PRESENTATION ABSTRACTS FOR CUPC 2022

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Abstracts

Abstracts for all oral and poster presentations are presented below, sorted by the individual oral presentation sessions and times. Poster Session Abstracts are presented later in the document, starting on page 24, and are sorted alphabetically.

Session F1: Theoretical Astrophysics

09:00 – 11:00 on Friday October 29 in the Gryphon/Ken Danby Room at Delta Hotels Guelph

(09:00 – 09:15) Fuzzy Dark Matter: Dead or Alive?!?

Boris Zupancic and Lawrence Widrow

Department of Physics, Engineering Physics & Astronomy, Queen's University and Arthur B. McDonald Canadian Astroparticle Physics Research Institute

The Schrodinger Equation (SE) is not just quantum mechanical; it describes galactic Dark Matter (DM) too. Fuzzy Dark Matter (FDM) is a hypothetical model in the form of a particle so light that its de Broglie wavelength is light years long. The distribution of FDM thus behaves like a density wave, following the SE on galactic and cosmological scales. Recent simulations suggest FDM would cause galaxies to evaporate over time, spitting stars out of orbit. However, these simulations are not fully self-consistent, and should be verified. That is, a system comprised of FDM and particles should reside and evolve in the gravitational potential produced by both the FDM and particles. This talk presents: the background information on FDM, the argument for its elimination as a DM candidate, and preliminary results of our own fully self-consistent simulations of gravitational interactions between FDM and particles, in a 1D model of a galaxy.

(09:15 – 09:30) Webb gAlaxy COunter (WACO): A Simple Notebook for JWST Data Analysis and Visualization

Ashley Ferreira[1], Yusuf Ahmed[1], Dhvani Doshi[1], and Daniel Reimer[2]

[1]University of Waterloo and [2]McGill University

Our team recently participated in the NASA Space Apps 2022 Hamilton event and took on an advanced CSA challenge called "Exploring the distant universe with James Webb Space Telescope". Over the weekend, with help from Space Apps mentors and JWST resources already developed by the Space Telescope Science Institute, we created a notebook for JWST data analysis and visualization for students just beginning in astronomy research like us. The last step of the notebook demonstrates a method to estimate the number of galaxies in an image. This work is available on a public GitHub repository so that other students can use and improve this notebook. As a fun addition we also developed a Children's short story on JWST with the help of AI to inspire future astronomers! This presentation will cover how you can easily do this as well.

(09:30 – 09:45) Hydrodynamic Stability of Black Hole Mimickers

Joshua Cadogan and Eric Poisson

Department of Physics, University of Guelph

In recent years, gravitational wave data has been used to provide insight into the structure of compact stellar bodies like black holes. However, the stellar dynamics of many physically possible stars of similar density have yet to be investigated. Hence there is a need to explore the dynamics of such black hole 'mimicking' stars. Here, the stability of a thin shell of perfect barotropic fluid containing a spherical dark matter kernel, colloquially termed a "gravastar", was investigated. The permissible radii (normalized by the kernel radius) for an equilibrium solution were found to be between 0 and 0.492136 or 0.957875 and 1 uniquely. However, through a perturbative analysis it was concluded that these configurations are dynamically unstable; thus, such a stellar body is not predicted to exist naturally.

(09:45 – 10:00) MODELLING MULTIMODE PULSATIONS IN CLASSICAL CEPHEID STARS

Jay Allison

Mount Allison University

The objective of this research project is to use computer simulation to model a classical cepheid star which exhibits multimode pulsation, and then analyse the properties of this model to put forth a mechanism for why certain cepheids develop these pulsations. The majority of classical Cepheids, important distance candles in astronomy, pulsate in either the fundamental or first overtone. However, a small but significant minority appear to display a frequency modulated with a higher overtone. There is no currently accepted hypothesis as to why. This research project used a combination of software suites to simulate stellar evolution, and energy, density, and material flow within the star. A 7 solar mass model began displaying clear pulsation, and Fourier analysis of the luminosity data also suggests higher overtones are present. Future work on this project includes recreating this result using different parameters to prove convergence.

(10:15 – 10:30) TURBO KILONOVAE: WAVELENGTH-DEPENDENT CENTRAL ENGINE HEATING IN KILONOVAE

W. Callum Wareham[1], Michael Müller[1,2,3], and Daniel M. Siegel[1,2,3]

[1]Department of Physics, University of Guelph; [2]Perimeter Institute for Theoretical Physics; [3]Institute of Physics, University of Greifswald

Most heavy elements in the universe are thought to be synthesized in the extremely hot, neutron-rich material ejected from a merger event between two neutron stars (NSs). This nucleosynthesis and resulting radioactive decay (the r-process) powers an astronomical electromagnetic transient termed a "kilonova," peaking on timescales of days to weeks after merger. The resulting kilonova lightcurve can be accurately modelled to the factor of a few level with semi-analytical prescriptions; however, most modelling efforts in the past have incompletely incorporated the effect of the leftover "merger remnant" on the kilonova. We have extended existing semi-analytical kilonova models to more accurately account for such a remnant central engine, applying our new model to the case of a long-lived NS remnant. We find that models invoking a radiative transfer prescription determining the location in the merger ejecta at which the central engine power is thermalized are imperative for accurate modelling.

(10:30 – 10:45) THE CURVATURE IN ΛCDM UNIVERSE

Yi Wang[2], Jessie Muir[1]

[1]Perimeter Institute for Theoretical Physics and [2]Dalhousie University

In the last two decades, progress in Cosmology has been shaped by increasing precision. Cosmological collaborations like Dark Energy Survey (DES), Dark Energy Spectroscopic Instrument (DESI), and future surveys like Dark Energy Science Collaboration (DESC) bring us to the era of precision cosmology. However, as data get more precise, the constraining power is limited by the accuracy of modelling tools. Furthermore, most modelling tools available now have been developed and tested with the assumption of a flat universe. So in order to constrain the curvature density Ωk which is the parameter that describes the geometric shape of the universe, it is urgent for us to validate the reliability of these tools on curved geometry. This project will assist the analysis of future surveys, thus paving the way to a higher precision goal of Cosmology.

(10:45 – 11:00) IMPACT OF COSMIC RAY HADRONIC HEATING ON STAR FORMATION IN GALAXIES

Michelle Kao

Theoretical and Computational Astrophysics Thematic Group, National Center for Theoretical Sciences (Taiwan)

Cosmic rays are highly energetic charged particles produced by cosmic accelerators such as supernova remnants. Cosmic rays can regulate star formation activities by thermalizing the interstellar medium through collision and ionization processes, momentum transfer by scattering in magnetic fields, and the production of secondary leptons. In my project, I explored secondary electron thermalization in dense molecular clouds. I will first describe the cosmic ray heating efficiency in the Milky Way and the association of cosmic ray abundance with star formation rate. I will then explain the parameters I considered for the hadronic interaction and the molecular cloud model. Finally, I will compare the hadronic heating rate of cosmic rays in the Milky Way with that of the local starburst galaxies, showing the significance of cosmic ray heating in star-forming galaxies.

