particles, e.g. in mining industry, and the plasma discharges seems to have great potential. Indeed, as it is highly reactive and can be sustained in different media at different pressures, plasma may provide innovative solutions to this field, particularly because it can be developed at low-cost. This contribution presents a study of air-driven pulsed nanosecond discharges in contact with micrometer powders that have different size distributions, namely 20-38, 38-106, and 106-150 µm. The plasma interacts with the microparticles and erodes its surface, while producing a distribution of particles with smaller size. This finding has been evidenced by scanning electron microscopy imaging. Under such conditions, we monitored the temporal evolution of the discharge electrical characteristics and found a comprehensive relationship. The evolution of plasma properties, using optical emission spectroscopy technique, will be also provided. Finally, as the gap distance plays a crucial role on the discharge mode and, thus, on the plasma-particles interactions, the influence of this parameter on the above mentioned properties will be discussed.

W2-5 DPE IV (DPE) | DEP IV (DEP) - MDCL 1116 (13:15 - 14:45)

-Conveners: Daria Ahrensmeier

[3479] (I) Engaging diverse student interests through independent projects (13:15, 30 minutes)

Presenter: FORDE, Nancy

When designing coursework and assessment, there can be a tension between prescribed content and engaging diverse student interests. In this talk, I will describe how I have attempted to balance this tension by including independent projects as part of coursework. I have used independent, student-chosen projects as part of a third-year classical thermodynamics class, a third-year biophysics class, and a fourth-year biophysics lab. I’ll describe the guidance given to students for the scope and presentation styles of these projects. My desire to provide students with more control over their lives during the pandemic led me to substantially broaden the scope of projects in the biophysics lecture course. Students chose projects ranging from technical reports on papers from the primary literature, to research proposals, to review articles on a biophysics topic or experimental technique, to blog posts or infographics presenting the marvelous physical properties of biological systems. The target audience for these projects ranged from their peers to graduating high school students. I’ll describe how assessment for these diverse projects was conducted, how students participated in peer review, and provide some student feedback. Students and I have found independent projects to allow them to deepen their scientific learning along an axis of interest to them, and to present their findings in a format that excites them and allows them to develop their scientific communications skills.

[3481] (I) Development of hybrid assessments for a electricity and magnetism service courses (13:45, 30 minutes)

Presenters: HARLICK, Ania (University of Toronto), ADAMS, Elijah (University of Toronto), BOOTH, Rebecca (University of Toronto)

Reliable and authentic assessment methods are pivotal in both grading and improving student learning process. Traditionally all courses include a mixture of assessments that can be classified as formative or summative, with the classification tied to the type of the activity and the grade associated with it, not necessarily to the function and intended use of the feedback it provides. This project investigated a revaluation of the existing course components and restructuring them to design a cohesive set of evaluation methods that combine various assessment types. The prime focus of the newly designed assignments, activities, experiments, and exams, was the information that is returned to the student, while implementing elements of formative assessment into pieces conventionally used for grading, incorporating testing into low-stake activities, designing space for self-assessment and improvement. The final product will be a comprehensive set of hybrid assessments that can be adjusted and adapted to help each individual identify and overcome their own challenges and meet their learning goals.

[3103] Bringing physics to life with experiential learning (14:15, 15 minutes)

Presenter: TERRANA, Alexandra (Minerva University)

This talk will describe elements used in an introductory university physics course to bring physics to life and help students see and use the world around them as their lab. The audience will learn common challenges associated with this mission and discover the key principles to develop a framework for designing real-world experiential learning activities in physics courses at any level. This initiative is motivated by the improved learning that results when students apply concepts from the classroom to the world around them and to themselves. This is true across many fields but is especially important in physics, where theoretical knowledge should be paired with hands-on experimentation and observation so that students can explore the full scope of the scientific method. Although labs try to achieve these goals, they often fall short, particularly when they focus on reproducing the expected outcome from a particular experimental setup. This is a missed opportunity for students to engage in open-ended inquiry and experimental design, and it does not lead to meaningful real-world connections. At Minerva University, rather than simulate real-world phenomena in a lab, students make a lab out of the real world and themselves! Minerva is a 4-year liberal arts institution that combines an innovative general education curriculum, a pedagogical model centered around active learning, and a global experience in which students rotate through seven different cities over the four years. As one component of this approach, every course has a “location-based” assignment, meaning that it includes certain elements that require students to go out and interact with their city of residence. This talk will showcase an example of a location-based assignment in an introductory physics course in which students apply a variety of fundamental physics concepts, including mechanics, fluids, and thermodynamics. But rather than dealing with idealized systems of blocks, pulleys, and strings, students apply the concepts to themselves! Their own bodies become their laboratory, allowing for deeper, more tangible, connections with the course material. The talk will highlight the scalability of this initiative and outline how it can be adapted to various levels of physics.

[3048] Case Studies for Small-Group Student Collaboration in Large-Enrollment Introductory Physics Classes (14:30, 15 minutes)

Presenter: Dr ANTIMIROVA, Tetyana

The goal of this project is to enhance students’ collaboration with activities that reduce the reliance on multiple choice questions that are common in large-enrollment introductory physics classes, by providing students with new opportunities to collaborate on more open-ended scenarios, such as: mini-case studies. Course materials, in the form of mini-case studies were created. They were designed to target the most fundamental concepts of the first-year physics curriculum. These collaborative group activities are used to promote active learning and promote a sense of community in the partially flipped classroom. Originally the project was envisioned for the on-campus large class setting, however the COVID-19 pandemic and the challenges of engaging students during remote learning made the need for these types of activities even more pressing. Examples of the case studies activities will be demonstrated.

W2-10 DAMOPC I (DAMOPC) | DPAMPC I (DPAMPC) - MDCL 1008 (13:15 - 14:45)

-Conveners: Jens Lassen

[3056] (G*) Atomic Shell Structure of the Entire Periodic Table Using an Alternative Approach to Orbital-Free Density-Functional Theory (13:15, 15 minutes)

Presenter: LEMAITRE, Phil

The principal aim of orbital-free density-functional theory (OF-DFT) over its competitors is to reduce the computational effort required to efficiently calculate properties of quantum systems, thereby increasing the feasibility of many applications to large interacting systems. A novel implementation of OF-DFT is achieved using the isomorphism between classical statistical mechanics in 3+1 dimensions and quantum statistical mechanics in 3 dimensions, to which quantum density-functional theory is replaced with polymer self-consistent field theory for ring polymers. This new OF-DFT is used to calculate the electron densities and their associated binding energies for every element on the periodic table, using a simple Fermi-Amaldi exchange-correlation potential and an Edwards-Flory-Huggins interaction potential from polymer physics to represent the Pauli exclusion effect. The theory predicts quantitatively accurate electron densities (where sufficient experimental data exist for comparison) and binding energies within 5% of the experimentally measured values for elements up to Cadmium, drifting beyond this mark for heavier elements due to the increasing importance of relativistic effects in these atoms.

[3142] (G*) A Projection Operator Approach to Charge-State Distributions following the beta-Decay of ^{6}He (13:30, 15 minutes)

Presenter: BONDY, Aaron

The beta-decay of helium-6 provides a testing ground in searching for physics beyond the Standard Model, which predicts the kinematics of this decay. A large discrepancy between our theory and experiments at U. of Washington [1] has emerged in the amount of double ionization following beta-decay. The theoretical method utilizes correlated Hylleraas wave functions and is not satisfactory in partitioning the charge states since E > 0 states contain an overlap between the single and double continua. We have developed a projection operator formalism using product states that improves the agreement by a factor of four, but still a substantial disagreement remains. We report on our use of delta function matrix elements, using the method pioneered by Drachman [2], to measure the ground-state component of our pseudostates to inform modifications so that E > 0 states are represented more accurately. We propose that boundary conditions at the origin should contain the same information as the asymptotic ones used in collision and photoionization studies. [1] R. Hong, et al., Phys. Rev. A 96, 053411 [2] R. J. Drachman, J. Phys. B: Atomic and Molecular Physics 14, 2733 (1981).

[3140] Relativistic corrections to helium two-photon decay rates (13:45, 15 minutes)

Presenter: BONDY, Aaron

Two-photon transition rates are important in determining astrophysical quantities such as population balance in planetary nebulae. We recently calculated two-photon decay rates in heliumlike ions including the finite nuclear mass effects [1]. We have now perturbatively added relativistic corrections to these results, giving the most precise and accurate calculations to date. We first tested the relativistic corrections to dipole transition integrals for the equivalent one-electron case We derived (and will report on) one-electron Breit-Pauli operators that are equivalent to the corresponding Dirac operators by expanding in powers of the fine-structure constant α. A continuous gauge parameter is used, and the operators are compared with the long-wavelength QED operators derived previously for few-electron atoms [2]. [1] A. T. Bondy, D. C. Morton, and G. W. F. Drake. 102, 052807 (2020). [2] K. Pachucki, Phys. Rev. A 69, 052502 (2004).

[3066] (U*) Diagnostic technique to identify collision site in an ion trap (14:00, 15 minutes)

Presenter: DE URIOSTE TERRAZAS, Itzal

Atomic clocks made of trapped ions are subject to collisions with gases in the chamber. These collisions change the transition frequency of the trapped ions, affecting their use in the clock. When a collision occurs, the trap is removed, and all the ions are replaced since the affected ion (or ions) is unknown. I will present the theory to diagnose the collision site and how it can be mitigated.

[3522] Suppression of Raman Interaction due to destructive interference in Alkali Atoms (14:15, 15 minutes)

Presenter: TASHCHILINA, Arina (University of Alberta)

Raman interactions are a powerful tool for performing arbitrary rotations between two Zeeman levels of an individual ion or a neutral atom. Universality of the technique places it on central roles in many quantum technologies: single qubit gates in atomic quantum processors, mediating interactions in quantum simulators, and mapping quantum information into long-lived states in optical quantum memories, to name a few. The conventional three-level effective theory manifests that the fidelity of the Raman operation grows inversely proportional to the single photon detuning. In our work we show that this approximation does not always hold for all alkali atoms due to their multi-level structure. The destructive interference of the hyperfine sub-levels could fully suppress the Raman interaction at large detunings leaving us with some finite optimal fidelity in comparison to asymptotically ideal theoretical case. We use a formalism based on Clebsch-Gordan coefficients and rotational symmetries of atoms, which allows us to generalize our results to all alkali atoms. We experimentally show the effect on Rb-87 and discuss how to circumvent the problem.

time	[id] title	presenter
14:30	session end discussion, Q&A; (15 minutes)	

W2-4 Fundamental Symmetries and new physics at low energy II (DNP) | Symétries fondamentales et nouvelle physique à basse énergie II (DPN) - MDCL 1009 (13:15 - 14:45)

-Conveners: Russell Mammei

[3469] (I) Progress towards atomic parity violation measurements in francium (13:15, 30 minutes)

Presenter: GWINNER, Gerald (University of Manitoba)

Low-energy precision tests of electro-weak physics keep playing an essential role in the search for new physics beyond the Standard Model. Atomic parity violation (APV) experiments measure the strength of highly forbidden atomic transitions induced by the exchange of Z bosons between electrons and quarks in heavy atoms. APV is sensitive to additional interactions such as leptoquarks, and provides complementary sensitivity to parity-violating electron scattering. Our group is working towards a measurement in francium, the heaviest alkali, where the APV signal is about 18 times larger than in cesium. Since Fr has no stable isotopes, we have established an online laser trap at the ISAC radioactive beam facility at TRIUMF that can confine millions of cold francium atoms at micro-Kelvin temperatures in a volume of approximately 1 cubic mm, an ideal environment for precision spectroscopy. Recently, we have observed the highly forbidden 7s-8s magnetic dipole transition, a final milestone prior to observing APV. I will review our recent work and present a roadmap for APV. Supported by NSERC, TRIUMF via NRC, and the Universities of Manitoba and Maryland.

[3352] (G*) First Measurement of the 7s−8s M1 Transition in Francium (13:45, 15 minutes)

Presenter: HUCKO, Timothy (University of Manitoba)

Atomic parity-violation (APV) experiments play an important role as low-energy, neutral current, searches for physics beyond the Standard Model. Francium is an ideal candidate for APV experiments due to its high-Z and single valence electron. Our planned Fr APV experiment will probe the 7s−8s transition (506 nm) in an external electric field. Relativistic effects and hyperfine interactions give rise to an extremely weak magnetic dipole (M1) transition, with oscillator strength f 10^−13. In our experiment we use a magneto-optical trap to cool and trap 211Fr between a pair of transparent indium tin oxide field plates. To detect the faint M1 transition, we use an ultra-high vacuum compatible power build-up cavity that enhances the light power 4000 fold. I will discuss our measurements of the M1 and Stark-induced E1 transitions. Their comparison allows us to extract the strength of the relativistic M1 amplitude and compare it to recent theoretical predictions from literature. Our preliminary results suggest this first measurement will have better than 10% accuracy on the relativistic contribution to the M1 transition, similar to the difference between theory and experiment of the analogous transition in Cs. Current funding by NSERC (Canada), NRC (Canada) through TRIUMF, Univ. of Manitoba, and Univ. of Maryland is gratefully acknowledged.

[3373] (G) Optical pumping of francium atoms for the measurement of the 7S-8S scalar to vector transition polarizability ratio. (14:00, 15 minutes)

Presenter: SHARMA, Anima

Low-energy precision electro-weak physics tests are advocated as part of the search for physics beyond the Standard Model. We are working towards a measurement of atomic parity violation (APV) in francium, Fr (Z = 87), the heaviest alkali in a magneto-optical trap (MOT) online to ISAC at TRIUMF. The transition of interest in Fr is between the 7S and 8S states, where the parity violating (PV) observable will be the interference between a parity-conserving “Stark induced” E1 amplitude, created by applying a dc electric field to mix S and P states, and the vastly weaker PV amplitude. To explore the Stark amplitude, in particular the ratio of the scalar to vector transition polarizability, we need to know the population distribution of atoms in the magnetic sublevels, *m*, of the ground state. I will talk about our strategy for preparing the spin polarization of atomic states in Fr in a MOT which will also help in exploring the m-level dependence of the interference of E1 and our recently observed magnetic dipole M1 amplitude. Following our success in fast switching of the magnetic fields, I will discuss our plan for detection of spin-polarization using Raman techniques, and some improvements for our detection system. These developments will pave the path towards atomic parity violation in francium. This work is supported by NSERC, NRC, TRIUMF, U Manitoba, U Maryland.

[3073] Advances in the Spectroscopy of the 1S-2S Transition in Antihydrogen (14:15, 15 minutes)

Presenter: OLIN, Art (TRIUMF (CA))

The antimatter equivalent of the hydrogen atom, antihydrogen, is an outstanding testbed for studies of matter-antimatter symmetry. Here we report the first simultaneous observation, with few ppt precision, of the d→d and c→c hyperfine components of the 1S-2S transition in antihydrogen trapped in a 1T magnetic field. Our c→c measurement is the first in either hydrogen or antihydrogen, while the d→d measurement is in agreement with our previous measurement and with measurements in hydrogen. Together with our ground state hyperfine splitting measurement we have determined the antihydrogen 2S hyperfine splitting with 0.3% precision. These results were obtained using a new experimental protocol which allows characterization of the relevant spectral lines in just one day, representing a 70-fold improvement in the data-taking rate and improved control of systematics compared to our previous work. We show that this protocol is applicable to laser cooled antihydrogen with dramatic implications for both the speed and precision of future tests of fundamental symmetries. ALPHA Collaboration: C. J. Baker, W. Bertsche, A. Capra, C. Carruth, C. L. Cesar, M. Charlton, A. Christensen, R.Collister, A. Cridland Mathad, S. Eriksson, A. Evans, N. Evetts, J. Fajans, T. Friesen, M. C.Fujiwara†, D. R. Gill, P. Grandemange, P. Granum, J. S. Hangst, W. N. Hardy, M. E. Hayden, D. Hodgkinson, E. Hunter, 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, J. M. Michan, T. Momose, P. S. Mullan, J. J. Munich, K. Olchanski, A. Olin, J. Peszka, A. Powell, P. Pusa, C. Ø. Rasmussen, F.

Robicheaux, R. L. Sacramento, M. Sameed, E. Sarid, D. M. Silveira, D. M. Starko, C. So, G. Stutter, T. D. Tharp, A. Thibeault, R. I.Thompson, D. P. van der Werf & J. S. Wurtele

[3210] (G*) Precision Antihydrogen Annihilation Reconstructions using the ALPHA-g Detector (14:30, 15 minutes)

Presenter: Ms WOOSAREE, Pooja (University of Calgary Dep. of Phys. and Astronomy (CA))

The ALPHA (Antihydrogen Laser PHysics Apparatus) collaboration aims to test fundamental symmetries with matter and antimatter by testing CPT (charge conjugation, parity reversal, time reversal) theory and observing whether antimatter follows Einstein's Weak Equivalence Principle (WEP), where the acceleration due to gravity that a body experiences is independent of its structure or composition. A measurement of the gravitational mass of antimatter has never been done before, as previous experiments used charged particles, which meant the experiments were dominated by electromagnetic forces. The ALPHA-g apparatus will use electrically neutral antihydrogen atoms produced in a vertical Penning-Malmberg trap and hold the antihydrogen in a magnetic well. Once the antihydrogen is released, the position of the resulting annihilations can be reconstructed with a radial time projection chamber (rTPC) surrounding the trapping volume. Tracing the annihilation position within the rTPC is imperative to measuring the gravitational mass of antihydrogen. Simulations of antihydrogen annihilations, and how to calibrate the detector for z-positions will be discussed. This data will be used to measure the gravitational mass of antihydrogen; an important measurement in testing the fundamental symmetry of matter and antimatter. The ALPHA-g apparatus is currently being commissioned at CERN, and the first gravitational measurements of antihydrogen are underway.