Session F2: TRIUMF and the Standard Model

09:00 – 11:00 on Friday October 29 in the Flanders Room at Delta Hotels Guelph

(09:00 – 09:15) Magnetic Shielding and the Search for the Neutron Electric Dipole Moment

Ryan Curtis
TRIUMF

The TUCAN collaboration is seeking to measure the neutron electric dipole moment using the future Ultra Cold Neutron facility at TRIUMF. These measurements require the use of high precision magnetic fields, therefore the experiment must be shielded appropriately from external magnetic fields that can contribute to the highly precise field. This presentation will go over steps to measure and increase the shielding of the experiment to account for external magnetic fields.

(09:15 – 09:30) Ancillary detector for Rare-Isoptope Event Selection (ARIES)

Serene Rodrigues, V. Vedia, R. Umashankar, A.B. Garnsworthy, D. Bishop, M. Constable, S. Georges, S. Hodges, L. Mantle, W. Royer, G. Pasquino, M. Spinazze, L. Tomlin, and M. Winokan
TRIUMF, University of Surrey, University of British Columbia, and University of Waterloo

The 76-element Ancillary detector for Rare-Isotope Event Selection (ARIES) is the new beta-tagging scintillator array made for the Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei (GRIFFIN) spectrometer at TRIUMF-ISAC. The design is optimized for GRIFFIN's rhombicuboctahedral geometry and will provide a 92% solid angle coverage and 114 unique opening angles for β–γ angular correlation measurements. ARIES is made of ultra-fast plastic (BC-422Q) and with an Aluminum optical reflector coating that are formed into a self-supporting structure that minimizes gamma ray attenuation. Custom-designed electronics enable simultaneous readout of an energy signal and a signal for ultra-fast coincidence timing from each detector element. The testing of the silicon photomultipliers, charge sensitive amplifier and the properties of the scintillator tiles is reported.

(09:30 – 09:45) Photon Emission Asymmetry Detector

Mathias Roman
University of Ottawa and TRIUMF

In order to do B-nmr spectroscopy, TRIUMF needs to have spin-polarized samples. The goal of this research project was to design a detector with 2 arrays of fibers as well as a simulation tool which could help us measure the efficiency of spin-polarization schemes. To do this, we simulated a spin-polarization process and used Clebsch-Gordan coefficients to assess the probability of different transitions and from there, design a detector.

(09:45 – 10:00) Delayed Charged Particle Spectroscopy with Regina Cube for Multiple Particles

Dhruval Shah
University of Regina and TRIUMF

Ever wondered how all the elements that we find here on Earth came to existence? Explosive astrophysical scenarios such as x-ray bursts, supernovae, and neutron-star mergers produce short-lived rare isotopes that subsequently decay back to stability by various modes of radioactivity. With the use of powerful detection instrumentation, these exotic nuclei can be studied at rare-isotope beam facilities such as the TRIUMF Isotope Separator and Accelerator (ISAC). A new radiation detector array, consisting of six double-sided silicon strip detectors, is being developed by the nuclear physics group at the University of Regina, which will be coupled with the GRIFFIN spectrometer at TRIUMF. This state-of-the-art detection system will be used to study exotic decay modes including α-decay and β-delayed charged-particle emission (βp, β2p, βαp). An overview of the design and construction of this detector array will be given in this talk.

(10:00 – 10:15) Thermal Control and the Scintillating Bubble Chamber Experiment

Ezri Wyman
Department of Physics, Engineering Physics & Astronomy, Queen's University

The Scintillating Bubble Chamber (SBC) is a dark matter detection experiment improving upon the bubble chamber technology that has been used for decades. SBC uses superheated liquid argon doped with xenon in the active volume of the experiment which allows for energy reconstruction of bubble events using generated scintillation light. Keeping these elements in a superheated state requires temperatures down to 130K (-143C) and measuring the temperature accurately and precisely is vital for understanding the nucleation threshold for bubble events. This motivated the development of a system of Resistance Temperature Detectors (RTDs) to monitor the temperature of the experiment at various points both around the quartz jars containing the active volume and throughout the cooled areas of the experiment. This allows any thermal concerns to be observed and corrected before they cause problems for the data or the safety of the experiment. Each dark matter experiment that probes new areas of the mass and cross section parameter space for dark matter helps us reach new understanding of what dark matter may be. SBC is an important piece of that puzzle, and thermal control is an important piece of SBC.

(10:15 – 10:30) DESCANT – Probing Exotic Beta Decays Through Neutron and Gamma-Ray Detection

Vanshika Sharma

Department of Physics & Astronomy, University of British Columbia; TRIUMF

The neutron, whilst being a key element of nuclear reactions is infamous for being challenging to detect due to its lack of charge. DESCANT, the Deuterated Scintillator Array for Neutron Tagging, is an array of seventy detectors that assist in the efficient detection of neutrons via secondary reactions with the scintillator liquid, which in this case is deuterated benzene. DESCANT's ability to detect both gamma rays and neutrons, allows it to work in coherence with high-precision gamma-ray spectroscopes such as GRIFFIN offering us an insight into pivotal processes such as beta-delayed neutron emission. The unison of these detectors allows us to find half-lives and neutron-emission probabilities which are key to forming a complete understanding of the astrophysical r-process and allowing for safe operation of nuclear reactors. This motivates the urgent maintenance of DESCANT, involving careful data collection, replacement of parts and reassembly, optimizing a particles journey from decay to detection.

(10:30 – 10:45) Ultracold Neutron Detection with Scintillating ZnS and 6Li Detectors

Igal Press

University of Winnipeg, TUCAN, and MITACS

Ultracold neutron (UCN) detectors are needed for a variety of projects including the TUCAN (TRIUMF Ultra Cold Advanced Neutron) experiment at TRIUMF (Canada's particle accelerator center, in Vancouver, BC). Two UCN detectors were tested at the Japan Proton Accelerator Research Complex (J- PARC, Tokai, Japan). The different detector technologies tested were made of (1) scintillating glass containing 6Li atoms, and (2) a phosphorescent screen of ZnS that was coated with 10B. The 6Li and ZnS detectors were characterized using both cold and ultracold neutrons and compared to two reference detectors. A 3He detector operating at 10 atm was used to characterize the CN runs and the DUNia-10 detector operating near atmospheric pressure with a 3% partial pressure of 3He was used to characterize UCN runs.

(10:45 – 11:00) Investigating Pygmy Dipole Resonance in 92Sr Using the GRIFFIN Array at TRIUMF

Elliot Wadge, Pietro Spagnoletti, Corina Andreoiu, Kevin Ortner, Isaiah Djianto, Dominic Annen

Simon Fraser University

In the field of Nuclear Science, gamma-ray spectroscopy remains one of our most powerful tools for investigating the fundamental structure of nuclei and the nuclear force. We used one of the largest spectrometers in the world Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei (GRIFFIN) to investigate the properties of 92Sr. With the ultimate aim of discovering the existence of a collective phenomenon called pygmy dipole resonance within 92Sr, which is thought to be a neutron skin oscillating with a proton-neutron core. Beyond fundamental understanding of the nucleus, pygmy dipole resonance is also of relevance to the r-process in nuclear synthesis which is responsible for the formation of some heavier elements. In my work, I was able to lay the foundation for further research into pygmy dipole resonance by calibrating and correcting data from each of the 60 crystals in the GRIFFIN array used in the experiment and by identifying over 40 newly observed levels using timing data.