W2-3 Biophysics Outside the Box (DPMB) | Biophysique hors de la boîte (DPMB) - MDCL 1102 (13:15 - 14:45)

-Conveners: Melanie Campbell

[3148] (I) Functional and Functionalized Membranes (13:15, 30 minutes)

Presenter: RHEINSTADTER, Maikel

Cell membranes are complex dynamic structures, and their composition and structure are major determinants of pathology. It is now commonly accepted that the membranes' physical properties, such as fluidity and thickness, are determining factors for permeability, partitioning of drug molecules, and protein aggregation. Membrane-interacting molecules can in some instances be expected to have a greater therapeutic potential than traditional therapies targeting receptors or enzymes. I will provide a perspective on the basic mechanisms how physical membrane properties can affect diseases, and the therapeutic potential of changing membrane properties to target certain diseases. We developed red blood cell based hybrid liposomes for targeted drug delivery with antiviral and antibiotic properties that show great therapeutic potential because of their biocompatibility. We also use these ideas and techniques in our start-up (www.synth-med.com) that develops smart membrane-based sensors for the detection of pathogens in water and food.

[3239] (G) Diversity-generating host-disease coevolution with CRISPR adaptive immunity (13:45, 15 minutes)

Presenter: BONSMA-FISHER, Madeleine

Bacteria are under constant threat from viruses, and some bacteria possess adaptive immune systems that provide protection through a genomic 'memory' of past viral infections. In conjunction with viral evolution, this creates a diverse population of bacteria where each cell has a unique viral genomic imprint. The fate of the bacterial population depends on the rate at which memories are updated to track evolving viruses. How does the dynamic fitness landscape generated by adaptive immunity impact population diversity and the rate of evolution? We find with a simple stochastic population dynamics model that viruses experience a changing fitness that both drives and reigns in diversity: new virus mutants that escape immune targeting have high fitness and experience selective dynamics associated with low diversity, while established virus clones experience immune targeting and lose their fitness advantage, going extinct following neutral dynamics associated with high diversity. Both diversity and the speed of evolution depend sub-linearly on viral mutation rate in contrast to a linear dependence under neutral dynamics. The effectiveness of adaptive immunity is captured by bacterial average immunity which depends inversely on diversity and is a crucial experimental observable. Average immunity determines clone fitness, population outcomes, and the durability of immune memory, which we measure in published experimental data. This work lays a theoretical foundation for understanding immunity in co-evolving populations.

[3030] (G*) The role of ammonium ions in prebiotic RNA polymerization in hot-cold and hydration-dehydration cycles (14:00, 15 minutes)

Presenter: DUJARDIN, Alix

The RNA world proposed by Gilbert in 1986 envisions that the first genetic polymers that formed on the early pre-biotic Earth were based on RNA polymerization and replication. Ever since, researchers have tried to synthesize RNA without enzymes by using catalysts such as clay, lipids, and inorganic salts. We investigated the formation of RNA by using hot-cold and hydration-dehydration cycles in the presence of different compounds that have been reported or suggested for their catalytic function. This study uses a novel simulation chamber to mimic hot-cold and hydration-dehydration cycles with unprecedented resolution and duration. When analyzed by gel electrophoresis and Molecular Dynamics (MD) computer simulations, we found that ammonium salts are an excellent catalyst for RNA synthesis and can form RNA polymers of >150bp. Efficiency of different ammonium salts can be related to their molar Gibbs energy of formation (ΔG): the smaller ΔG the better due to the formation of smaller crystallites that allows for more uniform mixing. Importantly, we find that the length of RNA-polymers is not directly related to the number of cycles. Irregular cycling, with a more prolonged hot dehydration phase, increases the polymerization rate while prolonged humid phases were detrimental to polymerization. From MD simulations, nucleotides form tight clusters in the aqueous phase in the presence of ammonium ions, driven by hydrogen bonding between ions and nucleotides. The ability to form these hydrogen bonds makes ammonium different from other inorganic salts. Nucleotides in these clusters form ‘pre-polymers’ when adsorbing and stacking on a substrate during the dry phase, ready to form phosphodiester bonds via condensation reactions during the hot and dry phases of the cycles.

[3296] (G*) The roles of secondary metabolite production in sustaining microbial diversity (14:15, 15 minutes)

Presenter: Mr LUI, Ga Ching (University of Toronto)

High diversity at steady state is theoretically difficult to be attained in well-mixed systems, in which there are only a small number of growth-limiting factors. Broadly speaking, it is related to degrees of freedom present in the system. To account for the rich diversity observed in nature, various mechanisms such as fluctuation and spatial heterogeneity have been proposed. A typical way that has been suggested to resolve this conundrum is to hypothesize the environment being modified by the production of an equally rich variety of secondary metabolites that are all growth-limiting. While this has been suggested by experiments to be a major mechanism in sustaining the coexistence of a small handful of strains in small systems, whether this explanation of diversity can be extended to very large systems with hundreds to thousands of species remains to be seen. Equally perplexing is the idea that secondary metabolites strengthen the coupling between species; In principle this should drive down diversity unless nontrivial structure is present in the community. It is therefore likely that increasing the number of growth-limiting factors is only one of several roles that secondary metabolite plays; Diversity is maintained by the combined effect of these roles. Here, I use a mechanistic model of resource competition involving chemostats, which is a continuous culture device that controls bacterial growth rate at steady state in a well-mixed environment, with one externally supplied resource and only one single secondary metabolite. In particular, I focus on how cross-feeding and toxin production, in conjunction with metabolic constraints, modify the environment as well as the effective interspecific couplings to support the coexistence of a large number of species. Naturally arise from the model are the concept of keystone species, in the absence of which will lead to collapse of the entire community, and the stabilizing effect through changing the environment to bring the system to coexistence. Transitions from coexistence at steady state to persistence with oscillatory trajectories is also studied, and that changes in topologies of interaction networks are predictive of these transitions. And finally, I illustrate the low-dimensional description of these large systems, which sheds light on how diversity is maintained by the structures of microbial communities.

[3238] (G*) Using Phytoglycogen as an Agent to Improve the Water Solubility of Bioactive Compounds (14:30, 15 minutes)

Presenter: VAN HEIJST, Nicholas

Phytoglycogen (PG) is a compact, dendrimeric and naturally occurring polysaccharide produced in the kernels in sweet corn. PG is soft, porous, bioavailable and nontoxic which makes it ideally suited for applications in human health and nutrition. In the pharmaceutical field, many newly-introduced drugs suffer from poor water solubility and the enhancement of their bioavailability is a major challenge for the industry. Recently, nanotechnological approaches such as emulsification and encapsulation have been proposed as techniques to improve drug solubility. We explore means to improve the solubility of the insoluble carotenoid astaxanthin (ASX) via PG. We have developed a technique that incorporates roto-evaporation and freeze-drying to create a dehydrated ASX-PG powder which is readily dispersed in water and creates stable solutions of ASX in concentrations several orders of magnitude beyond what is naturally seen in water. We use ultraviolet-visible spectroscopy (UV-VIS) to characterize the activity of the ASX solutions and surface plasmon resonance imaging (SPRi) to quantify the degree of binding between the ASX and PG. Our preliminary work shows promising results that PG is a safe, natural and effective solubilizing agent for the insoluble ASX.

W2-2 Fields, Particles, and Strings II (DTP) | Champs, particules et cordes II (DPT) - MDCL 1016 (13:15 - 14:45)

-Conveners: Arundhati Dasgupta

[3327] (I) Quantum finite elements (13:15, 30 minutes)

Presenter: SEAHRA, Sanjeev

The finite element method is a well-known technique to approximate solutions of partial differential equations on complex geometries. In this talk, I consider the quantization of the classical finite element method as applied to a scalar field propagating on a closed spatial manifold equipped with a random triangulation. This is intended to be a toy model of quantized matter inhabiting the kind of random discrete geometry envisioned by certain approaches to quantum gravity.

[3432] (G*) One problem in a 'melon' (milion) (13:45, 15 minutes)

Presenter: GIROUX, Mathieu (McGill University)

It was recently showed that the dual to the vector space of Feynman integrals have a very physical interpretation through unitary cuts. In this talk, we want to use this new technology to answer questions at two-loop. In particular, we initiate the loop-by-loop program and investigate the recursive loop-structure of the 'watermelon' diagram, which is relevant for self-energy calculations in Quantum Field Theory. We will discuss it's first iteration, which boils down to extracting the two-loop watermelon (sunrise) differential equation from one-loop watermelon (bubble) data. We will also elaborate on connections between the so-called 'canonical' differential equations, ε-factorized differential equations and modular invariance.

[3383] (G*) The complex symmetron: global strings in non-minimally coupled scalar-tensor theories (14:00, 15 minutes)

Presenter: NEZHADSAFAVI, Ali

Topological defects, such as monopoles, cosmic strings and domain walls, have been extensively studied in theories with fields minimally coupled to gravity. With the surging interest in alternative gravity theories, it is interesting to investigate the novel characteristics of defects in theories with non-minimally coupled strings. Previous works in this filed have already yielded interesting properties of domain walls in the symmetron model. In this work, we study a generalization of the symmetron model where the scalar field is complex, with the theory allowing for stable global string solutions. We have used the Crank-Nicolson scheme to evolve configurations of strings, loops and matter halos. Our results show, similar to the case of the domain walls in the real symmetron model, the strings become more stable as they attach themselves to matter halos. We also show that consequently a string loop can be become stable as it attaches itself to a distribution of matter halos.

[3401] (G*) Interaction of Gravitational waves with Yang-Mills waves (14:15, 15 minutes)

Presenter: GOSALA, Narasimha (University of Lethbridge)

Gravitational waves (GWs) provide a new window to observe the universe. Detecting GWs requires an understanding of the interaction of GWs with the matter. In this view, we discuss the interaction of gravitational waves with SU(2) Yang-Mills waves. In particular, we discuss how a Yang-Mills wave gets modified in the background of a gravitational wave. We also discuss some of the implications of the results in Early universe cosmology

[3306] (G*) Sorkin-Johnston Effective Field Theory (14:30, 15 minutes)

Presenter: Mr SHAWQI, Shafayat (University of Alberta)

Quantum Effective Field Theory (EFT) in curved spacetime is our most advanced and established framework on the path towards a quantum theory of gravity. However, unlike its flat space counterpart, the theory lacks a unique notion of vacuum or energy, which complicates decoupling from ultraviolet (UV) degrees of freedom. Here, we present an EFT quantization procedure based on the Sorkin-Johnston (SJ) vacuum prescription, which sets a unique vacuum state for the UV degrees of freedom based on the infrared (IR) state and geometry. We call this framework SJ-EFT, which achieves *covariance* and *decoupling* at the cost of locality. We then apply this prescription to a system of two coupled oscillators, representing UV and IR modes in a simple toy model for an EFT, and see that the effective action has imaginary non-local contributions (in time), a feature expected for future-included quantum theories. However, the non-local terms in this toy model are exponentially suppressed. More generally, SJ-EFT can provide a playground to explore non-local quantum phenomena that one may expect from a generic theory of quantum gravity.

W2-1 Machine Learning in HEP and Novel Reconstruction Tools (PPD) | Apprentissage automatique en PHE et nouveaux outils de reconstruction (PPD) - MDCL 1110 (13:15 - 14:45)

-Conveners: Swiatlowski, Max (TRIUMF)

[3161] Machine learning techniques to enhance event reconstruction in water Cherenkov detectors (13:15, 30 minutes)

Presenter: PROUSE, Nick

Hyper-Kamiokande is the next generation water-Cherenkov neutrino experiment, building on the success of its predecessor Super-Kamiokande. To match the increased precision and reduced statistical errors of the new detectors, improvements to event reconstruction and event selection are required to suppress backgrounds and reduce systematic errors. Machine learning has the potential to provide these enhancements to enable the precision measurements that Hyper-Kamiokande is aiming to perform. This talk provides an overview of the areas where machine learning is being explored for water Cherenkov detectors. Results using various network architectures are presented, along with comparisons to traditional methods and discussion of the challenges and future plans for applying machine learning techniques.

[3195] (G*) New background discrimination methods for the NEWS-G dark matter search experiment (13:45, 15 minutes)

Presenter: COQUILLAT, Jean-Marie

In Fall 2019, the NEWS-G experiment used its latest detector, a 140 cm diameter Spherical Proportional Counter (SPC) to search for low mass dark matter at the *Laboratoire souterrain de Modane* (LSM), in France. When a particle interacts with an atom of gas inside the SPC, the ensuing recoil ionizes the gas and produces primary electrons that drift towards the centre of the sphere due to a radial electric field. Close to the central anode, the electric field is so strong that the electrons start themselves ionizing the gas, resulting in a Townsend avalanche. All the drifting secondary ions induce a current in the sensor which produces a characteristic signal. Although lead and polyethylene shields protect the detector against most of the background coming from the environment, the majority of the detected signals are still unrelated to WIMP interactions. In particular, electronic spikes and events correlated to alpha particles are a significant source of undesirable signals. Some of these unwanted background events can be discriminated against by their pulse shape, which differs from the characteristic shape of physical pulses. The objective of the background discrimination is to correctly identify and remove a maximum of the background signals, while keeping the maximal proportion of potential events of interest. This talk will present a description of the newly developed algorithms to differentiate spikes from WIMP candidate events and exclude the undesirable background.

[3343] (G*) Improving Muon-Pion & Electron-Pion Separation at Belle II with Machine Learning Using the Novel Pulse Shape Discrimination in CsI(Tl) (14:00, 15 minutes)

Presenter: BEAUBIEN, Alexandre (University of Victoria)

The Belle II experiment, based at SuperKEKB, is collecting e+e- collision data at the Upsilon(4S) resonance energy. Many Belle II analyses require tagging methods that involve electrons, muons or pions, where the misidentification of these particles introduces important systematic uncertainties. The new pulse shape discrimination (PSD) tool implemented in the 8736 CsI(Tl) crystal Electromagnetic CaLorimeter (ECL) exploits the faster rise time of CsI(Tl) signals induced by hadronic interaction relative to those of purely electromagnetic interactions and is part of an effort to improve our ability to identify hadronically interacting particles. This talk will show how PSD, used within machine learning classification models, improves the discrimination between muons and pions, as well as electrons and pions, using only data from the ECL. These models are trained on a GEANT4 simulated data set of electrons, muons and pions at various energies using the energy, shape, type, and hadronic contribution (from PSD) of the associated ECL clusters. This allows the model to recognize the patterns that characterize the pion hadronic clusters from purely electromagnetic clusters, resulting in an output that characterizes how likely a cluster is to originate from a charged hadronic pion versus a non-hadronic lepton. The resulting models are tested on early data from Belle II to determine performance.

[3370] (G*) Machine learning to denoise pulses from a p-type point contact germanium detector (14:15, 15 minutes)

Presenter: ANDERSON, Mark

In this talk, I present a convolutional autoencoder trained to denoise pulses from a p-type point contact high-purity germanium (HPGe) detector. HPGe detectors are frequently used in the search for rare event interactions, such as neutrinoless double-beta decay, due to their intrinsic purity and excellent energy resolutions. However, electronic noise can make the identification of signal events challenging, especially at low energies. An effective denoising algorithm could help in identifying signals which would otherwise be too noisy to distinguish from backgrounds. It could also improve the measurements of pulse amplitudes. I first describe the implementation details of the denoising autoencoder. This includes the motivation behind the network architecture and three training procedures, one of which requires simulations of the detector and two that require only noisy detector data. Results on both detector simulations and real data from an ^{241}Am source show that the autoencoder is more effective than traditional denoising methods, does not distort the pulses, and can be used to improve the energy resolution under various circumstances. Furthermore, the methodology described here can be easily extended to work with technologies other than HPGe detectors. For example, our group is beginning to apply these methods to spherical proportional counters and bubble chambers with promising results. Our group is also exploring the use of the latent representation from the encoder for other tasks including multi-site event discrimination and peak finding. This deep learning-based approach for denoising pulses is thus broadly applicable to the particle astrophysics community and beyond.

[3262] (G*) Machine Learning for Noise Removal in NEWS-G (14:30, 15 minutes)

Presenter: ROWE, Noah

In this talk I will present preliminary results regarding the application of machine learning techniques for noise removal on signals from spherical proportional counters (SPCs) with the NEWS-G experiment. In SPC detectors, a primary ionization, created by a particle interacting with the gas, drifts towards a central anode. When ions approach the anode, the electric field becomes strong enough to trigger secondary ionizations, resulting in an amplified detector signal. Evaluation of these techniques include tests on simulated pulses with added noise, and quantifying model effects on physics goals such as primary ion counting and energy resolution. Successful implementation of this technique will reduce errors on event measurements (energy, drift time, etc.) and lower the analysis threshold, thereby enabling the experiment to search for lower mass dark matter events.

Health Break with Exhibitors | Pause santé avec exposants - MDCL Hallways (14:45 - 15:15)

W3-6 ML in HEP and Rare Background Searches (PPD) | Apprentissage automatique en PHE et recherche d'interférences rares (PPD) - MDCL 1110 (15:15 - 16:30)

-Conveners: Danninger, Matthias (Simon Fraser University (CA))

[3214] (G*) A method to understand the effects of pileup in the DEAP-3600 detector (15:15, 15 minutes)

Presenter: BINA, Catherine

DEAP-3600 is a single-phase dark matter detector that uses liquid argon scintillation to search for spin-independent weakly interacting massive particles (WIMPs). Identifying background events is vital in WIMP searches due to the extremely small WIMP-nucleon interaction probability. To precisely model backgrounds, pileup—multiple interactions happening in a single event—must be understood. Pileup can be studied using our periodic trigger—a 40 Hz, threshold-less trigger—which provides snapshots of what is occurring in the detector at random moments. One method to study pileup in DEAP-3600 is by mixing the raw waveforms of periodic trigger events with physics events.