Session F3: Mathematical Physics and Condensed Matter Physics

09:00 – 11:00 on Friday October 29 in the John McCrae Room at Delta Hotels Guelph

(09:00 – 09:15) Development of a Modulation-Free Laser Frequency Stabilization Setup Operating at Both 780 nm and 795 nm for Atomic Lifetime Measurements (Virtual Presentation)

J. Randhawa, T. Vacheresse, G. Carlse, E. Ramos, C. Walsh, A. Pouliot and A. Kumarakrishnan
Department of Physics and Astronomy, York University

We are pursuing precise, comparative determinations of the radiative lifetimes of the Rb 5P3/2 and 5P1/2 excited states using the technique of photon echoes. The experiment relies on laser frequency stabilization of homebuilt external cavity diode lasers to atomic resonances at 780 nm and 795 nm. A standard technique for stabilizing the laser frequency involves lock-in spectroscopy. Here, a lock-in amplifier is used to modulate the laser frequency and produce a dispersion-shaped error signal required to lock the laser frequency to the desired atomic resonance. The inherent disadvantage of this technique is the need for laser frequency modulation. Alternative modulation free schemes that can be constructed using homebuilt electronics and without lock-in amplifiers include the Dichroic Atomic Vapour Cell Laser Lock (DAVLL) and its Doppler-free variant (DF-DAVLL). We describe characterizations of the frequency stability of DF-DAVLL feedback loops operating at the desired wavelengths using measurements of the Allan Deviation (AD).

(09:15 – 09:30) A Novel Electrolyte for High-Temperature Cycling of Lithium-Ion Batteries

Alison Clarke, Tina Taskovic, and Jeff Dahn
Department of Physics & Atmospheric Science, Dalhousie University

As concern about climate change grows around the world, the need for cleaner energy use has become clear. Better energy storage capability is a vital part of this transition as it allows electricity to be saved for later, increasing grid efficiency and reducing greenhouse gas emissions. Most storage systems use lithium-ion batteries, due to their high energy density and long lifetime. Increasing the tolerance of Li-ion batteries to extreme temperatures would enable longer lifetime in hot climates. Li-ion cells with a novel electrolyte, dimethyl-2,5-dioxahexanedioate (DMOHC), can operate at temperatures of 85°C and higher. This work explores DMOHC electrolytes by investigating their physical properties and the performance of Li-cells that contain DMOHC. Viscosity and conductivity measurements as well as charge-discharge cycling results are shown for lithium-ion cells with DMOHC electrolytes. These results improve our understanding of this novel electrolyte and represent a promising step towards a more sustainable future.

(09:30 – 09:45) How to Run Numerical Simulations with FEniCSx

Max Sun
Collaborative Laboratory for Applied and Interdisciplinary Mathematics, University of Ontario Institute of Technology

A brief overview on how to formulate and simulate 3D models numerically with FEniCSx, a popular open-source computing platform for solving partial differential equations (PDEs).

(09:45 – 10:00) Electrical Control of Magnetism in Kitaev Materials

Griffin Howson and Jeffrey G. Rau
Department of Physics, University of Windsor

A fascinating class of frustrated magnetic systems are 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 nearby magnetic phases is crucial in advancing our understanding of this exotic phase of matter. We explore the effect of strong magnetoelectric coupling in Kitaev materials on their classical magnetic phases. Using a combination of numerical algorithms, we produce a phase diagram as a function of the applied electric field and polarization parameters. The polarization parameter phase diagram reveals a sequence of ordered phases with large unit cells, suggesting potentially incommensurate behaviour. This behaviour persists over a finite window of the electric field in the generalized Kitaev model, relevant for describing materials like α-$RuCl_3$. Estimates for physical electric fields inducing this behaviour will be presented.

(10:00 – 10:15) FEYNMAN PERIODS AND GRAPH THEORY

Shannon Jeffries
University of Waterloo

We investigate a degree preserving variant of the delta-Y transformation in graph theory that is relevant for understanding Feynman integrals in phi^3 scalar field theory. This transformation acts on graphs derived from Feynman diagrams to help simplify the calculation of Feynman periods. We discuss the equivalence classes defined by this operation and make some observations linking the structure of these classes to the Feynman periods. This talk aims to shine some light on one of many connections between physics and combinatorics.

(10:15 – 10:30) INTEGRATION OF LITHIUM-GELATIN SOLUTION IN SIMPLE CHROMOGENIC WO_3 DEVICES

Maxwell MacCallum
Department of Physics and Astronomy, Trent University

Chromogenic materials are materials that change color when exposed to various stimuli. Among them, photochromic (photon activated coloration) and electrochromic (electrically activated coloration) materials are often the most practical for everyday use as their stimuli are controllable or predictable. Development of electrochromic devices are often limited by the ion conducting later in the devices, the addition of which may benefit photochromic devices, drawing attention to photo-electrochromic devices for the research community. With the focus of making a photo-electrochromic device, we chose tungsten oxide (WO_3) as our primary candidate due to the large base of research on the material. A self-sealing lithium-gelatin solution was prepared for use as an ion conducting layer and used in the construction of electrochromic devices. In tests, the ion conducting layer performed effectively for electrochromic tests. The self-sealing properties of the ion conducting layer acted effectively as a medium for both the electrochromic and photochromic devices, and shows promise for the construction of a photo-electrochromic device.

(10:30 – 10:45) ANALOGUE EVENT HORIZON IN A BOSE-EINSTEIN CONDENSATE

David Tyler, Duncan O'Dell, Liam Farrell, and Maxim Olshanii
Department of Physics and Astronomy, McMaster University

In a Bose-Einstein condensate (BEC), the majority of the bosons occupy the lowest quantum state and share the same wave function. The Gross-Pitaevskii equation (GPE) is a nonlinear equation which describes this wave function. We consider a one-dimensional BEC initially confined within an infinite potential well. When this potential is released, the BEC expands outwards. Using the Thomas-Fermi approximation, Olshanii et al. have derived an analytical solution for the time evolution of this system which is analogous to a hydrodynamic shock wave. We use the Crank-Nicolson method to numerically solve the GPE for this system. We then analyse the features of this numerical solution and compare the results to the aforementioned analytical solution. We find that the flow of the outer edges of the BEC exceeds the speed of sound in the material, indicating the presence of an analogue event horizon in this system.

(10:45 – 11:00) THE STERN-GERLACH EXPERIMENT UNDER THE SCOPE OF ELECTROMAGNETISM

Amirali Atrli
Department of Physics, University of Toronto

Due to its direct demonstration of angular momentum quantization, the Stern-Gerlach experiment is of great importance in quantum mechanics. In the original version of this well-known experiment, a neutral silver atom is sent through a non-homogenous magnetic field and is deflected due to its non-zero magnetic dipole moment. The observed result is that the atoms are deflected either up or down by a specific amount, which implies the quantization of the angular momentum of silver atoms. This presentation will focus on the electromagnetic details of the experiment. After a brief overview of the Stern-Gerlach experiment, an analysis of the non-homogenous magnetic field and the force and torque exerted by it on the silver atom will be done, and it will furthermore be shown that the deflection of the silver atom is, as expected, in the direction of the gradient of the magnetic field.