[3043] Ex-situ Measurement of Radon Emanation for Ultralow-background Experiments (15:30, 15 minutes)

Presenter: Dr ADHIKARI, Pushparaj (Carleton University)

Radon provides one of the most significant backgrounds in low background experiments since it is an inevitable product of natural uranium and thorium. It is continuously emanated from materials and is noise to rare event particle detectors especially dark matter search experiments because of the alpha decays from the subsequent Po-218, Po-214, and Po-210. A radon emanation detection system, which includes a stainless steel emanation chamber, a low background ZnS(Ag) cell, a radon transfer and collection assembly, and a charcoal trap has been developed and used to study radon emanation from materials in vacuum and in gas. In this talk, the hardware of the system and measurements of radon emanation rates from various materials will be presented.

[3093] Alpha Quenching Factor in Liquid Argon (15:45, 15 minutes)

Presenter: SETH, Susnata (Department of Physics, Carleton University, Ottawa, Ontario, K1S 5B6, Canada, Arthur B. McDonald Canadian Astroparticle Physics Research Institute, Queen’s University, Kingston, Ontario K7L 3N6,Canada)

Mitigation of background events in liquid argon induced by alpha decays is important for detectors searching for Weakly Interacting Massive Particles (WIMP), theoretically motivated dark matter candidates. The quenching of alpha scintillation light must be understood to correctly account for and mitigate backgrounds from alpha particles. This work aims to measure the alpha quenching factor for liquid argon based on measurements of the scintillation light, using signals from alpha decays originating from ^{222}Rn, ^{218}Po and ^{214}Po isotopes. Details of the quenching analysis and fits to Birks’ law for alpha quenching will be presented in this talk.

[3117] Calibrating eV-Sensitive Detectors at the Université de Montréal Tandem Accelerator (16:00, 15 minutes)

Presenters: MICHAUD, Emile, DE BRIENNE, Francois (Université De Montreal)

Understanding the sensitivity of ultrasensitive detectors used in dark matter research requires equally sensitive calibration facilities. The 4.8 keV neutron beam at the Université de Montréal tandem accelerator facility is being upgraded with boron-loaded neutron detectors to provide neutron scatter recoils at energies below 100 eV. This capability is required to characterize the cryogenic silicon and germanium detectors of the SuperCDMS experiment. We will present results of an initial run of a SuperCDMS (Super Cryogenic Dark Matter Search) silicon HVeV detector at the existing facility to evaluate the facility's neutron signal and background rate following the planned upgrade.

[3191] Developing a simulation for estimation of SiPM optical crosstalk levels (16:15, 15 minutes)

Presenter: MINCHENKO, Dmytro (University of Alberta)

SiPMs are photodetectors capable of single photon counting and are widely used in particle physics experiments, like neutrino or dark matter detectors. One of the biggest issues in developing new SiPMs is considering their optical crosstalk levels. Its characterization and understanding are of extreme importance for future detector development. In this work, we develop a simulation based on Geant4 that estimates optical crosstalk for a given SiPM geometry. First, we propagate the charge carrier created in the silicon bulk. Then, using Geant4, we simulate avalanches and track the propagation of the photons created in the avalanches. Lastly, we analyze this data and calculate optical crosstalk levels as the function of overvoltage. We also obtain the light distribution of the secondary photons emitted from the surface of a SiPM. The code is verified by comparing the obtained cross talk levels and light distributions with the measured data of Hamamatsu VUV4 and FBK HD3 SiPMs and will be used to predict and find the optimal geometry parameters to minimize crosstalk levels of possible future SiPM designs.

W3-10 Applied Physics I (DAPI) | Physique appliquée I (DPAI) - MDCL 1016 (15:15 - 16:30)

-Conveners: Louis Poirier

[3330] (G*) Universality in Prediction Markets (15:15, 15 minutes)

Presenter: ROCK, Keanu Mason

In a prediction market, traders buy and sell contracts linked to the outcome of real-world events such as "Donald Trump will be Re-Elected President on November 5, 2024". Each contract (share) pays the bearer 1 dollar if the event happens by the given date, and expires worthless (0 dollars) otherwise. At any given time, therefore, these contracts trade between 0 and 1 dollar, the price representing the market's perception of how likely the event is (e.g. 0.63 dollars = a 63% probability). The price fluctuates as traders buy and sell in response to new information–e.g. Polls, scandals, and other relevant developments–ultimately hitting $1 ($0) when the event does (does not) come to pass. Most of the past literature studying prediction markets has focused on how accurate these "crowdsourced" assessments of probability are in predicting the final result. Comparatively little attention, however, has been paid to the *dynamics* that drive the market to that accurate (or inaccurate) prediction. Here, we ask whether there are universal patterns driving the dynamics of prediction markets and how prices change in response to new information. We use tools of information theory and complex systems to quantify the price dynamics of nearly 3,000 contracts from a popular online prediction market – PredictIt. The markets therein cover a wide range of events ranging from election results, to the outcomes of legislative votes, to career milestones of politicians. Despite this heterogeneity, we uncover striking universal patterns in the statistics of price fluctuations and volume of contracts traded over time. In addition, we quantify the long-term *memory* present in contract prices; allowing us to classify time series as "mean-reverting", "random", or "trending", with the time series in each category exhibiting qualitatively similar shapes. Our findings suggest that the complex human interactions driving prediction market dynamics can be embedded in a relatively low-dimensional space of variables. This could open the door to mechanistic modeling of apparently high-dimensional socio-financial systems.

[3017] (U*) Earth-Like Stratospheric Clouds Do Not Impede Transit Spectroscopy with JWST (15:30, 15 minutes)

Presenter: DOSHI, Dhvani Chetan

The search to find habitable planets outside of our Solar System is made possible through the observational method of transit spectroscopy. Transit spectroscopy can help determine the chemical composition of an exoplanet's atmosphere. This is achieved by analyzing the light that passes through the upper atmosphere of the planet as it transits in front of its host star. Clouds significantly mute molecular features in transit spectra because they prevent light from probing the deeper layers of the atmosphere. High altitude aerosols are particularly problematic as they obscure more of the atmosphere. Most clouds on Earth form in the troposphere and hence do not significantly affect its transit spectrum: these deeper, denser layers of the atmosphere are opaque to transit spectroscopy in any case. Earth occasionally has stratospheric/high tropospheric clouds at about 15-20 km, suggesting that they could substantially limit the observable depth of the underlying atmosphere. We use solar occultations of Earth's upper atmosphere to create synthetic JWST transit spectra of Earth analogs orbiting dwarf stars. Unlike previous investigations, this work uses clear and cloudy sightlines from the Atmospheric Chemistry Experiment's Fourier Transform Spectrometer on the SCISAT satellite. The maximum difference in effective thickness of the atmosphere between a clear and globally cloudy atmosphere is 8.5 km at 2.28 microns. After incorporating the effects of refraction and noise, JWST would not be able to detect Earth like stratospheric clouds if an exo-Earth was present in the TRAPPIST-1 system, as the cloud spectrum only differs from the clear spectrum by a maximum of 10 ppm. To conclude, Earth-like stratospheric clouds will not impede JWST transit spectroscopy, and thus will not heavily impact the measured abundances of biosignatures of exo-Earths.

[3190] (G*) Quantifying radiolysis effects for in-situ Rutherford Backscattering Spectrometry (RBS) (15:45, 15 minutes)

Presenter: FELTHAM, Hunter

The titanium oxide surface is responsible for many of the properties associated with the metal, creating a hard, uniform, and thermodynamically stable protective coating. Because of these characteristics, titanium has found uses in biomedical implants, aerospace engineering, corrosive industrial piping, and other areas where high strength and low weight are required. Our project is aimed on the understanding of atomistic mechanisms of TiO_2 formation, using Rutherford Backscattering Spectrometry (RBS) for elemental depth profiling during the growth, including oxidation rates, and role of anodization potential on Ti oxide layer structure and morphology. RBS is a powerful ion beam analysis tool used to determine thickness at a nanometer scale, such as that of the oxide observed on titanium and elemental depth distribution Our research involves using a specially designed in-situ cell with an ion-permeable silicon nitride window to provide a barrier between the ultra-high vacuum (UHV) required to perform RBS and the liquid electrolyte solution required for anodization. The thin silicon nitride window is coated with titanium and exposed to the liquid electrolyte; RBS measurements are taken as the titanium metal is anodized to titanium oxide. To determine information about the growth mechanism of titanium, in-situ anodization during RBS is performed, leading to information about the growth mechanism of titanium oxide. In-situ RBS results show a significant increase in the oxidation rate of titanium compared to equivalent ex-situ measurements, as well as spontaneous TiO_2 film growth, without applied potential, in the presence of high-energy He^+ particles interacting with electrolyte. The preliminary findings as to the radiolysis products of liquid electrolyte accelerating the oxide growth rate of titanium oxide in-situ will be presented.

[3005] (U*) A Joint Chirp-Rate-Time-Frequency Transform for Non-templated BBH Merger Gravitational-Wave Signal Detection Using Spectrograms (16:00, 15 minutes)

Presenter: LI, Xiyuan (The University of Western Ontario)

With the development of machine learning (ML) algorithms, attempts to use ML techniques like artificial neural networks (ANNs) in the binary black hole (BBH) and binary neutron star (BNS) merger gravitational wave (GW) detection have been made by W. Wei et al. (2021) and many others. Despite the surge of interest in all types of ANN architectures, time-frequency spectrograms remain one of the preferred input data structures due to their relevance to some highly efficient and robust image ANN architectures. Traditional Fourier transforms (FT) based time-frequency decomposition methods have difficulties identifying continuous frequency changes since FTs only fit the input signal to waveforms with constant frequency. BBH and BNS merger GW signal frequency varies continuously by nature and are chirp signals. A transform method that incorporates the rate of frequency change (chirp-rate) may be crucial to improving the performance of existing BBH and BNS merger GW signal detection image ANNs by providing chirp-rate enhanced spectrograms. Building upon the foundation of the linear chirp transform (LCT) by O, A, Alkaishriwo & L.F. Chaparro (2012), in this paper, we develop a version of the short-time linear chirp transform (STLCT) and two types of the joint-chirp-rate-time-frequency transform (JCTFT) for spectrogram generation. Those methods are achieved by replacing the constant frequency waveform model with a linear chirp model. We validate the STLCT and JCTFTs using BBH merger GW waveforms with noise generated using the numerical relativity corrected effective-one-body (EOBNR) formalism and advanced Laser Interferometer Gravitational-Wave Observatory (aLIGO) zero-detuned noise models. We plan to further demonstrate the positive effects of JCTFTs on merger signal detection image ANNs in follow-up studies.

[3508] An investigation of power loss in a thickness-mode piezoelectric transducer (16:15, 15 minutes)

Presenter: RODRÍGUEZ, Orlando (Departamento de Física, Instituto de Ciencias Básicas, Universidad Tecnológica de la Habana, “José Antonio Echeverría” (CUJAE), La Habana, Cuba)

A fundamental problem that limits the functional capacity of a piezoelectric transducer in high-power applications is its intrinsic operational power loss. The phenomenon may generate a self-heating and temperature increase of the device, which in turn may degrade the piezoelectric material utilized in its implementation and finally the transducer performance. Thus, power loss reduction in piezoelectric transducers is an issue extensively investigated by many researchers. In this context, basically two critical frequencies have been comparatively examined to excite these transducers, namely the resonance and antiresonance ones. But, more recently other operation points have been examined. This work presents a computational investigation of power loss in a thickness mode piezoelectric transducer excited at its fundamental resonance. In the investigation, it is shown the existence of an optimal operation point located between its fundamental resonance-antiresonance frequency interval, where a remarkable power loss reduction may be obtained, regarding excitations at both mentioned critical frequencies.

W3-9 Laser Development (DAMOPC) | Progrès dans les lasers (DPAMPC) - MDCL 1008 (15:15 - 16:30)

-Conveners: Jens Lassen

[3358] Metamaterials and the Lambert W functio (15:30, 15 minutes)

Presenter: Prof. JISRAWI, Najeh (Department of Physics and Astronomy and King's University College, Western University)

The generalized Lambert W function has been found useful in various problems like the square well, double potential well, Double Dirac Delta potential and the electronic properties of graphene nanoribbons (GN). In the example of GN, it is shown that the solutions to the equations governing the electronic states are closely related to the Lambert W and the Generalised Lambert W Function. In all these examples a geometric analytic solution is obtained that provides better visualization of the problem at hand. A similar analysis is used to get a geometric- analytical solution of the transverse magnetic and electric mode for the step-index electromagnetic waveguide. The allowed modes of propagation for light waves in varying refractive indices are studied in detail, especially for the negative and complex values of the refractive indices [1]. Metamaterials are capable of a very strong interaction with the magnetic component of light. Therefore, the range of response to radiated light is expanded beyond ordinary optical limitations. In addition, as artificially constructed materials, both the magnetic and electric components of the radiated light can be controlled as light propagates through the metamaterial. Desired waveguide properties can be obtained with the appropriate electromagnetic response of the metamaterial. Transformation optics relates to the capability of bending light or electromagnetic waves in any preferred or desired fashion, for a desired application. The precise degree of electric and magnetic response can be precisely controlled in a metamaterial. Since effective control can be maintained over the responses of the material, this leads to an enhanced and highly flexible gradient-index material [2]. The Lambert curve solutions provide interesting possibilities to study metamaterials. [1] Narola et al. J. Phys. Commun.4, 065001 (2020). [2] Chen et al. Nature Materials, 9(5), 387–396 (2010).

[3034] Coherence, nonclassicality and entanglement of continuous-variable states (15:45, 15 minutes)

Presenter: Dr HERTZ, Anaelle (University of Toronto)

The quantum nature of a state of a bosonic quantum field can manifest itself in its bipartite entanglement, in its coherence and in its optical nonclassicality. Each of these distinct properties have been viewed as a resource, notably for quantum computing and quantum metrology, and can be measured with a variety of witnesses, measures and monotones. The question then naturally arises what the quantitative relations are between them. In this work, we first introduce, for each state of a bosonic quantum field, its quadrature coherence scale (QCS), a measure of the range of its quadrature coherences. We then link the QCS to optical nonclassicality: optical classical states have a small QCS and a large QCS implies strong optical nonclassicality. In addition, we try to clarify the relation between optical nonclassicality and bipartite entanglement, for multi-mode fields, by providing quantitative and computable bounds relating those quantities. We show in particular that strongly entangled states are strongly optically nonclassical.

[3348] (G*) Stellar representation of extremal Wigner-negative spin states (16:00, 15 minutes)

Presenter: DAVIS, Jack

The Majorana stellar representation is used to characterize maximally Wigner-negative spin states with respect to the SU(2)-covariant Wigner function. Comparisons are made to alternative definitions of nonclassicality, including anticoherence, the geometric measure of entanglement, and P-representability. Despite varying low-dimensional agreement between these definitions, the maximally Wigner-negative states are generally found to disagree with the others, with their higher order constellations not corresponding to a Platonic solid when available, or any other similar geometric embedding. We further find for spin systems with $j \leq \frac{7}{2}$ that random constellations/states are not particularly Wigner-negative relative to the maximum. we will also review our proof that all spin coherent states of arbitrary dimension are not positive-definite.

time	[id] title	presenter
16:15	session discussion, Q&A; (15 minutes)	

W3-1 New Physics and Dark Sector (DTP/PPD) | Nouvelle physique et secteur sombre (DPT/PPD) - MDCL 1105 (15:15 - 16:45)

-Conveners: Evan McDonough; Danninger, Matthias (Simon Fraser University (CA))

[3188] (G*) Dark Matter-neutrino interactions through one-loop diagrams (15:15, 15 minutes)

Presenter: MACÍAS CÁRDENAS, Karen (Queen's University)

The nature of Dark Matter is an ongoing and relevant object of study in astroparticle physics. Despite our best efforts to identify its possible particle properties, the results have been null, which has led to a plethora of models describing viable connections to the Standard Model. In particular, loop models of Dark Matter, for example the scotogenic model, have received attention in the last decade but their phenomenology in regard to Dark Matter interactions with neutrinos in the Early Universe has not been widely studied. We aim to explore whether parameters of one-loop models with Majorana and scalar Dark Matter-neutrino interactions such as the Dark Matter mass, the thermally averaged cross-section, and the couplings can be constrained by Early Universe data like the Lyman-α forest, Cosmic Microwave Background (CMB) anisotropies and the Matter Power Spectrum, and give rise to the observed relic abundance.

[3171] Spin-dependent dark matter-electron interactions (15:30, 15 minutes)

Presenter: Dr WU, Chih-Pan (Université de Montréal)

Detectors with low thresholds for electron recoil open a new window to direct searches of sub-GeV dark matter (DM) candidates. In the past decade, many strong limits on DM-electron interactions have been set, but most on the one which is spin-independent (SI) of both dark matter and electron spins. In this work, we study DM-atom scattering through a spin-dependent (SD) interaction at leading order (LO), using well-benchmarked, state-of-the-art atomic many-body calculations; and derive exclusion limits with experiments data. The detector's responses to the LO SD and SI interactions are analyzed. In non-relativistic limit, a constant ratio between them leads to an indistinguishability of the SD and SI recoil energy spectra. Relativistic calculations however show the scaling starts to break down at a few hundreds of eV, where spin-orbit effects become sizable.

[3011] (I) Z' Bosons in Supersymmetry: Mass Limits, Dark Matter, Anomalous Magnetic Moments, and Flavour Anomalies (15:45, 30 minutes)

Presenter: FRANK, Mariana (Concordia University)

Augmenting MSSM by an Abelian $U(1)^\prime$ gauge symmetry offers a viable solution to the μ problem in supersymmetry. Unfortunately, in most instances, collider phenomenology of such models is limited by stringent limits on the $Z^\prime$ boson mass from the ATLAS and CMS collaborations. Here we investigate possibilities of lowering the mass in either leptophobic models, by employing kinetic mixing, or in models with non-universal $U(1)^\prime$ charges. We explore implications of such models on resolving flavour anomalies in B decays and $(g-2)_{\mu,e}$ discrepancies. We verify consistency of these models with dark matter bounds and indicate the most promising collider signals.