Session F4: General Physics

15:00 – 17:00 on Friday October 29 in the Gryphon/Ken Danby Room at Delta Hotels Guelph

(15:00 – 15:15) Machine Learning Techniques in Photon Detection for Dark Matter Searches

Madelyn Kaban, Azizah Mahmood, Jonathan Zarling, Zisis Papandreou
University of Regina

The Jefferson Lab Eta Factory (JEF) is an upgrade of the GlueX Experiment at Jefferson Lab, USA, to explore rare decays of the eta meson. A primary objective of JEF, within its rich physics program, includes a search for new sub-GeV gauge bosons. The JEF experiment requires an upgrade of the inner part of the GlueX lead glass forward calorimeter with high-granularity, high-resolution PbWO4 crystals. The calorimeter will improve the separation of clusters in the forward direction and the energy resolution of reconstructed photons by about a factor of two. Sophisticated Monte Carlo simulations are required to model the behaviour of the upgraded FCAL in terms of its ability to accurately classify impinging subatomic particles. I worked to develop and apply machine learning algorithms to determine a probabilistic "photon-merger factor" as a function of photon energy and physical separation.

(15:15 – 15:30) Two-Dimensional Numerical Simulations of Mixing Under Ice Keels

Sam De Abreu, Rosalie Cormier, Mikhail Schee, Erica Rosenblum, and Nicolas Grisouard
University of Toronto, University of Manitoba, and Brown University

Arctic sea ice is going through drastic decadal changes as sea ice thickness and roughness decline, resulting in an unknown transition in upper-ocean mixing. We explore this question using 16 two-dimensional numerical simulations of an ice keel of various shapes and speeds mixing a two-layer ocean. We categorize each simulation by identifying four upstream and five downstream flow regimes and assess the keel's ability to mix fresh and salty water. We find that downstream mixing increases monotonically when the keel draft becomes larger relative to the mixed layer depth. Furthermore, mixing is more sensitive to relative keel draft than keel velocity or the salinity gradient between the mixed layer and deeper ocean. Keels can also mix as deep as five times the depth of their draft. Finally, we identify which flow regimes are available to different regions in the Arctic and use decadal trends to predict future upper-ocean mixing.

(15:30 – 15:45) Characterization of Extreme Tip Jets off Cape Farewell, Greenland

John H. Wood[1] and G. W. K. Moore[1,2]
[1]Department of Physics, University of Toronto and [2]Department of Physical & Chemical Sciences, University of Toronto Mississauga

Greenland's topography prevents winds from travelling over its surface. Instead, they speed up along its coast. The tip jet off Cape Farewell on August 19, 2022, at 12H is of particular interest, appearing more extreme than seen before. Using satellite data and numerical weather prediction models, we characterize this event. Both point and area-based statistics are used to find that the event consists of high percentile winds in an uncommon contiguous region of roughly 395,402 square kilometers. 181,248 hourly samples of winds in this region were analysed by computing the fraction of points whose speed met or exceeded the 98th percentile at that point. Full coverage was found only on the event of interest, while 60 samples had coverage at or above 90%, and 855 had coverage at or above 50%.

(15:45 – 16:00) Analyzing Written Responses to Integrated Testlet Physics Assessments

Victoria Arbour
Department of Physics and Astronomy, Trent University

Standard assessment methods such as multiple choice, worked problems, and oral assessments are limited in their ability to assess physics learning. The Integrated Testlet (IT) is a novel approach to assessment that utilizes an "answer-until-correct" format to provide instantaneous feedback to the learner, while also allowing educators to evaluate students' deeper understanding of course content. This project addresses whether there is a relationship between the way a student engages with an IT physics assessment and their performance. Preliminary results suggest a positive relationship between performance and drawing diagrams, selecting options, and connecting questions; a negative relationship between performance and eliminating options; and no relationship between performance and emphasizing information. These results help identify potential best practices on IT physics assessments.

(16:00 – 16:15) Measuring the Speed of the Domino Effect

Angela Xiang and Ania Harlick
Department of Physics, University of Toronto

The familiar and seemingly simple phenomenon of dominoes toppling is unexpectedly full of non-trivial physics. Existing descriptions of this effect range from simple arguments with dimensional analysis to more complicated models that consider friction and other interactions between dominoes. So far, no one has been able to fully capture the complexity of this children's toy. We explore the accuracy of existing models, both numerically and through comparison with experiment. Somewhat surprisingly, we find that the simplest models considering only the interaction between adjacent dominoes are in better agreement with data than models that consider the interactions of the whole chain of dominoes.

(16:15 – 16:30) Meaningful Impact: Science Communication with the McDonald Institute Summer of Science

Yasi Shahidian and Madelynn Mast
Department of Physics, Engineering Physics & Astronomy, Queen's University; Arthur B. McDonald Canadian Astroparticle Physics Research Institute

Public science communication and early learning opportunities are essential for early academic recruitment. Programs like the Summer of Science through the McDonald Institute are essential in engaging with students and providing their first experience with academia, university life, and cutting-edge physics research. Summer of Science 2022 was designed for both high school and middle school students in a hybrid learning environment. Topics such as the scientific method, intro to the standard particle model, and more were covered over the course of the summer. This talk will discuss the techniques and skills that went into designing this program.

(16:45 – 17:00) Optimization and Stabilization of Cooling Processes of Neutral 87Rb Atoms with Machine Learning

Nicholas Milson, Arina Tashchillina, Joseph Lindon, Anna P. Czarnecka, Lindsay J. LeBlanc
University of Alberta

When trapping and cooling atomic clouds for cold-atom experiments, cycle-to-cycle variations in the number of atoms can lead to unwanted fluctuations in final measurements. External parameter fluctuations, such as in ambient temperature and stray magnetic fields, are leading contributors to these variations, in addition to instabilities within the system itself. To understand the influence of each parameter on the atom number, we seek to measure and record many parameters over many experimental cycles and construct a model of the atom-number response. This is a high-dimensional problem, to which machine learning lends itself well. A neural network is used to model the atom number at various stages of our atom cooling system as a function of several parameters measured around the laboratory. Standard methods in neural network optimization improve computation time, and accuracy of out-of-sample predictions. Dimensionality reduction, adaptive learning rates when optimizing the model, and regularization by dropping connections of neurons yielded robust and consistent predictions. Using this approach, we develop a neural-network model that successfully predicts our atom number in experiments, and we are working towards using this information to reduce instabilities in the atom number.