[3398] Dark Sector Production via Proton Bremsstrahlung (16:15, 15 minutes)

Presenter: FOROUGHI-ABARI, Saeid (University of Victoria)

Experiments using proton beams at high luminosity colliders and fixed-target facilities provide impressive sensitivity to new light weakly coupled degrees of freedom. With these experiments in mind, we revisit the production of dark vectors and scalars via proton bremsstrahlung, making use of a model that describes the underlying nucleon scattering cross-section in the forward direction due to pomeron exchange. We compare the resulting distributions and rates with those obtained via variants of the Fermi-Weizsacker-Williams approximation and provide production rate distributions for a range of beam energies, including those relevant for the proposed Forward Physics Facility at the High Luminosity-LHC. In addition, we extend the application of proton bremsstrahlung to other long-lived dark sectors such as axion-like particles (ALPs) with gluon coupling and millicharged particles.

[3002] Searching for Minicharged Particles at the LHC's Run-3 with the Phase-I MoEDAL-MAPP Detector (16:30, 15 minutes)

Presenter: Dr STAELENS, Michael (University of Alberta)

The MoEDAL Apparatus for Penetrating Particles (MAPP) Experiment is designed to extend the searches for new physics at the LHC carried out by the baseline Monopole and Exotics Detector at the LHC (MoEDAL) Experiment. The recently approved Phase-I MAPP detector (MAPP-mCP) is on schedule for deployment this year and set to begin data taking in spring 2023. This independent detector system, located in the UA83 gallery adjacent to the MoEDAL detector region at IP8, is separate from the baseline MoEDAL detector and will enable searches for new feebly-interacting particles (FIPs) --- avatars of new physics with small couplings $<<1$ abound in various BSM theories, such as minicharged particles (mCPs) --- produced in the high energy pp collisions at the LHC. The ground-breaking physics program of the MAPP Experiment covers numerous scenarios that yield potentially revolutionary insights into several foundational questions: what is the nature of dark matter? is there a hidden/dark sector? and what is the mechanism of electric charge quantization? This presentation begins with an overview of the MAPP Experiment and the design of the Phase-I MAPP detector, followed by a simple model of mCPs arising from kinetic mixing of a massless dark photon gauge field with the SM hypercharge gauge field. Thereafter, we focus on several dominant production mechanisms of mCPs (χ) at the LHC across the mass-mixing parameter space of interest to MAPP: Drell-Yan pair-production ($q \bar{q} \rightarrow \chi \bar{\chi}$), heavy quarkonia decays (e.g. $J/\psi \rightarrow \chi \bar{\chi}$), and direct decays of light vector mesons (e.g. $\rho \rightarrow \chi \bar{\chi}$). We modelled these processes computationally using MadGraph5, Pythia 8, and EPOS-LHC, respectively. Finally, we present the physics reach of the Phase-I MAPP detector for mCPs potentially produced at the LHC's Run-3 through such mechanisms.

W3-2 Frontiers in Theoretical Physics I (DTP) | Frontières en physique théorique I (DPT) - MDCL 1115 (15:15 - 16:30)

-Conveners: Spekkens, Robert (Perimeter Institute for Theoretical Physics)

[3001] (I) Causality and modifications to Einstein's gravity (15:15, 30 minutes)

Presenter: CARON-HUOT, Simon (McGill University)

Does our world respect causality at all energy scales? We explore constraints on gravitational dynamics which stem from this assumption. Parameterizing long-distance effects of possible new heavy particles using effective field theory (EFT), we study causality of 2 to 2 scattering processes. Due to its energy growth, the gravitational force turns out to be particularly difficult to modify. I will present two-sided bounds which show that a wide class of modifications to four-dimensional Einstein's gravity, require either the existence of light higher-spin states, or violation of causality as we understand it.

[3359] (G*) Quantum Corrections to Hawking Radiation (15:45, 15 minutes)

Presenter: SCHNEIDER, Mathew (McMaster University)

Dr. Stephen Hawking's derivation of the eponymous Hawking radiation marked a significant step forward in the ongoing explorations into quantum theories of gravity. However, despite the significance of this work, higher order quantum corrections to the energy flux have not been calculated in most part due to the difficulty of such QFT calculations in curved space. To avoid this, we make use of the universal Hadamard form of the Wightman function in the coincident limit when near the black hole event horizon, where the propagator becomes a function of a single variable σ (the Synge world function). This can then be used to calculate the radial Klein-Gordon energy flux at the horizon and therefore out to infinity. This novel way of calculating the Hawking radiation can lead to further questions on the effects of higher order corrections such as field self-interactions, heavy particle loops, etc. where the details can be added explicitly and without directly performing the curved space QFT calculations.

[3529] Gravitational time dilation, free fall, and matter waves (16:00, 15 minutes)

Presenter: CZARNECKI, Andrzej

I demonstrate that a de Broglie wave of a particle in a gravitational field turns towards the region of a smaller gravitational potential, causing the particle to fall. This turning is caused by clocks running slower in the smaller potential. I use the analogy of ocean waves that are slower in shallower water and turn towards beaches. This approach explains the free fall qualitatively and quantitatively without postulating motion along geodesics and with only elementary algebra. This talk is based on a paper published in Am.J.Phys. 89 (2021) 634-638, e-Print: 2007.13851

W3-8 Soft Condensed Matter II (DCMMP) | Matière condensée molle II (DPMCM) - MDCL 1116 (15:15 - 16:30)

-Conveners: John Dutcher

[3295] (G*) Bending a floating film using capillary forces (15:15, 15 minutes)

Presenter: DUTCHER, Lauren

Thin polymeric films have important applications including coatings for microelectronic devices. To study these nanoscale systems, we investigate the deformation of a floating glassy film where the inclusion of a liquid/solid contact line on top of the floating film introduces a capillary tug. The system is constructed by preparing a nanometric glassy film, which floats atop a thin supported liquid film. A third liquid film partially covers the assembly introducing the contact line boundary. Thus, at the stepped transition from a bilayer to a trilayer, the topmost liquid layer exerts a capillary pressure on the rigid layer. The contact line perturbs the rigid layer and in this geometry the bending of the intermediate rigid film mitigates the role of capillarity in a way that has not been previously studied. Atomic force microscopy is used to visualize the topology of these samples at the stepped border.

[3223] (G*) Measuring elastocapillary dissipation in droplets moving along soft elastomer films (15:30, 15 minutes)

Presenter: KHATTAK, Hamza

When a droplet interacts with a soft surface, it can deform the material it contacts. This property leads to a plethora of unique physical phenomena with applications in fields ranging from water collection to surface sensing. We explore droplet dynamics on soft materials using a micropipette-based technique to simultaneously image, and measure the forces on, a microscopic droplet dragged along the surface of a soft elastomeric polydimethylsiloxane (PDMS) film. By changing the thickness of the elastomer film, we can control the compliance of the substrate independent of surface chemistry. We are also able to control and measure the presence of uncrosslinked PDMS chains in our system. We model the dynamics of the droplet-substrate interaction and expect dissipation to scale with the size of the capillary deformation. We find agreement between our model and experimental results.

[3063] (G*) Dispersion and Orientation Patterns in Nanorod-infused Polymer Melts (15:45, 15 minutes)

Presenter: AFRASIABIAN, Navid

The dispersion and orientation of nanorods in a polymeric matrix have a direct impact on the mechanical and physical properties of the final material. Our molecular dynamics simulations show a direct relationship between the concentration and the order of the system when rod-polymer attractive interactions are applied. At lower concentrations, nematic droplets of nanorods form while at higher concentrations, the nanorods distribute isotropically and uniformly throughout the melt. This behaviour is attributed to the interplay of the enthalpic and entropic effects. A closer look at the conformation of the polymers also reveals that the interfacial chains are stretched out and have higher radius of gyrations.

[3125] (G*) Lifshitz Critical Point in Diblock Copolymer Blends (16:00, 15 minutes)

Presenter: WILLIS, James Daniel

We examine the phase behaviour of blends composed of complementary diblock copolymers, one with composition f and the other with composition 1-f. Self-consistent field theory (SCFT) calculations have predicted a Lifshitz critical point in this system at f=0.21. This is a special point where uniform and modulated ordered phases meet the disordered phase. However, Lifshitz critical points are believed to have a lower critical dimension of four and thus should not exist in three dimensions. The Lifshitz point is predicted presumably because SCFT neglects fluctuation effects. To test this explanation, we evaluate the phase diagram for complementary diblock copolymers using recent advancements in field-theoretic simulations.

[3312] (G*) Dynamical self-consistent field theory simulation of dendritic phytoglycogen nanoparticles (16:15, 15 minutes)

Presenter: MORLING, Benjamin (University of Guelph)

Phytoglycogen (PG) is a naturally occurring, highly branched, glucose dendrimer that is extracted from sweet corn as soft, compact nanoparticles [1]. We use dynamical self-consistent field theory (dSCFT) to simulate the dynamical evolution of a PG nanoparticle solubilized in water. We evolve the 11-generation dendrimer using an efficient, stable operator decomposition of the dendrimer into its branches. By varying the strength of the interactions between the PG nanoparticle and water, we are able to tune the size and the degree of hydration of the nanoparticle to be in agreement with the values measured using small angle neutron scattering (SANS) [1]. We show that our model is capable of reproducing the 'hairy' morphology of PG nanoparticles as inferred from rheology, SANS, and atomic force microscopy measurements. [1] J. Simmons et al. *Biomacromolecules* **2020**, 21, 4053-4062.

<u>W3-7 Light and Matter (DCMMP) | Lumière et matière (DPMCM)</u> - MDCL 1010 (15:15 - 16:30)

-Conveners: Michael Bradley

[3388] (G*) Towards an on-demand, all electrical single-photon source (15:15, 15 minutes)

Presenter: HARRIGAN, Stephen (University of Waterloo)

Single-photon sources (SPSs) are an elementary building block for quantum technologies. An ideal SPS is deterministic, on-demand and produces exactly one photon per pulse. Despite the large interest in single photons for both fundamental and applied applications, an ideal SPS remains elusive. The most common SPSs today are heralded single photons based on parametric down-conversion, which are neither on-demand nor deterministic. Many proposals for an ideal SPS have been made. One such proposal is the integration of a single-electron pump (SEP) in proximity to a p-n junction in a direct bandgap semiconductor^1. By using the SEP to deterministically inject individual electrons from the n-side into the p-side, single electrons can combine with a hole to produce a single photon. The operation of SEPs with sub-parts-per-million accuracy indicates that multi-electron injection, and therefore multi-photon pulses, will occur at a negligible rate. We report on progress towards such a single-photon source, describing both our progress in electrical measurements of SEPs and optical measurements of p-n junctions in undoped AlGaAs/GaAs heterostructures. Undoped AlGaAs/GaAs allows the integration of both electrons and holes in the same device^2. Provided that the injection rate is slower than the exciton lifetime, single-photon pulses will not overlap. The sub-nanosecond exciton recombination lifetime in GaAs should therefore allow photon emission rates above 1 GHz. References: B. Buonacorsi *et al*. Appl. Phys. Lett. **119**, 114001 (2021) A. Shetty *et al*. Phys. Rev. B **105**, 075302 (2022)

[3290] Optical Properties of SiGeSn Alloys Fabricated by Ion Implantation (15:30, 15 minutes)

Presenter: Mrs EKERUCHE, Chinenye (The University of Western Ontario)

The continuous advancement of photonics and the need for integration of electronics and photonics systems has been a motivation for trending research in Si-photonics. New materials are being developed with suitable properties for new infrared detector technologies for optoelectronics. We focus on photodetectors for Si-photonics by developing optimized SixGe1-x-ySny photodetector materials for short wavelength infrared (SWIR) operation. We fabricated SixGe1-x-ySny alloys by ion implantation to obtain different compositions of Si, Ge and Sn (Si, x = 0.7 - 1.0, Sn, y = 0 - 0.08) for operation at wavelengths of 1.2 – 1.5µm. The composition was controlled to tune the bandgap. Samples were then annealed in forming gas at temperatures in the 400-800 oC range for 30 minutes to reduce implantation-induced defects. The composition, depth profile, and effects of annealing were determined by Rutherford Backscattering Spectroscopy (RBS) analysis (with channeling). X-ray Photoelectron Spectroscopy (XPS) was used to study chemical states of the alloy, and minute shifts in binding energy were observed throughout the sample depth. Although no strong evidence of Sn segregation was observed from XPS and RBS, the SEM results revealed Sn segregation at 600oC and above, at high Sn concentrations. RBS also revealed significant diffusion, as well as crystallization of Ge and Si at 600oC and above. Spectroscopic ellipsometry was applied to study changes in optical properties in the 600 - 1200nm range due to alloying. SiGeSn alloy samples exhibit differences in optical characteristics from the Si reference, for instance increased light absorption and lowering of light penetration depth in the 600-1200nm range. SiGeSn alloy growth by ion implantation provides an effective way to achieve monolithic integration on a Si wafer, and thus provides an attractive alternative for development of SWIR detectors in a broad wavelength range.

[3424] (I) Simulating the dynamics of photo-excitations in disordered materials (15:45, 30 minutes)

Presenter: Prof. SIMINE, Lena (McGill University)

Abstract not yet received.

W3-3 Cell and Membrane Biophysics (DPMB) | Biophysique de la cellule et des membranes (DMPB) - MDCL 1102 (15:15 - 16:30)

-Conveners: Melanie Campbell

[3344] (G*) Vesicle Viewer: Online visualization and analysis of small-angle scattering from lipid vesicles (15:15, 15 minutes)

Presenter: LAURENT, Aislyn

Large volumes of complex experimental data require time, expertise, and equally complex tools to process. This creates a barrier, where experienced researchers and new students alike lack the resources required to maximize the utility of their results. Vesicle Viewer is a free online tool designed to break down those barriers, and assist researchers at all levels in processing critical information contained in small-angle scattering (SAS) data. Small-angle X-ray and neutron scattering are among the most powerful experimental techniques for investigating the structure of biological membranes. Vesicle Viewer utilizes a modified scattering density profile (SDP) analysis called EZ-SDP in which key bilayer structural parameters, such as area per lipid and bilayer thickness, are easily and robustly determined. Notably, included is a model able to describe an asymmetric bilayer, whether it be chemically or isotopically asymmetric. Through the strategic application of well-established python libraries, this easy-to-use data visualization tool can allow researchers at any level to take full advantage of their SAS data and maximize the use of limited resources. Find this web-based application, available for anyone to use, here: https://vesicleviewer.dmarquardt.ca/.

[3266] (U*) MEMBRANE BASED BIOSENSOR FOR THE DETECTION OF ANTIBIOTICS (15:30, 15 minutes)

Presenter: Ms MICHAL, Feigis (McMaster University)

Biosensors can be used for the electronic detection of substances or molecules. Two critical components in a sensor's design are the bio element and the transducer which convert molecular interactions into a readable, concentration dependent signal. Cell membranes are ideal bio elements as they provide a naturally high selectivity and sensitivity. However, using their full potential is challenging. We present a membrane-based biosensor for the rapid screening of antibiotics. Commercially available gold electrodes are functionalized by applying solid supported cell membranes. Two membranes were tested: the membrane of E-coli bacteria as well as the membrane of human red blood cells. We show that the presence of antibiotics can be detected electronically through electrochemical impedance spectroscopy (EIS) and the molecular interaction of the antibiotic can be analyzed by simultaneously fitting the real and imaginary component of the impedance signal. These innovative sensors combine membrane biophysics with an electronic readout and machine learning for rapid screening and identification of antibiotics including a prediction of the Minimum Inhibitory Concentration (MIC).

[3384] (U*) Can Confocal Microscopes Detect Transcriptional Condensates? (15:45, 15 minutes)

Presenter: HODGINS, Lydia

Recently, it has been proposed that gene transcription occurs in transcriptional condensates. Transcriptional condensates are membraneless nuclear compartments formed through liquid-liquid phase separation. These condensates create regions with a high concentration of transcription factors which could provide an environment for transient transcription factor binding to efficiently govern specific gene expression. The existence of transcriptional condensates, however, is not firmly established. The goal of this project was to predict whether condensates containing the Bicoid protein could be detected using a confocal microscope. Bicoid is a transcription factor in *Drosophila melanogaster* embryos which controls anterior-posterior patterning of the embryo. The project began by examining the structure of Bicoid with bioinformatic tools. It was found that Bicoid contains intrinsically disordered regions necessary for a protein to undergo liquid-liquid phase separation. Then confocal images of a nucleus containing a Bicoid condensate were simulated under varying physical and imaging parameters. These images were analyzed by fitting photon counting histograms and by filtering the image for pixels with intensities greater than a threshold value. The motivation of this analysis was to see if condensates can be identified from deviations in intensities. The results of the analysis indicated that deciphering noise in concentration from photon noise is challenging due to the temporal and spatial scale of transcriptional condensates existing at the limit of that of a confocal microscope.