Session F5: Quantum Computing and Optics

15:00 – 17:00 on Friday October 29 in the Flanders Room at Delta Hotels Guelph

(15:00 – 15:15) SEAQUE (Satellite Entanglement and Annealing QUantum Experiment)

Nouralhoda Bayat, Joanna Krynski, Nigar Sultana, Paul Godin, Zhenwen Wang, Thomas Jennewein, Kelsey Ortiz, Spencer Johnson, Liam Ramsey, Matteo Stefanini, Tiphaine Kouadou, Logan Power, Richard Eason, Qi Lim, Subash Sachidananda, Daniel Pardo Suarez, Josh Aller, Bradley Slezak, Phil Battle, Alexander Ling, Michael Lembeck, Makan Mohageg, Paul Kwiat

CSA, NSERC, CFI, ORF, IQC, University of Waterloo, University of Illinois Urbana Champaign, National University of Singapore, AdvR Inc., NASA, and JPL

In order to set up the stage for a global quantum network, an infrastructure for quantum computers and quantum sensors to communicate securely is required. The critical stepping stone to this infrastructure is establishing a free-space quantum light-based communication system. SEAQUE (Satellite Entanglement and Annealing QUantum Experiment) is the first collaborative North American mission to demonstrate two communication technology tests from space. The milk-carton-size device will be installed on Nanoracks Bishop Airlock on the International Space Station, exemplifying the viability of orbiting nodes connecting quantum transmitters and receivers over a great distance. The payload will contain an entanglement source based on integrated optics to produce photon pairs used to communicate with the ground and test the bell's inequality. The SEAQUE mission will also test a self-healing method to demonstrate the extension of the lifetime of devices like itself by relieving the radiation-caused degradation of the photon detectors via laser annealing the detectors using a bright laser.

(15:15 – 15:30) Real-Time Communication with Quantum Encryption

Jack Bishop

BaSQuANa; Institute of Quantum Computing, University of Waterloo

The need for quantum-resistant encryption is becoming ever more apparent. Quantum key distribution has been demonstrated between two parties, but typically only in a trivial network topology. A network-adaptive quantum key management and routing software is demonstrated, as well as a hybrid key exchange method using classical encryption, post-quantum algorithms and quantum key distribution. These tools are used to encrypt a video conference through a quantum-safe private network.

(15:30 – 15:45) DIY: Qubits for Quantum Computing

Luca Galler

Department of Physics, University of Alberta, University of Waterloo

Quantum computation may open new opportunities for solving problems that are currently intractable using conventional computers. Part of this revolution is the use of a promising technique known as neutral atom arrays. Creating these atomic arrays involves cooling rubidium-87 atoms down to near absolute zero and trapping them using optical and magnetic techniques. These trapped atoms can be induced into an entanglement state and become qubits for computational purposes. In this presentation I will discuss quantum computation using neutral atoms as well as the progress we've made in Dr. Lindsay LeBlanc's lab in regards to designing and assembling a neutral atom array. More specifically, I'll dive into the different components involved in cooling and trapping atoms such as an ultra-high vacuum system and a 3D magneto-optical trap. Through conducting research on neutral atom arrays and quantum phenomena, we aim to work towards developing a novel distributed quantum computing system.

(15:45 – 16:00) MIP*=RE

Benjamin Wong

University of Waterloo and Institute for Quantum Computing

SEGFAULT "Flux this Shift! There must be a better way," you say, staring in disappointment at a C++ program that's destined to never integrate Coulomb's Law. I've got one Bell of a sales pitch for you. Instead of drudging through endless lines of code trying to get computer science to produce new physics, why not put the sock on the other foot and use physics to produce new computer science? The elephant in the room for computer-altering physics is the prospect of building a quantum computer. However, I'll spare you from yet another explanation of Shor's polylogarithmic factoring algorithm. I would like to entice you to come to my talk with the promise of two extremely humble ideas. First, we'll see how backwards time travel affects the theoretical limits of computing. Second, we'll see that quantum-entangled gods could help us solve computational problems that are provably impossible.

(16:00 – 16:15) Active Magnetic Field Compensation System in One-Axis

Yeh-In Kang, Arina Tashchilina, Lindsay J. Leblanc, and Jacob Byers
Department of Physics, University of Alberta

Variations in the background magnetic field may cause inconsistency in the number of atoms present in a Magneto Optical Trap (MOT), which are commonly used in Bose-Einstein Condensate (BEC) apparatuses. To remedy this a magnetic field compensation system is sometimes used. This project consisted of a magnetic field compensation system in one-axis. It was designed to compensate effects from uniform near DC fields such as the Earth's magnetic field. Greater consistency in the MOT would maximise the number of atoms trapped thus increasing the robustness of experimental conditions. The system consists of 2 magnetoresistive sensors that sit opposite to each other at the edges of a control zone that is contained between a pair of Helmholtz coils. The field generated by these coils are controlled using the sensors and an analog proportional controller. The system was able to achieve compensation on the order of -15.8 dB.

(16:15 – 16:30) Dispersion Engineered Slow Light

Ozan W. Oner[1,2], Kaustubh Vyas[2], Daniel Espinosa[2], Sebastian Schulz[3], and Ksenia Dolgaleva[1,2]
[1]School of Electrical Engineering and Computer Science, University of Ottawa; [2]Department of Physics, University of Ottawa; [3]University of St. Andrews

Emerging computing technologies are requiring higher data rates than the networks they currently interact with. For these systems to function effectively, data exchange needs to be completed in a timely manner without bottlenecks. Currently, transmitting information optically via fiber optic cables is the fastest method. There exists, however, problems associated with the fundamental limits of electronic signal processing. Nonlinear optical processes can overcome the shortcomings of electronic signal processing. As such, a Si photonic crystal etched with a Kagome lattice geometry has been developed to access slow-light modes. A slow-light mode aspires to enhance nonlinear optical interactions, especially four-wave mixing, the phenomenon of importance for various all-optical signal processing operations.

(16:30 – 16:45) Complete Characterization of Laser Electric Fields using Frequency Resolved Optical Gating

Leah Frackleton
University of Ottawa

Ultrafast lasers play a key role in modern science and technology. It is therefore important to be able to fully characterize the ultrafast laser fields. However, due to their high frequencies, it is impossible to directly measure ultrafast optical fields using the same measurement techniques used as for radio or other low frequency waves. Frequency Resolved Optical Gating (FROG) is a self-referencing technique for directly measuring the electric fields of ultrafast laser pulses on the femtosecond (10^{-15} s) scale. FROG uses an iterative fitting algorithm which allows for the retrieval of the complete electric field and, therefore, the phase of the input laser pulse. This talk will explain the need for and concepts underlying the FROG technique, starting with the measurement of low-frequency waves, to classical optical techniques such as interferometry, and finally the use of nonlinear optics in laser electric field characterization.

(16:45 – 17:00) Ultrafast Transient Absorption Microscopy

Liam Morrison, Lilly Daw, Grant Wilbur, Kimberley Hall
Department of Physics & Atmospheric Science, Dalhousie University

Ultrafast Transient Absorption Microscopy (uTAM) is a pump-probe spectroscopic technique used to study excited state dynamics. Developed to provide additional spatial information and reveal local features of microscopic areas of sample, in recent years uTAM has demonstrated advantages to modern solid-state optical research compared to other micro-spectroscopic techniques. Namely, high optical and temporal resolution and a capacity to study non or weakly fluorescent molecular species has made uTAM a valuable method in applications for material science and solid-state research. Research underway at Dalhousie University aims to exploit the advantages of uTAM in determining time-resolved carrier densities of certain compounds. The purpose of the presentation will be to address the operation of uTAM, as well as its values in modern research, and its upcoming place in Dalhousie University's laboratories.

Session F6: Nanomaterials and Biophysics

15:00 – 17:00 on Friday October 29 in the John McCrae Room at Delta Hotels Guelph

(15:00 – 15:15) Nanoscale Deformations of Floating Polymer Films

Julia Azzi, Lauren Dutcher, Carmen Lee, and Kari Dalnoki-Veress
Department of Physics and Astronomy, McMaster University

Thin polymer films are often used as coatings in microelectronic devices. Understanding the factors that govern their stability can lead to further technological advancements. This work studies a system of stacked polymer films where a thin deformable solid layer is placed atop a liquid body. We impose a small controlled perturbation by partially covering the solid layer with a thin liquid layer. At the solid/liquid contact line there is a controlled upwards force due to the liquid surface tension, which causes the solid sheet to bend and the fluid beneath it to flow. The deformation of the solid layer is studied using optical microscopy and allows us to probe polymer flow on the nanoscale.

(15:15 – 15:30) Squeezing a Granular Aggregate in a Spinning Cylinder

Lisa Bhatia, Johnathan Hoggarth, and Kari Dalnoki-Veress
Department of Physics and Astronomy, McMaster University

The spinning drop method is one of the classic techniques used to quantify the interfacial tension, or surface energy, between two immiscible liquids with differing densities. An air bubble moves to the centre of rotation and changes shape when spun in a water filled cylinder. If the cylinder is rotated faster, the bubble elongates, and similarly, if rotation is slowed down, it compresses and becomes more spherical. With experiments, we study a granular analogue of this system. A small aggregate of microscopic, sticky oil droplets forms a cluster along the centre of a cylinder in response to centrifugal forces. The cluster undergoes changes in shape as the rotation speed is varied. The spinning-aggregate experiment can be used to investigate the connections between liquids and granular systems, alongside probing the boundary between continuum liquids and granular solids.

(15:30 – 15:45) Characterization of Microparticles in Free Space and Liquid Cultures Using Optical Tweezers (Virtual)

E. Ramos, G. Carlse, J. Randhawa, C. Walsh, T. Vacheresse, A. Pouliot and A. Kumarakrishnan
Department of Physics and Astronomy, York University

We have developed simple techniques to precisely characterize the physical properties of micrometer-sized particles trapped in free space using optical tweezers. In these experiments, particles are confined in three dimensions by the optical dipole force in the vicinity of the focal plane of a laser beam. We image the kinematics of trapped particles on fast time scales using a video microscope containing a high-speed camera and an acousto-optic modulator to amplitude modulate the trapping force. We apply these techniques in liquids where the effects of laser heating have an impact on the particle kinematics. We present preliminary results and discuss applications such as measurements of the particle mass and the local temperature of the fluid.

(15:45 – 16:00) Propelling Microscopic Droplets Along Thin Fibers

Aileen Shanzeela, Hamza Khattak, and Kari Dalnoki-Veress
Department of Physics and Astronomy, McMaster University

Small droplets can spontaneously move on conical fibers to minimize the surface energy of the system—a feature used by cacti and other plants to harvest water from the air. Similar ideas are being developed to carry out fog harvesting in arid regions of the globe. Here we investigate a related concept: propelling droplets with two fibers. In this work we look at small fluid droplets suspended between two, even smaller, fibers. We manipulate the motion of droplets by controlling the relative distance and angle between the fibers, and observe their motion using optical microscopy techniques. Such a mechanism provides a new tool with which to control flow of small droplets and understand the fundamental physics behind droplet migration dynamics.

(16:00 – 16:15) Visualizing the Flow Created by Flagella-Motile Bacteria Trapped in Vesicles Using Fluorescent Microbeads

Lucas Chu, Liu Yu, Shariful Sakib, Riaz Mahmud, and Cécile Fradin
Department of Physics and Astronomy, McMaster University

Magnetospirillum spirillum are motile magnetotactic amphitrichous bacteria, having two flagella at each pole to propel themselves. Flow created by amphitrichous flagella have rarely been studied. By using magnetotactic bacteria, we can control which direction, thus, which flagellum, is used to create flow. We trap the bacteria in lipid vesicles with fluorescent microbeads. Using fluorescence microscopy and an in-house written particle tracking algorithm we can then track the location and velocity of these beads as it changes with the flow caused by the flagella over time.

(16:15 – 16:30) A Nephrotoxicity Assay Using the Membrane-Based Sensor Platform

Hannah Krivic, Sebastian Himbert, Ruthie Sun, Michal Feigis, and Maikel Rheinstadter
Department of Physics and Astronomy, McMaster University

Biological sensors are devices used for detecting substances or molecules through an electrical signal. There are many types of biosensors, each of which has its own unique properties and applications. 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 platform used for nephrotoxicity testing and rapid screening of antibiotics. Commercially available gold electrodes are functionalized by applying a renal membrane analogue. Dielectric membrane properties are measured using electrochemical impedance spectroscopy (EIS) and used to detect the membrane resistance, or otherwise membrane damage. These innovative sensors combine membrane biophysics with an electronic readout, providing an analysis of hemolytic activity, as well as a prediction of the Minimum Inhibitory Concentration (MIC).

(16:30 – 16:45) Using Atomic Force Microscopy to Measure the Stiffness and Radius of Acid Hydrolyzed Phytoglycogen

Ashley Geddes, Benjamin Baylis, Yasmeen El-Rayyes and John Dutcher
Department of Physics, University of Guelph and Mirexus Biotechnologies Inc.

Scattering occurs when cloud particles interact with incoming radiation. Rayleigh & isotropic scattering applies for small particles. Mie scattering which is predominantly in the forward direction occurs for larger particles. Photons scatter numerous times in the cloud before exiting from top or bottom. The reflectance was found for different incident angles for the case of zero cloud absorption. Photons incident at near horizontal trajectory are less likely to be transmitted through the cloud than those incident perpendicularly. Reflectance is lower for forward scattering than for isotropic or Raleigh scattering.

(16:45 – 17:00) Diffusion-Based Cross-Linking in Polymer Fibers: Applications in Science and Medicine

Xander Gouws, Laurent Kreplak, and Andrew Rutenberg
Department of Physics and Atmospheric Science, Dalhousie University

Cross-linking has greatly expanded the versatility of polymers in material science and biotechnology. Our group has modeled the formation of diffusion-based cross-links using partial differential equations to uncover their spatiotemporal distribution within polymer fibers. We find that core-shell structures are created when the cross-linking agent is either highly reactive or present in high concentrations. This work has applications in understanding the impacts of aging on biofibers in the body, radial inhomogeneities seen in collagen fibrils, and in developing novel drug delivery systems.