[3012] (G*) Erythro-PmBs: A Novel Polymyxin B Delivery System Using Antibody-Conjugated Hybrid Erythrocyte Liposomes (16:00, 15 minutes)

Presenter: KRIVIC, Hannah

As a result of the growing world-wide antibiotic resistance crisis, many currently existing antibiotics have become ineffective due to bacteria developing resistive mechanisms. There are a limited number of potent antibiotics that are successful at suppressing microbial growth, such as polymyxin B (PmB); however, these are often deemed as a last resort due to their toxicity. We present a novel PmB delivery system constructed by conjugating hybrid erythrocyte liposomes with antibacterial antibodies to combine a high loading efficiency with guided delivery. The retention of PmB is enhanced by incorporating negatively charged lipids into the red blood cells' cytoplasmic membrane (RBCcm). Anti- E. coli antibodies are attached to these hybrid erythrocyte liposomes by inclusion of DSPE-PEG malemeide linkers. We show that these Erythro-PmBs have a loading efficiency of ~90%, and are effective in delivering PmB to E. coli, with values for the minimum inhibitory concentration (MIC) comparable to those of free PmB. MIC values for K. aerogenes; however, were significantly increased well beyond the resistant breakpoint, indicating that inclusion of the anti- E. coli antibodies enables the Erythro-PmBs to highly selectively deliver antibiotics to specific targets. This versatile platform can be used for different types of antibiotics and bacterial targets. Krivic H, Himbert S, Sun R, Rheinstadter MC. Erythro-PmBs: A highly selective polymyxin B delivery systemusing antibody-conjugated hybrid erythrocyte liposomes. Under Review. *ACS Infectious Diseases*. 2021

[2985] (G*) Dynamic behaviour of microtubules around the critical temperature and effect of the electric field produced by these vibrations on its environment (16:15, 15 minutes)

Presenter: Dr NGANFO YIFOUE, Willy Aniset (Université de Dschang)

In this paper, we study the microtubule as a ferroelectric system. The behaviour of microtubules around the critical temperature was evaluated, and the effect of the electric field produced by the microtubules on its environment was determined. Also, the mean-field theory approximation (MFTA) was used to evaluate the total polarization and free energy around the critical temperature. These parameters are evaluated according to the physiological and critical temperatures in the absence and the presence of the electric field produced by the vibrations of the microtubule network. Results show that the microtubule (MT) has a spontaneous polarization in the absence of an electric field which collapses above the critical temperature. Moreover, the transition from ferroelectric to paraelectric state occurs with increasing physiological temperature. The microtubule stability is observed at the minimal free energy. The free energy is higher in the paraelectric state than in the ferroelectric state and changes its behaviour at high temperatures. The electric field stabilizes and orients the microtubule in the direction of the field. The microtubule produces electric fields that strongly interact with its biological environment at a short distance while long-distance interactions are weak.

W3-4 DPE V (DPE) | DEP V (DEP) - MDCL 1009 (15:15 - 16:30)

-Conveners: Daria Ahrensmeier

[3448] (I) Teaching quantum computing through quantum software (15:15, 30 minutes)

Presenter: DI MATTEO, Olivia (The University of British Columbia)

In winter 2022, I designed and delivered an undergraduate course in quantum computing for 4th year computer engineering students at UBC. The core tenet of the course was "implement *everything*": roughly half the lecture time consisted of live-coding the theory and algorithms to show how they are implemented in practice, and demonstrating tools that are used on a daily basis in research. I will give an overview of the course, assessment strategies, and highlight what worked well and what didn't. Furthermore, while quantum computing is inherently interdisciplinary, it is still quite often taught by people with physics backgrounds, in physics departments. As the subject becomes more popular and expands to lower-year undergraduate courses in a variety of departments, we require different approaches to both what content is covered, and how. To exemplify this, I will discuss how teaching the course to a computer engineering audience has caused me to majorly rethink the order in which quantum computing material is taught in order to make it more accessible.

[3286] Fully Immersive VR in Teaching and Science Outreach (15:45, 15 minutes)

Presenter: Mr BARRETT, Jonathan (MUN)

While certainly not a replacement for hands-on physics labs, the fully immersive virtual reality (VR) technology creates opportunities for new learning experiences that would otherwise be too expensive or impossible implement, such as observing high-energy particle scattering or touring the Solar System. A standard VR system is also relatively easy to transport and set up, making it an excellent tool in science promotion, especially for programs engaging small groups of pre-selected students, such as girls, rural students, or Indigenous youth. We demonstrate that at the modern VR systems such as HTC VIVE or Oculus Rift are now affordable to most university physics program and can be set up and run by physics majors with some minimal training in courses such as Astrophysics and Subatomic Physics. The fully immersive VR technology also provides excellent training opportunities for students interested in developing their own physics simulations.

[3274] (G*) Virtual Learning Resources for Education and Training in Neutron Scattering (16:00, 15 minutes)

Presenter: ZI, Yijia (McMaster University)

Neutron scattering is one of the most powerful experimental techniques in the modern study of materials. Neutrons are used to investigate the structure and dynamics of materials on an atomic scale, helping scientists to understand the properties of materials ranging from high-temperature superconductors to red blood cells and turbine blades. However, access to neutron beams is in short supply. There is only one facility for neutron scattering in Canada (the McMaster Nuclear Reactor), and opportunities for in-person teaching and learning are rare. The goal of this project was to develop virtual learning resources for education and training in neutron scattering techniques and applications. This project consists of three parts. First, we have created a series of videos explaining the basic principles of neutron scattering targeting first-year university students in physics. These videos can be used individually or as add-on materials for the first-year introductory physics course. Second, we have created a series of virtual lab experiments targeted at upper-year undergraduate students. These experiments can be combined to form a one-semester practical introduction to neutron scattering, or they can be used individually as modules in an existing upper-year laboratory or experimental methods course. Third, we have also developed two new virtual instruments that simulate neutron scattering beamlines at the McMaster Nuclear Reactor. This includes virtual versions of the McMaster Alignment Diffractometer (MAD) and the McMaster Small-Angle Neutron Scattering facility (MacSANS). This simulation explains the function of the instrument and provides users opportunities to conduct virtual experiments with a variety of materials.

[3478] (U*) Novel methods to model the spread of COVID-19 in Kingston and inform public health policy (16:15, 15 minutes)

Presenter: MICUDA, Ashley (Queen's University)

In this study led by a group of multidisciplinary undergraduate students, a novel model for the propagation of COVID-19 was developed to understand the spread in Kingston, as well as the effect of vaccination interventions. The simulation is coded using the

Monte Carlo method with an agent-based model in python, to simulate a realistic COVID-19 situation using current known virus parameters. With team members from various faculties, disciplines, and levels of education (undergrad, masters, and postdoc) working on this project, undergrads get the opportunity to learn how to collaborate with people within the department that have different areas of strength and physics knowledge. Students also had the opportunity to work alongside experts from other departments, including the Department of Health Sciences, which gives us experience working with individuals from other specialties. The modelling framework was originally developed in the context of research with an all-physics group over the summer of 2020 and has since been enhanced by adding the input of students from other disciplines. Each person has been developing a broad set of practical research skills with a focus on certain skills of use in physics (as this is primarily a physics-based group). These skills include evaluating scholarly articles and extracting information relevant to our project, developing proposals and applying for funding, communicating our results through scientific writing, and learning to code in Python which is a very useful skill in many fields of science. This project involves learning to develop complex production software collaboratively using the version control software Git. Throughout this project, students get to see the entire software life cycle, from initial planning and creating a simple model, then incrementally adding new features and improving the model, and finally making production level code for use by our peers. Along the way, learning new programming techniques such as Monte Carlo simulations, learning to write strong code, and gaining experience critically examining and optimizing software. From this, preliminary findings highlight the reduction in spread from non-pharmaceutical interventions using the developed agent-based modelling techniques.

W3-5 Panel Report on ICWiP Mtg + DGEP Networking Session (DGEP) | Rapport sur la réunion CIFEP et session de réseautage DGEP (DGEP) - MDCL 1309 (15:15 - 16:30)

-Conveners: Barkanova, Svetlana (Grenfell Campus of Memorial University)

[3501] (I) Panel Report from 7th IUPAP International Conference for Women in Physics (15:15, 30 minutes)

Presenters: CAMPBELL, Melanie, RANGAN, Chitra (University of Windsor)

The Canadian delegation* to the 7th IUPAP International Conference for Women in Physics was a diverse group of physicists with representation from universities and national labs. The delegates presented a poster on the progress of gender equity in physics in Canada, participated in workshops and contributed to the development of resolutions submitted to IUPAP for adoption. In this talk, we present a short overview on the progress of gender equity in Canada, and share the lessons learned from ICWIP2020. *The Cdn delegation included: M. Campbell, Dept. of Physics & Astronomy, Univ. of Waterloo; E. Corrigan, Dept. of Physics, University of Guelph; S. Ghose, Dept. of Physics & Computer Science, Wilfrid Laurier Univ.; A. Kwiatkowski, TITAN Program, TRIUMF; C. Rangan, Dept. of Physics, Univ. of Windsor; S. Scarfe, Faculty of Education, Univ. of Windsor; and T. Antimirova, Dept. of Physics, Ryerson Univ.

time	[id] title	presenter
15:45	DGEP Networking Session (45 minutes)	

Division Judges Meeting - Oral and Poster Competition | Rencontre des juges des divisions - compétition orale et compétition affiche - MDCL 2230 (16:30 - 17:30)

Decide Competitors for Thurs. PM.

-Conveners: William Whelan

Student Session : Industry Meet & Mingle | Session étudiante : Rencontre avec l'industrie - MDCL 1110 (16:45 - 18:00)

-Conveners: D'Souza, Ian (Honeywell); Cluff, Daniel (University of Exeter)

CAP President's Report | Rapport du président de l'ACP - Manu Paranjape - MDCL 1305/07 (16:45 - 17:45)

-Conveners: Thompson, Robert (University of Calgary)

CAP-level BSOC and BSPC Judges Meeting | Réunion des juges (niveau ACP) pour MCOE et MCAE - MDCL 2230 (17:30 - 17:45)

-Conveners: William Whelan

Break: (for those who purchased tickets) Take Rented Bus, or personal car, to Banquet Dinner (18h00-19h10) | Pause: (pour ceux qui ont acheté des billets) prendre le bus loué, ou une voiture personnelle vers le banquet (18h00-19h10) - Front of MDCL (18:00 - 18:30)

Break for Dinner (18h00-20h00) | Pause pour souper (18h00-20h00) (18:00 - 20:00)

CAP Banquet + Fellows Recognition Dinner - Limited seating. Tickets will not be sold at the door | Banquet et reconnaissance des Fellows de l'ACP - Sièges limités; aucun billet vendu à l'entrée - Off campus venue - Royal Botannical Gardens (18:30 - 21:30)

-Conveners: Paranjape, Manu (Université de Montréal)

Thursday, 9 June 2022

Visit CAP Congress website (https://www.cap.ca/congress/2022) for information about meetings scheduled outside of Congress week, eg AGM, NSERC Community Update, Division business meetings (07:00 - 07:05)

Congress Registration and Information (7h30-13h30) | Inscription au congrès et information (7h30-13h30) - MDCL Lobby (07:05 - 07:30)

CINP Board Meeting | Réunion du conseil de l'ICPN - MDCL 2230 (07:30 - 08:45)

CINP Board meeting

-Conveners: Garth Huber

R1-7 Materials for Energy Applications (DCMMP) | Matériaux pour applications en énergie (DPMCM) - MDCL 1010 (08:45 - 10:15)

-Conveners: Clancy, Patrick (McMaster University)

[3428] (I) The asymmetric charge-discharge kinetics in Li$_{1-x}$Ni$_{1+x}$O$_2$ from first principles (09:15, 30 minutes)

Presenter: Prof. XIAO, Penghao (Dalhousie University)

The ever-increasing demand on Li-ion batteries requires the cathode materials to be inexpensive and environmentally friendly. LiNiO$_2$ is such a promising Co-free cathode. However, the presence of Ni in the Li layer (Ni$_{Li}$) becomes more common without Co, which limits its electrochemical performance. These excess Ni could randomly distribute in the bulk due to Li deficiency during synthesis, or/and form a surface densified phase due to oxygen loss during cycling. Their interactions with Li, on top of Li-Li interactions, further complicate the non-dilute Li diffusion. In this talk, I will combine the density functional theory (DFT), cluster expansion and kinetic Monte Carlo (KMC) simulations to identify the effects of Ni$_{Li}$ on Li transport in realistic conditions. Interestingly, both types of Ni$_{Li}$ impede Li transport at the end of charge and discharge, but not at the beginning. This asymmetry kinetics cannot be solely explained by the Li diffusivity as a function of Li contents but stems from the phase boundary orientation between Li orderings. Ni$_{Li}$ from synthesis smooths the voltage plateaus and contributes to the 1st cycle capacity loss. Ni$_{Li}$ from degradation hinders Li transport more severely when the densified phase fully covers the particle surface. Moreover, this surface phase kinetically traps the last 25% Li for an extremely long time during charge but shows little impedance when Li%>25%. These understandings could open new ways to engineer the transport properties of LiNiO$_2$-based materials.

[3427] (I) High Performance Nano-Engineered Ion-Exchange Membranes for Clean Energy Systems (09:45, 30 minutes)

Presenter: Prof. KAUR, Jasneet (Brock University)

The increasing energy demand and global climate change entails for designing next-generation clean energy technologies. It is critical to address increasing global concerns pertaining decarbonization of economy and development of clean and sustainable energy conversion and storage technologies using advanced materials. Many types of clean energy storage and conversion systems are still emerging technologies, and these will continue to be part of extensive research over the next twenty years due to the increasing demand of clean energy and challenges in the existing technologies. Moreover, to focus on newly emerging applications, such as wearable electronics and powering electric vehicles, advanced materials with superior multifunctional capabilities that enable high performance, durability and lightweight designs for robust and flexible energy storage and conversion devices are highly demanded. For realizing this, serious efforts need to be undertaken to improve the performance of the electrodes and designing novel solid-state electrolytes by engineering multifunctional materials to achieve significantly improved capacity, high-rate capability, enhanced safety, and longer life cycle. We designed and created high performance solid-state electrolytes by nanoengineering a special class of layered materials using novel technology for scalable production. These electrolytes are electrochemically stable, highly conductive, and mechanically robust, which provide specific ion conduction for various types of ions, including protons, hydroxides, and lithium ions. The strategy of synthesizing solutions for creating the chemical structure of ion exchange membranes (IEMs) is using advanced functional two-dimensional (2D) nanomaterials which provide requisite properties to the final structure of IEMs. The casted IEMs exhibit outstanding ion transport performance and cross the threshold of benchmark IEMs, conventionally used in the electrochemical energy storage and conversion industry such as fuel cells, electrolyzers, batteries, and supercapacitors.

R1-1 Precision and Dark Matter Experiments (PPD) | Expériences de précision et sur la matière sombre (PPD) - MDCL 1105 (08:45 - 10:15)

-Conveners: Rainer Dick

[3399] Magnetic Holding Field Requirements for UCN Precession in the TUCAN EDM Experiment (08:45, 15 minutes)

Presenter: MCCREA, Mark

The TUCAN EDM experiment aims to measure the neutron electric dipole moment (EDM) to a precision of $1\times 10^{-27}~e$cm, by making a precise measurement of the neutron precession frequency change in a parallel magnetic and electric field when the eletric field direction is inverted. To make this measurement a coil will be used to provide a homogeneous precession magnetic field of $B_0=1~\mu$T inside a magnetically shielded room. To maintain the ultra cold neutron polarization during the measurement cycle a very high magnetic field uniformity is required. I will describe the coil design, and how we plan to meet the magnetic requirements by being able to adjust the coil placements to submillimeter precision.

[3120] Radioactive Background Characterization of the Cryogenic Underground TEst Facility (CUTE) (09:00, 15 minutes)

Presenter: Dr SCORZA, Silvia

The Cryogenic Underground TEst Facility (CUTE) is fully operational in the low-radioactivity environment of the SNOLAB Underground Laboratory. Estimation of the background from radioactive processes via Geant4 simulation is crucial in informing the background budget for the facility. The radioactive background characterization of the CUTE facility will be presented along with the background model validation through comparison with recently acquired data.

[3094] DEAP-3600 Hardware Upgrades (09:15, 15 minutes)

Presenter: DAUGHERTY, Sean (Carleton University)

DEAP-3600 is a single-phase liquid argon (LAr) direct dark matter search experiment. DEAP uses a LAr target to search for weakly interacting massive particles (WIMPs), a prime candidate for dark matter. The LAr is contained within an acrylic vessel surrounded by 255 photomultiplier tubes in order to detect scintillation light. Background characterization for events that might mimic a WIMP interaction has been carried out with DEAP-3600 data. While these backgrounds are already very low, there are two sources of alpha backgrounds that can be improved: in the neck of the detector and from the particulates suspended in the bulk LAr. Upgrades to the detector will significantly reduce both of these sources. A new set of LAr flow guides coated in pyrene, a fluorescent material, will be installed in the neck of the detector to increase our rejection of these neck alphas. In order to reduce the backgrounds due to suspended particulates, two new methods of argon filtration will be used both to reduce the amount of dust entering the detector and also to allow for analysis of any dust extracted from the detector. These hardware upgrades are currently underway on DEAP-3600. These upgrades will both improve DEAP-3600 results and inform on construction of future dark matter experiments.

[3131] Searching for Dark Matter with Liquid Argon: DEAP-3600, DarkSide-20k, and Argo (09:30, 15 minutes)

Presenter: JILLINGS, Chris

This overview talk will feature the latest results from DEAP-3600, including world-leading constraints on Planck-scale mass dark matter. Located at SNOLAB, 2 km underground in Sudbury, Ontario, the DEAP-3600 experiment consists of 3.3 tonnes of liquid argon in a large acrylic cryostat instrumented with 255 photomultiplier tubes. The broad physics programme of DEAP-3600 will be presented, including measurements and searches for new physics. We present the continuing importance of liquid-argon detectors for dark matter and describe the DarkSide-20k detector under development at the Gran Sasso Laboratory in Italy, and Argo, a future multi-hundred tonne detector to be constructed at SNOLAB.