Session S1: Observational Astronomy, Space Science, and Theoretical Physics

09:00 – 11:00 on Saturday October 30 in the John McCrae Room at Delta Hotels Guelph

(09:00 – 09:15) Study of Neutrino Emission Spectra from Neutron Star Mergers

Paul Deguire

Department of Physics, University of Guelph

Neutron stars are very dense objects that result from the death of a main-sequence star with an original mass between 8 and 25 solar masses. Studying their interior can help us to understand the behaviour of ultra-compact matter. During the merger of a binary neutron star system, part of the gravitational energy is transferred to neutrinos that escape the stellar matter. Some of these neutrinos are possibly detected on the Earth. They carry information about the equation of state of neutron stars, and their detection in neutrino observatories can be compared to theoretical predictions. The latter depend, among other things, on models of the expansion of the Universe and its composition, the number of neutrinos produced during a merger, and of the merger rate in the Universe across time. Several sources can contribute to the spectrum of neutrinos, in the MeV energy range, detected on earth. Some sources are black hole accretion disks, supernovae and neutron star mergers. I will present the contribution from binary neutron star mergers to the neutrino spectrum, which is in order to understand the behaviour of compact matter.

(09:15 – 09:30) Black Holes Echos seen by Pulsar Timing Arrays

Hassan Subhi

University of Waterloo and Perimeter Institute for Theoretical Physics

The quest of unifying gravity with Quantum Mechanics has been a daunting path in the field of physics. In this project, a mathematical and data-driven approach has been adopted to lay out a route that uses the observation of Gravitational Waves to see possible hints of Quantum Gravity. The approach suggests there exists possible echoes following the merger event of black holes orbiting each other that are produced with the emission of Gravitational Waves. The cause of the Gravitational Wave echoes is attributed to the existence of Quantum Membranes at the event horizon of the black hole, which could follow from several paradigms such as firewall and fuzzball of black holes. The purpose of this work is to investigate such hints of echoes within Gravitational Waves that are seen by Pulsar Timing Arrays, such as the database of NANOGrav collaboration.)

(09:30 – 09:45) Star Formation Indicators in Different Phase Space Regions

Naman Jain, Laura Parker

Department of Physics and Astronomy, McMaster University

We investigate the effect of environment on the star-forming properties of galaxies by using their location within the projected-phase space and estimated values of time-since infall. Star formation in galaxies is traced using Hα equivalent width and Dn(4000) index measurements from the MPA-JHU value added catalogues, along with UV flux observations from the Galaxy Evolution Explorer (GALEX). Hα emissions traces the most massive stars, thereby indicating star-formation on timescales of ~ 10 Myr, while UV emission traces star-formation on timescales of ~ 100 Myr, and Dn(4000) is indicative of mean stellar age on gigayear scales. The varying timescales are also exploited to probe the most recent star-formation histories of galaxies in different environments. The differential star-formation rates are used to define populations of rejuvenating and recently quenched galaxies. We see strong trends of star-formation rates (SFR) with stellar masses and environment (characterized by time-since infall) for all star-forming indicators. We find that the SFRs of galaxies of a given mass bin strongly depends on the density of the environment and time-since infall. Additionally, we find that the SFR stays relatively constant until a time-since infall of 3-4 Gyr before it reduces sharply as a function of time-since infall. We also find that the distributions of rejuvenating and recently quenched galaxies in the phase space are similar, but rejuvenating galaxies are less massive than recently quenched galaxies.

(09:45 – 10:00) Predicting Molecular Gas Susceptibility to Ram Pressure Stripping in Virgo Cluster Galaxies

Celine Greis

Department of Physics and Astronomy McMaster University

Ram pressure stripping (RPS) can be described as the constant wind a galaxy experiences as it falls into a galaxy cluster. In that process, while moving through the intracluster medium, ram pressure and gravitational restoring pressure battle each other. Where ram pressure dominates the gas is stripped from the galaxy. It is found that a galaxy can be more resistant to RPS depending on the small structures of its molecular gas. With the high-resolution molecular gas maps of PHANGS, that effect can finally be taken into account. In our project we mapped the molecular gas of a sample of Virgo cluster galaxies to identify ram pressure stripping dominant regions within each galaxy. Finally, we obtained estimates of how much of their molecular gas is susceptible to ram pressure stripping. We used PHANGS CO data and stellar mass distribution maps of VERTICO to model the restoring pressure and to estimate the ram pressure that a galaxies experiences. Finally, we have found three galaxies with a significant amount of their gas susceptible to ram pressure stripping: NGC4254, NGC4548, and NGC4569.

(10:00 – 10:15) Summer Observational Astrophysics Retreat at the Mount Wilson Observatory

Ilyas Jaffer

Department of Physics, University of Ottawa; Mount Wilson Observatory

The Summer Observational Astrophysics Retreat (SOAR) at Mount Wilson Observatory (MWO) is a unique experience to take astronomy into your own hands on historical grounds, walking in the footsteps of giants. Ilyas Jaffer recounts his experience at SOAR 2022, as well as his 1-week research project on the band head strength of titanium oxide absorption bands in the spectra of cooler stars, in which he was able to produce confirming evidence that cooler stars do indeed have an increased opacity of TiO.

(10:15 – 10:30) The MASSIVE Survey: An Analysis of Giant Elliptical Galaxies

Stephanie Ciccone[1,2], Matthew Quenneville[3], John Blakeslee[4], Chung-Pei Ma[3], Jenny Greene[5], Stephen Gwyn[6], and Blanka Nyiri[7]

[1]Department of Physics and Astronomy, McMaster University; [2]Department of Physics, University of Guelph; [3]Department of Physics, University of California – Berkley; [4]NOIRLab; [5]Department of Astrophysical Sciences, Princeton University; [6]NRC Herzberg; [7]Department of Physics, University of Waterloo

By studying the properties of nearby massive early-type galaxies, we can learn about their evolutionary histories. The growth history of these galaxies can leave measurable impacts on their observed properties which we can carefully measure and thus discover strong correlations. This presentation explores the K-band photometry of 98 luminous early-type galaxies (ETGs) from the MASSIVE survey based on observations taken with the Canada-France-Hawaii Telescope. Using these images, my work focused on obtaining accurate total K-band luminosities (LK) and half-light radii (Re) by using elliptical modelling software, Imfit and ARCHANGEL. I used both to measure and compare the effective radius and the total magnitude of 60 target galaxies which are a part of the MASSIVE Survey. A data table compilation of all relevant values was constructed and the analysis procedure will also continue to be implemented in this survey work. These new values were used to explore the size-luminosity and Faber-Jackson relations for massive ETGs. Within this sample, clear evidence was found for curvature in both relations, indicating that the most luminous galaxies tend to have larger sizes and smaller velocity dispersion than expected from a simple power-law fit to less luminous galaxies. The measured relations are qualitatively consistent with the most massive elliptical galaxies forming largely through dissipation-less mergers.