[3219] Calibration and characterisation of an “achinos” multi-anode sensor for the SNOLAB commissioning of the NEWS-G experiment (09:45, 15 minutes)

Presenter: SAVVIDIS, George (Queen's University)

The NEWS-G experiment employs Spherical Proportional Counters (SPC) towards the direct search for light Dark Matter candidates in the 0.1 – 10 GeV mass range. The detector provides high sensitivity to low-energy recoil detection thanks to the choice of various gases and operating pressures. In addition, the sensitivity is enhanced by the properties of the central anode where the avalanche takes place. The electric field drives the drift of the primary ionization and provides the amplification needed to detect sub-keV nuclear recoils down to single-electrons. A novel multi-anode sensor, named "achinos", at the center of the SPC allows for operation at higher pressures, and higher primary ionization collection efficiency thanks to enhanced electric fields at large radii. Following the first implementation of the "achinos" for NEWS-G at LSM, France, the next use will take place at SNOLAB using Ne+7%CH4 as target gas. A series of characterization measurements towards achieving simultaneously high gain, stability and satisfying resolution in a two-channel "achinos" configuration is studied. In this talk, results of characterization and a series of calibrations will be presented.

[3293] Light-only Liquid Xenon (LoLX) Experiment for Cherenkov and Scintillation Light (10:00, 15 minutes)

Presenter: Dr REBEIRO, Bernadette Maria (McGill University)

The Light-only Liquid Xenon (LoLX) experiment has been developed to study the properties of light emission and transport in liquid xenon (LXe) using 96 Hamamatsu VUV4 SiPM modules. LoLX is also being used to investigate the timing structures of scintillation and Cherenkov light production in LXe and provide a better understanding of the effects of external cross-talk between neighbouring SiPM modules. An update of LoLX is being planned to investigate the long-term stability and performance of the Hamamatsu VUV4 SiPMs in LXe environment as well as measure the performance of FBK VUV-HD3 SiPMs. Such studies of cross-talk and validation of photon transport simulations are important for low background LXe experiments such as nEXO that will search for the neutrino-less double beta (0νββ) decay of Xe-136. To detect a 0νββ decay signal, nEXO will use SiPMs to register the LXe scintillation light and a segmented anode to measure ionization electrons. In this talk, I will present the status of LoLX as well as preliminary results and discuss future plans of the LoLX collaboration.

Best Student Poster Competition Finals Judging (Closed to delegates) | Jugement des finales de la compétition d'affiches étudiantes (session fermée) - MDCL 1305/07 (08:45 - 10:45)

-Conveners: William Whelan

R1-6 Testing the Standard Model and Searches for New Physics at Intermediate Energies (DNP) | Tests du modèle standard et recherche de nouvelle physique aux énergies intermédiaires (DPN) - MDCL 1008 (08:45 - 10:15)

-Conveners: Wouter Deconinck

[3021] (I) Deep Exclusive $\mathrm\pi^-$ Production using a Transversely Polarized $\mathrm{^{3}He}$ Target and the Solenoidal Large Intensity Device (SoLID) (08:45, 30 minutes)

Presenter: Prof. HUBER, Garth

The Solenoidal Large Intensity Device (SoLID) is a proposed next-generation detector to be installed at Jefferson Lab, to study hadronic structure at high luminosity ($>10^{37}$/s/cm^2) over the broad kinematic range enabled by the 12 GeV electron beam of the Continuous Electron Beam Accelerator. SoLID's symmetric azimuthal acceptance will enable Generalized Parton Distributions (GPDs) to be probed via the single-spin asymmetry in exclusive π^- electroproduction from a transversely polarized neutron (^{3}He) target. The $\sin(\phi-\phi_S)$ Fourier amplitude (ϕ: scattering plane-reaction plane azimuthal angle, ϕ_S: scattering plane-target polarization azimuthal angle) is particularly sensitive to the spin-flip GPD $\tilde{E}$, which is at present nearly unknown. The $\sin(\phi_S)$ amplitude is also extremely important, as it provides powerful constraints on the higher-twist transversity GPDs. I will give an update on the SoLID status, and present projections indicating a significant advance over the only measurement to date (HERMES 2010), with broader kinematic coverage and greatly reduced uncertainties.

[3335] (I) Beyond-Standard-Model Physics using Rare Eta and Eta-prime Neutral Decays (09:15, 30 minutes)

Presenter: PAPANDREOU, Zisis

Precision measurements of several eta and eta′ decay channels, with emphasis on rare neutral modes, will be carried out at the Jefferson Lab Eta Factory (JEF) in 2024 using an upgraded GlueX detector in Hall D. The combination of highly-boosted eta/eta′ production, recoil proton detection, and a new fine-granularity high-resolution 1600-crystal lead-tungstate insert in the forward calorimeter confers uniqueness to JEF compared to other similar experiments worldwide. JEF will search for new gauge bosons in portals coupling the SM sector to the dark sector in the invariant mass region below 1 GeV and will provide constraints on C-violating, P-conserving reactions.

[3465] (I) Global Extraction of Nucleon Generalized Parton Distributions from Deeply Virtual Compton scattering (09:45, 30 minutes)

Presenter: Dr SHIELLS, Kyle (Center for Nuclear Femtography)

Generalized parton distribution functions (GPDs) hold unprecedented information about the structure of hadrons. One prime example of what they can tell us is how the proton and neutron acquire their observable spin of 1/2, through what are known as spin sum rules. In the first part of this talk, I will discuss these spin sum rules, including one which is most accessible experimentally. These GPDs however, can only be probed from a relatively new line of exclusive scattering experiments. One such flagship process for doing so is Deeply Virtual Compton scattering (DVCS). I will highlight the relationship between this cross section and the GPDs. This will include a deep phenomenological look at how one can attain GPDs from DVCS. The greater scheme of the global extraction of GPDs will also heavily rely on lattice data, making it unique to the global analysis seen in the extraction of parton distribution functions from deep inelastic scattering processes.

R1-5 Polymer Physics Theory (DCMMP) | Théorie physique des polymères (DPMCM) - MDCL 1016 (08:45 - 10:15)

-Conveners: Robert Wickham

[3032] Stabilizing Binary Mesocrystals via Block Copolymer Blends (09:00, 15 minutes)

Presenter: XIE, Jiayu

Previous work has demonstrated that multiblock block copolymers with designed architectures offer unlimited opportunities to obtain novel nanoscale structures. However, synthesizing multiblock copolymers with complex architectures is challenging and expensive. In this research we explore the possibility of using blends of simple copolymers with designed secondary interactions as an alternative route to access desired structures. Specifically, we examined the phase behavior of ABC/DB/EB ternary blends and AB/CD binary blends using the self-consistent field theory, aiming to stabilize the desired binary mesocrystals composed of two types of spherical domains. Conditions for forming various binary mesocrystals are obtained from the resulting phase diagrams. We also discuss the mechanisms to form these novel phases in both cases. Our study offers a simpler approach to access the novel macromolecular binary mesocrystals and adds to the understanding of the self-assembling behaviour of block copolymer blends.

[3209] Multiphase Transitions Involving Confined Polymers in Solution (09:15, 15 minutes)

Presenter: CHANGIZREZAEI, Setarehalsadat

There has been a growing interest in the study of deformation of a nanochannel confined polymer as it plays an important role in biological phenomena such as DNA mapping, DNA condensation, protein folding, and chromatin organization. Therefore, it is important to investigate the statistics and dynamics of confined polymers and predict their time and space evolution. Acquiring information on polymer concentration can be used to model transient and steady-state non-equilibrium phenomena such as compression against defects and chain stretching and compression in crossing the region of low to high confinement. In our work, we studied the compression of a long polymer chain with 256 monomers confined in a nanochannel by being pushed in a fluid by a large sphere through the channel. We used LBMD(lattice-Boltzmann molecular dynamics) to model the particles and the fluid in the channel. We used a wide range of sphere speeds and investigated how the sphere's speed affects the configuration of a confined chain in a nanochannel. At different chain speeds, different states of compaction of the polymer are observed. At intermediate speeds, these states can coexist. We characterize and map out a phase diagram of these states.

[3089] Formation of Complex Spherical Packing Phases in Binary Blends of Diblock Copolymers (09:30, 15 minutes)

Presenter: LI, Yu

The emergence and relative stability of complex spherical packing phases in binary blends composed of A1B1 and A2B2 diblock copolymers are systematically studied using the polymeric self-consistent field theory. Phase diagrams are constructed in a large parameter space of the system. The results demonstrated that complex spherical packing phases including the Frank-Kasper A15 and phases, and the Laves C14 and C15 phases can be stabilized by the addition of longer A2B2 copolymers to asymmetric A1B1 - copolymers. Furthermore, the formation of complex spherical packing phases requires that the added A2B2 - copolymers have a longer A-block. A detailed analysis of the block distributions reveals the existence of inter-and intra-domain segregation of different copolymers, which provides a mechanism to aid the formation of spherical domains with different sizes and shapes. The predicted phase behaviours require that the added A2B2 - copolymers have a longer A-block and an overall chain length at least comparable to the host copolymer chains are in good agreement with available experimental and theoretical results. The study demonstrated that binary blends of diblock copolymers provide an efficient route to regulate the emergence and stability of complex spherical packing phases.

[3127] Fluctuation Effects on Diblock Copolymer Melts using Field-Theoretic Simulations (09:45, 15 minutes)

Presenter: Dr BEARDSLEY, Tom (University of Waterloo)

Self-consistent field theory (SCFT) has been remarkably successful in predicting the ordered phases of diblock copolymer melts. However, SCFT fails to predict the correct qualitative behavior along the order-disorder transition. It is well understood that this is because the saddle-point approximation of SCFT neglects fluctuation effects, which are particularly important for disordered phases. Here, we correct for this deficiency by performing field-theoretic simulations (FTS), where the field-theoretic Hamiltonian of SCFT is simulated. This brings the behaviour into full agreement with experiments. Most notably, the FTS provide the first confirmation that the complex Fddd phase is sufficiently stable to survive compositional fluctuations. As such, FTS appear to be a reliable means of accounting for the fluctuation effects neglected by SCFT. Furthermore, FTS can be easily generalized to more complex block copolymer systems, which is not the case for conventional particle-based simulations.

[3055] Memory effect in simulations of asymmetric diblock copolymers under thermal processing (10:00, 15 minutes)

Presenter: YANG, Yang

Recent experiments [Kim et al. Science 356, 520 (2017); PNAS 115, 847 (2018)] observed that the temperature protocol used to heat and cool an asymmetric diblock copolymer from its disordered micelle liquid state to its ordered micelle crystal phase, and back, can influence which ordered phase is found. This suggests some memory of the initial ordered micelle phase is preserved in the disordered micelle state. To develop an understanding of this memory effect, we perform simulations of a time-dependent Landau-Brazovskii model, which has stability regions for disorder, disordered micelles, BCC, FCC, as well as Frank-Kasper phases. Our protocol is to equilibrate a low-temperature ordered micelle phase, rapidly heat to just above the order-disorder transition, anneal for a time tH, then quench back to the low temperature and observe the time, tL, it takes for the ordered phase to (re-)form. For small tH, we find that the ordered phase re-forms quickly (tL is small), regardless of whether the original ordered phase is stable or metastable. We measure tL as a function of tH and find a threshold tH above which the system remains in the disordered micelle liquid over our (long) simulation time. We examine trends of this memory effect as we move around the low temperature region of the phase diagram. These results shed light to the origin of the experimentally observed memory effect.

R1-4 Precision Nuclear Processes and Beyond (DNP) | Processus nucléaires de précision et au delà (DPN) - MDCL 1110 (08:45 - 10:15)

-Conveners: Barkanova, Svetlana (Grenfell Campus of Memorial University)

[3468] (I) Using statistical methods to determine the astrophysical origins of heavy nuclei (08:45, 30 minutes)

Presenter: VASSH, Nicole (TRIUMF)

For more than 60 years the solar isotopic abundances have been providing clues to the astrophysical origins of elements such as the heavy species formed by the rapid neutron capture process (r-process). Although the era of multi-messenger astronomy presents new opportunities to probe single r-process events, the solar abundances still serve as the key informant of the contributions of a given site to the enrichment of the Solar System. To assess the dominant source of heavy r-process elements in a modern way, statistical methods offer a fresh and innovative approach. We apply such techniques to the r-process rare-earth abundance peak due to its high sensitivity to the nuclear properties of lanthanides as well as the astrophysical environment. I will describe recent results which derive the masses capable of forming the rare-earth peak in accretion disk winds as well as neutron star merger dynamical ejecta. I will also discuss how the latest precision measurements and upcoming experiments are in a prime position to illuminate key nuclear properties which affect these studies.

[3157] Cluster recognition using Machine Learning applied to Neutron star crusts (09:15, 15 minutes)

Presenter: Dr BOHORQUEZ, Jaime (University of Guelph)

The core of a neutron star can be considered as uniform nuclear matter with densities above the nuclear saturation density $n_0=3 \times 10^{14}~g/cm^3$. On the other hand, the outer crust of a neutron star is a Coulomb crystal with densities of several orders of magnitude below the nuclear saturation density. In between these two, we can find complex, non-uniform phases of nuclear matter called nuclear pasta, the product of the attractive-repulsive nuclear and Coulomb forces. The nuclear pasta phases and transitions are usually described with the help of the Minkowski functionals, which are a set of metrics to quantify geometrical shapes. In the present study, we use Molecular Dynamics to simulate nuclear matter under the conditions of nuclear pasta. We explore the use of Machine Learning algorithms to describe the phases and transitions of the nuclear pasta.

[3149] Study of cross-shell excitations near the 'island of inversion' using fusion-evaporation and Doppler shift methods (09:30, 15 minutes)

Presenter: STAROSTA, Krzysztof (SFU)

The 'island of inversion' centred on ^{32}Mg is characterized by ground state configurations with an inverted ordering of sd and pf (intruder) neutron orbitals due to nuclear deformation and nucleon-nucleon interactions. For neutron rich sd shell nuclei outside of the 'island of inversion', similar configurations incorporating the neutron pf shell occur in levels with high excitation energy and spin. Several recent studies have used fusion-evaporation reactions to preferentially populate and study these intruder states, including a recent experiment at the ISAC-II facility at TRIUMF in which the nuclides ^{25}Na and ^{28}Mg were produced following ^{12}C + ^{18}O fusion [1, 2]. In this experiment, fusion-evaporation exit channels were separated via time coincident identification of charged particles and gamma rays. Gamma-ray spectroscopy utilized the TIGRESS array at ISAC-II. Charged particles were detected and identified using a recently completed CsI(Tl) `ball' scintillator array, developed at Simon Fraser University and commissioned at TRIUMF [3]. Lifetime measurements of excited states populated in the channels of interest were performed using Doppler shift methods. Six new excited states in ^{25}Na and ^{28}Mg were identified, including candidates for the $I^{\pi}=5^+_1,6^+_1$ levels in ^{28}Mg. Evidence for negative parity states was also observed, including a candidate for the $I_{\pi} = 13/2^-_1$ level in ^{25}Na and an unusually long-lived state in ^{28}Mg thought to decay by an M2 transition ($I^{\pi}=(0,4)^{-}$). The energies of these levels are consistent with predicted intruder states arising from single neutron excitation to the pf shell, using the SDPF-MU and FSU shell model interactions. This data and its interpretation with respect to the `island of inversion' will be discussed, along with future plans to extend this work towards $N=20$ by studying ^{32}Si and other nearby nuclides populated following ^{12}C + ^{22}Ne fusion. [1] J. Williams et al., PRC 100 014322 (2019). [2] J. Williams et al., PRC 102 064302 (2020). [3] J. Williams et al., NIM A 939 1-9 (2019).

[3235] A Capillary Probe for Ion Extraction from Liquid Xenon (09:45, 15 minutes)

Presenter: COLLISTER, Robert (Carleton University)

Double beta decay is a process whereby two neutrons simultaneously decay into protons, emitting two electrons. These exceedingly rare decays have been observed with the emission of two neutrinos. However, if the neutrino is a Majorana fermion, i.e. it is its own anti-particle, double beta decays are also possible without the emission of any neutrinos. The ^{136}Xe $2\nu\beta\beta$ half-life has been measured to be on the order of 10^{21} years, with the lower limit on its $0\nu\beta\beta$ half-life being roughly 10^{25} years. Thus, multi-ton detectors are the next generation of search experiments. Then the search for neutrinoless beta decay is a challenge to push down backgrounds in order to observe these exceedingly rare decays. Where possible, observing the daughter ion, e.g. a ^{136}Ba from a ^{136}Xe double beta decay, would eliminate all other background signals. So-named barium tagging, then becomes the task of isolating and detecting a single ion in a potentially multi-ton detector medium. Many schemes have been proposed, and I will present progress towards using a capillary based probe for extracting individual ions from liquid xenon. I will show simulations of each step of the extraction and present the apparatus for the experiment.

R1-3 DPMB 101 Lectures (DPMB) | Conférences DPMB 101 (DPMB) - MDCL 1102 (08:45 - 10:15)

-Conveners: Cornelia Hoehr

[3470] (I) Advanced Near Infrared Spectroscopy Techniques for Biophotonics Applications (08:45, 45 minutes)

Presenter: Prof. DIOP, Mamadou (Lawson)

Near infrared tissue spectroscopy (NIRS) is a rapidly growing sub-filed of biophotonics with unique applications in both research and patient management. NIRS takes advantage of (1) the relative transparency of living tissue to near infrared (NIR) light to probe deep laying tissue beds such as the adult brain, and (2) differences in the absorption features of important biomarkers of tissue health such as blood, water, lipid to noninvasively quantify their concentration in living tissue. Further, the technology is safe, low-cost, and can be deployed at the bedside. This presentation will provide an introduction to light-tissue interaction and advanced NIRS methods for measuring biomarkers of tissue health. Notably, novel NIRS instrumentation and modelling will be presented as well as applications of NIRS for measuring cerebral blood flow and oxidative metabolism in neonates and adults.

[3471] (I) Single-molecule mechanical studies of unstable protein building blocks (09:30, 45 minutes)

Presenter: FORDE, Nancy

The most abundant protein on earth, collagen, forms the basis of our connective tissues and the extracellular matrix that surrounds our cells. It performs important structural and mechanical roles, holding our bodies together and helping our tissues to withstand a wide variety of forces. Surprisingly, collagen proteins are structurally unstable at body temperature. In this talk, which will be aimed at a very general Physics audience, I will introduce some of the fascinating physical properties of the unique triple-helix structure of collagen, and will highlight the results of our investigations into the sequence dependence of its mechanics and stability. Our single-molecule approaches include centrifuge force microscopy, optical tweezers and atomic force microscopy. Our work is revealing clues as to how stability is encoded within collagen's sequence, and how collagen's triple helix balances structural stability with responsiveness to applied force and chemical environment.

R1-2 Gravity and Cosmology II (DTP) | Gravité et cosmologie II (DPT) - MDCL 1009 (08:45 - 10:15)

-Conveners: Randy Lewis

[3052] (I) Deciphering the Baryonic Universe: A New Window Into the Cosmos (08:45, 30 minutes)

Presenter: PADMANABHAN, Hamsa

The history of baryonic material, particularly after the epoch of `Cosmic Dawn' -- the onset of the earliest stars and galaxies -- is widely considered the 'final frontier' of cosmological surveys today. The technique of intensity mapping (IM) has emerged as the powerful tool to explore this phase of the Universe by measuring the integrated emission from sources over a broad range of frequencies. A particular advantage of IM is that it provides a tomographic, or three-dimensional picture of the Universe, unlocking several thousand times more independent modes of information than one can obtain from conventional probes. I will illustrate how the description of dark matter haloes can be extended in a novel, data-driven framework to describe baryonic abundances and clustering over 12 billion years of cosmic time. Extensions of this model pave the way towards a comprehensive understanding of molecular gas evolution, by using the carbon monoxide (CO), ionized carbon and oxygen ([CII] and [OIII]), as tracers of large-scale structure. This innovative approach allows us to fully utilize the latest data to constrain cosmological parameters from future observations. I will present a host of fascinating implications for constraining physics beyond the LCDM model, including tests of the theories of inflation, the nature of dark matter and dark energy.

[3038] Equivalence of gravity theories in the covariant phase space (09:15, 15 minutes)

Presenter: MARGALEF, Juan (Memorial University)

Gravity can be described in several fashions. To name a few, we have the Einstein-Hilbert theories, the Palatini theories, and the Holst theories. In this talk, I will make a quick introduction of all of them (both in metric and tetrad variables) and prove their equivalence in the covariant phase space as well as the equivalence of the associated charges. This proof relies on the newly developed relative bicomplex formalism, which allows the inclusion of boundaries in a straightforward way.

[3400] Quantum Gravity Phenomenology (09:30, 15 minutes)

Presenter: DASGUPTA, Arundhati

We discuss the plausibility of detection of quantum gravity effects in astrophysics, in particular near strong gravitating systems such as black holes. We also comment on the plausibility of finding gravitons, the quanta of gravitational waves.

[3159] The gravitational field of a non-local superposition (09:45, 15 minutes)

Presenter: Prof. PARANJAPE, Manu

In a non-local quantum superposition of a massive particle, does the gravitational field behave as the classical superposition of two particles separated by a spatial distance with half the mass located at each position or does the system behave as a quantum superposition with a far more interesting and subtle behaviour? We compute the differential scattering cross-section under the interaction coming from the exchange of one graviton. We find that the scattering cross-section is not remotely represented by the classical picture, of potential scattering from two localized sources with half the mass at each source. We discuss how this result compromises the Newton-Schrödinger description of gravitation interacting with quantum matter.

[3347] Holographic Thermodynamics of AdS Black Holes: Central Charge Criticality (10:00, 15 minutes)

Presenter: MANN, Robert

We reconsider the thermodynamics of AdS black holes in the context of gauge–gravity duality. In this new setting -- where both the cosmological constant Λ and the gravitational Newton constant G are varied in the bulk -- we rewrite the first law in a new form containing both Λ (associated with thermodynamic pressure) and the central charge C of the dual CFT theory and their conjugate variables. We obtain a novel thermodynamic volume, in turn leading to a new understanding of the Van der Waals behavior of the charged AdS black holes, in which phase changes are governed by the degrees of freedom in the CFT. Compared to the 'old' $P-V$ criticality, this new criticality is 'universal' (independent of the bulk pressure) and directly relates to the thermodynamics of the dual field theory and its central charge.

Health Break | Pause santé - MDCL Hallways (10:15 - 10:45)

R2-4 Quantum Materials II (DCMMP) | Matériaux quantiques II (DPMCM) - MDCL 1010 (10:45 - 12:15)

-Conveners: Pereg-Barnea, Tamar (McGill University)

[3072] Probing a Novel Low Temperature State in Cs2AgBiBr6 via Resonance Raman Spectroscopy and Photoluminescence (10:45, 15 minutes)

Presenter: TOWER, Collin (Brock University)

Halide double perovskites are of interest due to their potential as high efficiency solar cell materials while eliminating toxicity and stability issues that affect current high efficiency perovskites[1]. Within this family, Cs2AgBiBr6 has advantageous characteristics as a solar cell material including strong absorption and long carrier lifetimes[2]. While a cubic to tetragonal structural phase transition upon lowering temperature to 120 K has been well-documented, there is another characteristic temperature near 40 K. Recent investigations involving the use of temperature dependent neutron and X-ray scattering suggest this phase transition to be due to a complex ground state comprised of a several hundred atom unit cell with elaborate rotations of the silver and bismuth octahedral groups[3]. We have employed optical and thermal techniques to further understand this low temperature phase transition and the impact it has on the optoelectronic properties responsible for the photovoltaic efficiency. Through polarized resonance enhanced Raman spectroscopy, the temperature dependence of the photoluminescence can be analyzed by fitting measured spectra to a series of Voight oscillators. The oscillator fitting parameters show a strong blue shift in the bandgap and deviate from the typical semiconducting exciton linewidth trend. In addition, the A1g/Ag phonon displays a hardening of the center frequency below 40 K. The investigation into this low temperature phase will aid in further developing the understanding of the optoelectronic properties of Cs2AgBiBr6 and similar halide double perovskites. [1] F. Igbari et al. Advanced energy materials 2019. 9 (12), 1803150. [2] A. H. Slavney et.al. Journal of the American Chemical Society 2016. 138 (7), 2138-2141. [3] He, Xing, et al. arXiv preprint 2021. arXiv:2112.04717.

[3071] Psudogap formation at the β to β' phase transition in the Chalcogenide As2Te3 (11:00, 15 minutes)

Presenter: Mr DION, Jeremy

The chalcogenides are a family of layered compounds that exhibit interesting properties. As2Te3 is a layered chalcogenide that has α, β and β′ polymorphic phases. β-As2Te3 exhibits significantly different electronic properties when compared to α-As2Te3, with the former metallic with significantly lower resistivity and the latter behaving as a typical semiconductor. Below a temperature of ≈200K, β-As2Te3 undergoes a structural phase transition to β′-As2Te3. Within the region of this transition a strong signature can be detected in the resistivity beyond which it resumes a metallic behaviour[1]. The driving mechanism behind this structural phase transition is currently unidentified. We have employed a phenomenological fit on the resistivity of the βand β′ phases of As2Te3 to better characterize the nature of this transition. Most notable is the occurrence of cross-transition invariance in the slope of the resistivity, a topic of considerable interest in other materials[2]. The magnitude of the β-As2Te3 to β′-As2Te3 transition anomaly as well as the width of the transition can be effectively modelled using this approach. Parameters acquired from fitting both warming and cooling measurements will be used to better investigate the hysteresis observed in this transition. Additionally, Drude and gapped Drude model fits to temperature-dependent infrared reflectivity data within the β and β′phases have revealed the formation of a concomitant pseudo-gap. The reflectivity spectra and Drude-model fits will be used to aid in the analysis of the the phase transition and provide context on the underlying mechanisms driving the electronic properties in the system. References [1] Cedric Morin, Serena Corallini, Julie Carreaud, Jean-Baptiste Vaney, Gaelle Delaizir, Jean-ClaudeCrivello, Elsa Branco Lopes, Andrea Piarristeguy, Judith Monnier, Christophe Candolfi, Vivian Nassif, Gabriel Julio Cuello, Annie Pradel, Antonio Pereira Goncalves, Bertrand Lenoir, and Eric Alleno. Poly-morphism in Thermoelectric As2Te3.Inorganic Chemistry, 54(20):9936–9947, 2015. PMID: 26418840. [2] Peter Cha, Aavishkar A. Patel, Emanuel Gull, and Eun-Ah Kim. Slope invariant T-linear resistivity from local self-energy. Phys. Rev. Research, 2:033434, Sep 2020.

[3133] Atomically Defined Wires on P-Type Silicon (11:15, 15 minutes)

Presenter: ALTINCICEK, Furkan (University of Alberta)

Dangling bonds (DBs) on a hydrogen terminated Si(100)-2x1 surface are silicon atoms unbound to hydrogen atoms. They are point defects with electronic states in the band gap. Placing DBs at strategic locations on the surface enables them to be used as fundamental components for atom-defined electronics. In this work, we use low temperature scanning tunneling microscopy techniques to create patterns on boron-doped silicon. We find that wire structures consisting of DB pairs exhibit 1D quantum wells within the band gap. Combining these wires with local point structures make them candidates for electronic control at the atomic scale. The wires exhibit relative immunity to environmental degradation. The natural reactive and thermal robustness of the dangling bond lines combined with vacuum encapsulation is expected to result in very long-lived circuitry. Synthesis and characterization of wires and wires adjacent to other structures will be shown.

[3482] Density changes in amorphous silicon provoked by swift heavy ions (11:30, 15 minutes)

Presenter: Prof. ROORDA, Sjoerd

Pure and gold-doped amorphous silicon membranes were irradiated with swift heavy ions (75 MeV Ag or 1.1 GeV Au ions) and studied by small angle X-ray scattering. The samples that were irradiated with 1.1 GeV Au ions produced a scattering pattern consistent with core-shell type ion tracks of 2.0 ± 0.1 nm (core) and 7.0 ± 0.3 nm (total) radius irrespective of gold doping and consistent with radii previously observed [Bierschenk et al., Phys. Rev. B 88, 174111 (2013)]. However the core must be less dense than the original amorphous silicon, not more dense as argued in the same report, because its density is nearly 4 % different from that of the surrounding material. The compressive stress required to maintain the core 4 % more dense would exceed the yield strength of amorphous Si. The entire track (core + shell) is slightly less dense than the surrounding material, putting it under a lateral stress consistent with the macroscopic ”hammering” deformation seen when tracks overlap. No tracks were found in samples irradiated with 75 MeV Ag ions, and no signature specific to the gold impurity doping could be observed.

[3391] Beta-SRF at TRIUMF - A Unique Facility to Characterize SRF Materials Near Fundamental Limits (11:45, 15 minutes)

Presenter: THOENG, Edward (TRIUMF)

Superconducting Radio-frequency (SRF) technology provides the cutting-edge technology that enables high performance acceleration for modern accelerator projects. RF losses are a major cost driver that both limit gradient and increase cryogenic demand. TRIUMF and U. Victoria have an active program in characterizing loss mechanisms in SRF materials using both muSR and beta-NMR. At TRIUMF, a facility, unique in the world, has recently been developed that allows a characterization of the Meissner state of SRF materials at field near the fundamental limits. The new facility and first results will be presented.

R2-5 Materials Synthesis and Characterization (DCMMP) | Synthèse et caractérisation de matériaux (DPMCM) - MDCL 1008 (10:45 - 12:15)

-Conveners: Dhirani, Al-Amin (University of Toronto); Al-Amin Dhirani

[2999] Surface Conduction Measurement of Si Nanostructures by Ohmic Two Probes in a Multi-probe Scanning Tunneling Microscope (10:45, 15 minutes)

Presenters: Dr KHADEMI, Ali (Metrology Research Centre, National Research Council of Canada), Dr PITTERS, Jason (Nanotechnology Research Centre, National Research Council Canada)

Improving the characterization of microscopic surface electronic properties is necessary for the miniaturization of electronic devices. Specifically, achieving the ultimate goal of miniaturization, which involves atomic-scale devices such as atomic-scale logic gates [1] and memories [2] composed of dangling bonds on hydrogen-terminated Si surfaces, demands characterization of ultra-small one- and two-dimensional structures. While imaging, fabricating, and measuring of local electronic properties of these ultra-small structures can be performed with a one-probe scanning tunneling microscope (1P-STM), assessing the electrical conduction properties lateral to the surface requires a two-probe (2P-) and four-probe (4P-) scanning tunneling microscope (STM). The advantage of 4P-STM conductance measurement over 2P-STM is that it can eliminate the probe-to-surface contact resistance and Schottky barrier in semiconductor samples. Yet, it is an arduous task to place four probes into a nano-scale region. Here, we propose a method to solve the considerable contact resistance issue with the 2P configuration [3]. Cleaning tip apices by field evaporation ensured metallic probes that produced linear IV curves on the metallic Si(111)-(7 × 7) surfaces and eliminated the problem of the Schottky barrier. By employing the Ohmic 2P-STM method, we measured the surface conductance on the Si(111)-(7 × 7) surface at low bias voltages that limited conduction through bulk states. Furthermore, we created nano and atomic scale regions on the surface of Si(111)-(7 × 7) and H-Si(100) using STM lithography and measured their conduction properties by utilizing the Ohmic 2P-STM. References: [1] T. Huff et al., Nat. Electron. 1, 636 (2018). [2] R. Achal et al., Nat. Commun. 9, 1 (2018). [3] J. Onoda et al., ACS Nano 15, 19377-19386 (2021).

[3083] “Nanoengineering” 2-D nanosheets (11:15, 15 minutes)

Presenter: DHIRANI, Al-Amin

Top-down approaches have enabled isolation of individual 2-D nanosheets from bulk materials and have revealed extraordinary optical and electronic behaviour at the nanosheet level. An alternate potential approach to fabricate 2-D nanosheets - and materials generally - is to employ a bottom-up strategy using nanostructures as building blocks. This approach affords tunability of material properties via choice of nanobuilding blocks and material architecture, leading to a possibility of nanoengineering materials (NEMs) potentially exhibiting emergent quantum phenomena (q-NEMS). Here, using various organic molecules and metal nanoparticles as building blocks, we present a bottom-up method to fabricate for the first time molecularly cross-linked self-assembled 2-D nanoparticle sheets (XSANS). XSANS fabricated with semiconducting “molecular wires” linkers (oligophenylene dithiol, HS-(C6H4)n-SH, with $1 \leq n \leq 3$) exhibit conductivity that decreases with increasing molecule length (the opposite trend of tunneling) and strongly enhanced molecular optical absorption (by at least ~6-orders) compared with those of unlinked molecules in solution. Spatially resolved finite difference time domain analyses and control measurements indicate that the enhancement cannot be attributed solely to strong local fields present in XSANS. However, they can be modelled provided the local complex dielectric constant is strongly modified upon cross-linking, suggesting quantum hybridization at a molecule – nanostructure (q-HYMN) level. Further, XSANS exhibit photoconductivity that reflect the hybrid molecule-metal nanoparticle character of these materials, in line with conductivity and optical results. The present results point to XSANS, and more generally q-NEMS, as a target of opportunity for a wide range of electro-optic behaviours that can be realized from the bottom-up given the vast number of organic and inorganic nano building blocks that can be synthesized in solution.

[3325] Transient nonlinear optical properties of nanostructures made of quantum dots and metallic nanoparticles (11:30, 15 minutes)

Presenter: FANG, Ningyan

Recently, transient nonlinear optical properties of quantum dots have attracted much attention in photonic and plasmonic studies. We have investigated the effect of the decay rate, surface plasmon polariton (SPP) coupling strength, and dipole-dipole interaction (DDI) strength on the time-dependent behavior of the power emitted from a three-level lambda-type quantum dot in plasmonic nanohybrids composed of metallic nanoparticles and quantum dots. We introduced the quantum density matrix elements that are directly related to power emission in order to present the results. By controlling the SPP and DDI coupling constant as well as the decay rate, we plotted the time evolution of density matrix elements and found that the strength of SPP coupling and decay rate do not affect the time that the system takes to reach the steady state, whereas the DDI couping strength does. The transient behavior also exhibits giant oscillations and significant enhancement in power emission. The present findings can be used in the development of nanotechnology and the fabrication of nanodevices such as nanosensors and nanoswitches.

[3162] SiGe nanocrystals in SiO2: optical and materials properties (11:45, 15 minutes)

Presenter: ADAM, Matheus

Silicon is the most used material in the electronic industry, with applications in many areas. Although it has excellent electronic properties, Si lacks light emission due to its indirect bandgap. Nonetheless, light emission in silicon nanocrystals due to the quantum confinement effect has been reported. This fact unlocked the potential for silicon-based optoelectronic devices, and many studies have followed to investigate quantum confinement in Si quantum dots (QDs). In this project, we explore the possibility of the addition of germanium to create silicon-germanium (SiGe) nanocrystals. The relative concentration of Ge has a direct influence on the optical properties since the bandgap depends on it. Besides being a widely used technique in the microelectronics industry, ion implantation can be used to make compounds beyond the chemical solubility limit, and allows the study of a range of concentrations of Si and Ge. By changing the Ge content, different wavelengths of emitted light can be achieved and adjusted according to the required applications. As an initial step, samples were implanted with Si+ at 40 keV into a 1μm thermally grown SiO2 film on a Si (001) substrate, to achieve a peak concentration of 17.5 at. % in relation to the matrix, and the chosen energy placed the implanted peak 50nm below the surface. Samples were subsequently implanted with 55 keV Ge with 0.5, 1.0, and 2.0 peak at. %, and thermally annealed for crystallization. The Ge implantation energy was calculated to put the Ge ion range at the same position as the Si ion range. For a second set of samples, Ge implantation was done after 1100C annealing, necessary for Si QDs growth. We present optical properties of these SiGe QD ensembles, studied with ellipsometry and photoluminescence.

[3282] A scanning tunneling microscopy study of a two dimensional organometallic network on the Ag(111) surface (12:00, 15 minutes)

Presenter: GALLAGHER, Mark

Self-assembly is one of the most important bottom-up fabrication strategies to produce two-dimensional (2-d) networks at solid surfaces. Driven by an intricate equilibrium between molecule–molecule and molecule–substrate interactions, these interactions can be used to generate stable extended 2-d geometric structures. For example, halogen-terminated molecules can be activated on surfaces to form 2-d π-conjugated polymers [1]. In this work we focus on a particular class of 2-d nanomaterials in which metal atoms are incorporated into the molecular layer. The structures are characterized by organometallic coordination, i.e. C-metal-C linkage, between adjacent molecules. These materials are predicted to exhibit novel properties, i.e. topological insulators, superconductivity, and other exotic quantum phases [2]. We study the adsorption of a tribromo-substituted heterotriangulene molecule (TBTANGO [1]) on the Ag(111) surface using room temperature scanning tunneling microscopy (STM) in ultrahigh vacuum. We find that deposition of TBTANGO molecules onto a substrate held at elevated substate temperatures (□ 240°C) yields a high quality extended porous two-dimensional molecular network of TANGO molecules with organometallic C-Ag-C linkage. Each pore consists of six dehalogenated molecules and the honeycomb network can be characterized by a hexagonal unit cell with a lattice constant of 19.8 ± 0.5 Å. Within error, the overlayer is commensurate with the silver substrate (□ 7a₀). In addition, the molecular overlayer exhibits a single orientation, indicating it is aligned with the high symmetry directions of the underlying substrate. At monolayer coverage, most of the surface is covered by the honeycomb network (80%), however adjacent to silver atomic steps we observe a novel compact molecular phase. This phase is characterized by a hexagonal unit cell with a lattice parameter of □ 9.1 Å. STM images are consistent with C-metal-C linkage, however in the compact phase the Ag atom/cluster is linked to 3 TANGO molecules. To our knowledge this bonding motif has not been observed previously in similar 2-d organometallic networks. [1] *Galeotti et al.*; Nature Materials **19**, 874–880 (2020). [2] *Dong et al.*; Prog. in Surf. Sci. **91**, 101-135 (2016).

R2-1 Applied Physics II (DAPI) | Physique appliquée II (DPAI) - MDCL 1016 (10:45 - 12:15)

-Conveners: Steffon Luoma

[3475] (I) Confirming internal microwave resonances in grape-sized aqueous objects using calorimetry, thermography, and FEM simulations (10:45, 30 minutes)

Presenter: SLEPKOV, Aaron (Trent University)

The localized and intense electromagnetic hotspots afforded by plasmonic resonances in nano-scaled metallic objects have led to many exciting biomedical applications. The equivalence between nanoplasmonic hotspots, and those due to morphology-dependent resonances in high-index dielectrics is a promising avenue of nanophotonic research. In the microwave frequency regime water is such a material (n~9), and thus cm-sized aqueous dielectric objects can become resonant to few-GHz light from microwaves, WiFi, and other communication-band sources. We are using experimental, analytical, and computational approaches for studying hotspots in aqueous monomer and dimers. Evidence for microwave resonances in grape-sized objects has been somewhat circumstantial; relying on preliminary thermal imaging and FEM simulations. Now, using a creative and relatively low-tech calorimetric approach, we have strong evidence for a fundamental volumetric resonance in isolated hydrogel spheres. Furthermore new free-space thermal imaging experiments elucidate the transition from dipole-like resonance in isolated spheres to intense hotspots at the nexus of dimers. These experimental findings are further supported by simulations that can identify which fundamental resonances in spherical monomers hybridize to yield either/both internal and point-of-contact dimer modes.

[3124] Catch basin rating curves (11:15, 15 minutes)

Presenter: Dr POIRIER, Louis (National Research Council Canada)

A full scale model roadway has been installed in the Coastal Wave Basin of the Ocean, Coastal and River Engineering facilities at the National Research Council in Ottawa in an effort to better understand the conveyance of catch basin covers. A total of eighty (80) catch basin rating curves were obtained for eight (8) different catch basin covers for various road configurations. The roads were inclined from 0.5 – 10.0 % and cross-slopes of both 2.0 and 4.0 % were studied. The flow of water to the roadway ranged from 0.001 – 0.40 m**3/s resulting in a water depth in advance of the catch basin covers from 0.001 - .147 m. The work will the experimental methodology used as well as the catch basin rating curves that have been obtained. The presented work is the result of a collaboration with one Canadian municipality. Future experiments with two other municipalities will also be discussed including various new catch basin cover types as well as new roadway configurations.

[3376] Tempological Control: Stable Synchronization through Time-Varying Networks (11:30, 15 minutes)

Presenter: CORNELIUS, Sean

State-based negative feedback is a control strategy employed by built and natural systems alike to stabilize their dynamics around a desired state--everything from flocking birds to the synchronous rotation of power generators. Usually, this process requires continuous control input to counteract deviations from the target state, which can be invasive and demand considerable amount of energy. Here, for networked systems whose function relies on the synchronization of their components, we introduce "tempological" (temporal + topological) control-- a noninvasive feedback control strategy that stabilizes synchronization without any control input. Instead, the scheme works by sporadic but deliberate alterations to the system's coupling network based on the system's dynamical state. We show that by strategically switching between different networks in this way, one can drive a set of oscillators to a stable, synchronous configuration even if *all* networks are individually unstable. We demonstrate the utility of our approach using both Kuramoto and Stuart-Landau oscillators, and establish theoretical guarantees on the success of "tempological control" in the thermodynamic limit.

[3207] Active Region Extent Assessment with X-rays (AREA-X) shown for the example of sensors for the ATLAS ITk tracker (11:45, 15 minutes)

Presenter: POLEY, Luise (Simon Fraser University (CA))

The development of sensors for new tracking detectors requires characterisation for a range of performance criteria like active area, inter-pixel inefficiencies and homogeneity, which have traditionally only been accessible through measurements in particle beams. In order to achieve sufficient position resolution, particle beam tests require extensive setups for particle tracking, which limit the data acquisition speed and necessitate complex reconstruction algorithms. Active Region Extent Assessment with X-rays (AREA-X) has been developed within the scope of the ATLAS ITk tracker as an alternative method to assess sensor characteristics such as the extent and shape of the depleted, i.e. active sensor area with applied bias voltage and extent and shape of inefficient areas. This method relies on the use of a monochromatic, micro-focused X-ray beam, available at Light Source beam lines, to scan over a sensor area of interest and utilises the induced sensor current to map the active sensor area. With no additional data acquisition methods being required, this method has been developed to be fast and reliable and not be limited by exposure time like traditional particle beam tests. The contribution presents an overview of the method and its development using test ATLAS ITk strip sensors and test structures as well as future plans for measurements of interest.

R2-3 DPMB Trainee Networking (DPMB) | Réseautage de stagiaires DPMB (DPMB) - MDCL 1102 (10:45 - 12:15)

-Conveners: Valerie Booth

R2-2 Frontiers in Theoretical Physics II (DTP) | Frontières en physique théorique II (DPT) - MDCL 1009 (10:45 - 12:15)

-Conveners: Mohammad Ahmady

[3530] Ultralight Dark Matter and Cosmological Condensed Matter Physics (10:45, 30 minutes)

Presenter: MCDONOUGH, Evan

The identity of dark matter remains a mystery, despite decades of theorizing and detection efforts. This includes the mechanism for its primordial production, its interactions with itself or with visible matter, and the very nature of dark matter, which could range from a Bose-Einstein Condensate to Black Holes. In this talk I will focus on dark matter in the extreme low mass range, which forms a class of models collectively referred to as ultralight dark matter. These models exhibit exciting new phenomena, such as exotic phases of matter (superfluid, superconducting) and vortex formation. They can be tested in a wide array of experimental arenas, ranging from the large scale structure of the universe to particle physics experiments. I will focus on models wherein ultralight dark matter is realized as a composite state in a confining gauge theory, as a quark condensate analogous to Cooper pairs (STUMP dark matter) or as Ultra Light Pion (ULP) dark matter, and discuss model-independent observables of ULDM. Finally, time permitting, I will touch upon the connection of ultralight dark matter to early dark energy and the Hubble tension.

[3345] Structural Aspects of Quasi-Topological Gravity (11:15, 15 minutes)

Presenter: Dr HENNIGAR, Robie (Institute for Cosmos Sciences, University of Barcelona)

Generalized quasi-topological gravities are higher-curvature extensions of general relativity with the defining property that the field equations of the theory remain second-order when restricted to certain metrics of interest. In this talk, I will discuss recent work classifying the structural aspects of these theories, proving their existence at arbitrary orders and dimensions, and counting the number of such theories. I will also discuss interesting universal aspects of the thermodynamics of black holes in these theories.

[3329] Unification of Quantum and Relativistic Measurements (11:30, 15 minutes)

Presenter: Prof. SHARP, Jonathan (University of Alberta)

The notions of observation differ substantially between quantum mechanics and special / general relativity (SR and GR) and represents a barrier to a consistent understanding of quantum spacetime. I will firstly review these differing approaches to observation (or measurement), and secondly, outline an approach to address this. **Quantum Measurement** Quantum measurement has a *non-deterministic* aspect. The theory of measurement in quantum mechanics is highly developed (Braginsky, 1995), although the 'measurement problem' (classical-quantum divide) persists. Measurements may either weakly or strongly impact the unitary evolution of the quantum system. In all forms however, indeterminism remains a factor. Even in the most sophisticated quantum measurement protocols, such as continuous observation of quantum jumps (Minev, 2019), a baseline indeterminism remains. **Relativistic Measurement** In SR/GR measurement outcomes are deterministic, however there are also *observer-specific*: a reported value can depend upon the observer. In SR, relative velocity determines certain measurement outcomes. In GR, the coordinate system (state of motion) plays this role. Nevertheless, for a specified *system-observer relationship*, outcomes can be uniquely determined. In the case of SR, definite outcomes are tied to the Lorentz boost, and so are conditional on a definite relative velocity between system and observer. While classically velocity definiteness is axiomatic, for quantum systems it is quite the opposite. **Momentum Basis** Can *non-deterministic* and *observer-specific* measurements be reconciled? Notice that velocity uncertainty (i . e . momentum superposition) will lead to relativistic indeterminacy. Momentum super-position renders the Lorentz boost indeterminant. For a consistent picture, we can also attribute measurement indeterminacy of quantum systems to momentum superposition, so that quantum uncertainty becomes a natural consequence of relativity. It follows that momentum (or velocity) is the preferred basis for quantum superposition. This also leads to a many-spaces ontology [3]. [1] Braginsky and Khalili, Quantum Measurement, Cambridge University Press, 1995. [2] Minev ZK et al. 200 Nature Vol 570 13 June 2019 https://doi.org/10.1038/s41586-019-1287-z [3] Sharp JC. One Universe, Many Spaces: A Non-Local, Relativistic Quantum Spacetime 10.20944/preprints201805.0003.v1

[3285] Fermionic FIMP dark matter models providing low-scale leptogenesis. (11:45, 15 minutes)

Presenter: Prof. POULOSE, Poulose (Indian Institute of Technology Guwahati)

With the WIMP dark matter getting more and more constrained by the direct detection experiments, alternate mechanisms like FIMP have been explored in the recent literature. We shall consider simple models with fermionic FIMP as dark matter candidates, which naturally couple with heavy right-handed neutrinos. In addition to providing observed dark matter abundance, such scenarios are capable of addressing the low scale leptogenesis, and generating light neutrino mass with right-handed neutrinos as light as 10 TeV. This is achieved by the influence of the dark sector through quantum corrections in the decay of heavy-neutrinos. In the talk, we shall explore the details of the dark matter sector and the leptogenesis in this scenario, and analyse the viable parameter space.

[3137] Solar Cells_and the Lambert W Function (12:00, 15 minutes)

Presenter: Prof. VALLURI, Sreeram (University of Western Ontario (UWO))

The Lambert W and Polylogarithm Functions have created a renaissance in solving problems in many diverse fields. They have found interesting and novel applications in areas such as solar cells, graphene, and double-gate metal-oxide semiconductor field-effect transistors (MOSFET). The multi-branched Lambert W function is relevant to the problem of arrays of solar cells experiencing varying light conditions. To compensate for varying light, it is necessary to perform load balancing calculations for obtaining the maximum power from the array. That is particularly a challenge with mobile arrays, and with temporary shadows such as produced by chimneys and other obstructions. The computations are time-consuming because the current-voltage (I-V) equations are, in their usual form, implicit and iterative root-finding is used. A Lambert W function explicit solution in some models has been known since 2004. However, the Lambert W method when applied to real-life solar cells employs very large numbers (dimensionless) which cause arithmetic overflow in customary computer hardware. We have devised a variant solution, which is suitable for use on small computers such as low-cost field micro-controllers and is explicit. It has deterministic and modest time requirements. The I-V characteristic S shaped kink curves have non-ideal behaviour that has been Investigation in our work. Accurate simulations will give us a more optimum I-V curve, leading to better solar cell efficiency. The new technique can reduce the costs of implementing mobile solar power. The Lambert W function as well as its variant, the LogWright Function, are relevant in tackling problems of underflow and overflow in the simulations. An inflection point is frequently associated with poor performance of the organic solar cell. This needs to be carefully studied. The "ladder of Lambert W function representations" provides a convenient systematization of the process of converting coordinates.

R2-0 Joint CINP-IPP Sessions (DNP/PPD) | Réunion conjointe de l'ICPN et de l'IPP (DPN-PPD) - MDCL 1305/07 (10:45 - 12:15)

-Conveners: Garth Huber

time	[id] title	presenter
10:45	Health Break | Pause santé (30 minutes)	
11:15	Health Break | Pause santé (30 minutes)	

Break for Lunch (12h15-13h15) | Pause pour dîner (12h15-13h15) (12:15 - 13:15)

CINP Annual General Meeting (with lunch) | Assemblée générale annuelle de l'ICPN (dîner inclus) - MDCL 1009 (12:15 - 13:15)

-Conveners: Garth Huber

R-STUD-COMP CAP Best Student Oral Presentations Final Competition | Compétition finale de l'ACP pour les meilleures communications orales d'étudiantes - MDCL 1305/07 (13:15 - 15:15)

-Conveners: William Whelan

time	[id] title	presenter
13:15	Competitor 1 (15 minutes)	
13:30	Competitor 2 (15 minutes)	
13:45	Competitor 3 (15 minutes)	
14:00	Competitor 4 (15 minutes)	
14:15	Competitor 5 (15 minutes)	
14:30	Competitor 6 (15 minutes)	
14:45	Competitor 7 (15 minutes)	
15:00	Competitor 8 (15 minutes)	

Health Break | Pause Santé - MDCL Hallways (15:15 - 15:45)

Judges Meeting and Announcement Preparation l Rencontre des juges et préparation d'annonce - MDCL 2230 (15:15 - 16:30)

-Conveners: William Whelan

R-PLEN1 Plenary Session | Session plénière - Cliff Burgess - MDCL 1305/07 (15:45 - 16:30)

-Conveners: Randy Lewis

[3531] Thinking Effectively About Gravity (the view from below) (15:45, 45 minutes)

Presenter: BURGESS, Clifford (High Energy Physics Group - McGill University)

We live at a time of contradictory messages about how successfully we understand gravity. General Relativity seems to work well in the Earth’s immediate neighbourhood, but arguments abound that it needs modification at very small and/or very large distances. This talk tries to put this discussion into the broader context of similar situations in other areas of physics, and summarizes some of the lessons which our good understanding of gravity in the solar system and elsewhere has for proponents for its modification over very long and very short distances. The main message is mixed: On one hand short-distance quantum effects are notoriously difficult to control in gravity and cosmology seems to like features (like light scalars and small vacuum energies) that are not generic to the long-wavelength limit of fundamental theories. These are crucial clues that would be silly to ignore. On the other hand, General Relativity successfully passes many stringent new observational tests and also seems to be almost unique in its ability to reconcile quantum effects with gravity on longer distances without being inconsistent. Neither of these seems to offer much scope for modification. I try to organize what the successes of GR might be telling us, and provide a score-card about it says about the various alternatives that have been proposed.

Student Awards Ceremony | Cérémonie de reconnaissance d'étudiant(e)s - MDCL 1305/07 (16:30 - 17:15)

-Conveners: William Whelan; Paranjape, Manu (Université de Montréal)

Close of Congress | Clôture du congrès - MDCL 1305/07 (17:15 - 17:30)

-Conveners: Paranjape, Manu (Université de Montréal)

4D detector workshop | Atelier sur les détecteurs 4D - MDCL 2230 (17:30 - 19:00)

Remote connection: https://cern.zoom.us/j/62568526830?pwd=b3FoY3BUZXZXSUVJY2w4R0oyb2lLZz09

-Conveners: Retiere, Fabrice (TRIUMF); Poley, Luise (Simon Fraser University (CA))

Friday, 10 June 2022

IPP AGM | AGA de l'IPP (09:00 - 12:00)

-Conveners: Michael Roney

time	[id] title	presenter
11:00	Break (20 minutes)	

IPP Scientific Council Meeting | Réunion du comité scientifique de l'IPP (13:00 - 14:00)

-Conveners: Michael Roney

IPP Inst. Members and Board of Trustees Meetings | Réunions des membres inst. et du conseil de l'IPP (14:00 - 17:00)

-Conveners: Adam Ritz; Roney, Michael (University of Victoria)