(10:30 – 10:45) Neutron Star Mass and Radius Constraints Using QLMXB's

Tyler Burgardt

Department of Physics, University of Alberta

Neutron stars are fascinating objects that cannot be replicated in a lab, as such we study Quiescent Low Mass X-ray Binaries to understand the physics taking place inside these neutron stars. We aim to explore how varying extraction radii, cutoff energy, abundance, binning, and atmosphere changes our mass and radius constraints. We vary all these to determine the effect each variable has on the mass and radius constraints on neutron stars. We use the Chandra X-ray telescope to look at NGC 6397. By varying all these parameters, we determined that the cutoff energy makes a very large difference, extraction radii makes a small but noticeable variation, abundance makes a massive difference, and finally the type of atmosphere (H or He) makes a very large difference. We explore these parameters to determine what needs to be considered when creating future mass and radius constraints on neutron stars.

(10:45 – 11:00) Radiation Exposure and Risk from Deep Space Exploration (Virtual)

Jocelyn Coulombe[1,2] and Samy El-Jaby[2]
[1]Department of Physics, University of Guelph; [2]Canadian Nuclear Laboratories

Understanding the heightened risks to crew health is of priority as the international space community prepares to explore deeper into our solar system. Among primary concerns is radiation exposure; it is likely that one or two long-duration missions will expose astronauts to a cumulative dose that approaches or exceeds current international space agency limits. As with radiological effects, the cumulative health impact of other injuries and illnesses documented during spaceflight is also inherently heightened with longer durations missions to farther destinations. This presentation will discuss the assessment of radiation exposure in space and the categorization of associated health effects. It will also review two conventional metrics used to quantify radiation-induced cancer mortality risk and their applicability to deep space missions. It will conclude by proposing the application of an existing public health risk model to space exploration, to communicate the overall impact of spaceflight on crew health, including that of radiation.

Session S2: Particle Physics and Dark Matter

09:00 – 11:00 on Saturday October 30 in the Terrace Room at Delta Hotels Guelph

(09:00 – 09:15) Event Selection Optimization of B-Meson Decays to Electrons in the ATLAS Detector at the LHC

Sarah Alshamaily
University of Victoria

The B-physics trigger in ATLAS has historically been focused on muon decays; however, a new set of triggers has been implemented to select di-electron events with an invariant mass region corresponding to b-hadron decays. This analysis studied rare B-meson decays. B-mesons are hadronic particles that consist of a bottom quark or antiquark, and another lighter quark or antiquark. Two specific decays were studied: resonant decays ($B \rightarrow K^* J/\psi$, where the J/ψ decays into an electron-positron pair) and non-resonant decays ($B \rightarrow K^* e^+e^-$). The purpose of this study is to determine whether the existing di-electron triggers in ATLAS can be improved for these specific processes. Three electron identification variables were used to emulate triggers with new parameter selections to determine which combination of those would allow for a better event selection efficiency. The results concluded that the current trigger configuration can be improved upon, but not using the simple pre-determined configuration information.

(09:15 – 09:30) Live Long and Prosper: The MATHUSLA Detector for LLPs at CERN

Rufat Ismayilov
Department of Physics, University of Toronto

MATHUSLA is a Long Lived Particle detector, expected to be functioning around 2025. It will be placed at the (LHC) Large Hadron Collider at CERN. The detection of Long Lived Particles requires precise triggering and background setting, therefore allowing the MATHUSLA detector to tune these settings as opposed to LHC, where it is impossible to detect such particles. The result of the MATHUSLA experiment will help us research and detect particles that are lifetime stretches up to Big Bang Nucleosynthesis. The experiment at the University of Toronto lab focused on testing wavelength shifting fibers (WLSFs) with Silicon Photo-multipliers (SIPMs). Silicon Photo-multipliers, electric pulses, scintillating bars, and an oscilloscope were used in the testing of the fibers. Our work consisted of measuring the time and energy delay and the attenuation of the fibers, thus allowing us to build a cosmic ray setup to detect cosmic rays with the best fiber chosen. The result of the experiment will help the team at the University of Toronto to build a small model of the MATHUSLA detector.

(09:30 – 09:45) MEASUREMENT OF THE STANDARD MODEL TOP QUARK AND HIGGS BOSON PAIR PRODUCTION

Harsh Jaluka, Pekka Sinervo, Sahibjeet Singh, Angela Xiang, and Joel Foo
Department of Physics, University of Toronto

The Higgs boson interacts with all massive particles and the strength of this interaction ('Yukawa coupling') can be measured experimentally by different types of decays involving the Higgs. One such decay is the $pp \to tH$ decay predicted by the Standard Model (SM), where two protons collide and decay into a top quark and Higgs boson pair. A measurement of this decay is currently being conducted at the ATLAS experiment in the boosted (i.e., high momentum in the transverse plane) all-hadronic final state. To effectively identify tH events, topological and kinematic properties were used to filter for potential tH events and simulations were generated for the tH signal and each type of background that is expected. These samples are based on the SM and act as models for the experimental data. Moreover, numerous 'tagging' algorithms have been developed to efficiently identify particles from detector data. In particular, the 'DL1' and 'DL1r' algorithms to tag bottom quarks, the 'contained' and 'inclusive' algorithms to tag top quarks and the 'boosted $H \to b\bar{b}$' algorithm to tag Higgs bosons are considered in this study. Each of these algorithms have different 'working points', which each provide a different signal to background rejection rate. To see which choices of algorithms and working points provides the most sensitive measurement of the tH pairs, the efficiency of each combination was studied. The simulations generated using the SM will be used as a comparison to the experimental data from the ATLAS detector. The degree of correspondence between the two will test how well the theory predicts reality, provide a measurement of the production rate of tH pairs and ultimately the Yukawa couplings.

(09:45 – 10:00) MEASUREMENT OF t-CHANNEL SINGLE TOP-QUARK CROSS-SECTION AT $\sqrt{s} = 5.02$ TEV

Kelvin Leong, Pekka Sinervo, and Sahibjeet Singh
Department of Physics, University of Toronto; ATLAS Collaboration

This presentation reports the analysis progress on a measurement of the t-channel single top-quark cross-section at a centre-of-mass energy of $\sqrt{s} = 5.02$ TeV using 257 pb^{-1} of proton-proton collision data collected in 2017 by the ATLAS experiment at the LHC. This measurement is the first measurement of its kind at $\sqrt{s} = 5.02$ TeV and can increase our understanding of the proton parton distribution functions. The main challenge in this measurement arises from the low cross-section at $\sqrt{s} = 5.02$ TeV, which necessitates a dedicated region to increase the signal-to-background ratio. Furthermore, a boosted decision tree (BDT) is being implemented to further differentiate signal events from background since one can obtain a better statistical significance on the cross-section by fitting to the BDT output. The measurement is on track to be published by early 2023.

(10:00 – 10:15) COMPARING NOVEL HIGHLY GRANULAR PARTICLE DETECTORS FOR $e - e^+$ EXPERIMENTS (VIRTUAL)

Simone Têtu
McGill University

The advancement of experimental particle physics relies on the observation of interactions occurring in particle accelerators such as the Large Hadron Collider and the prospective International Linear Collider. A new measurement optimization method is the use of Particle Flow Algorithms, which combine information from multiple detectors. This approach, however, requires unprecedentedly highly granular calorimeters. The CALICE collaboration, which is the largest group working on the development of high-performance detectors for the International Linear Collider, has developed and tested the Analogue Hadronic Calorimeter (AHCAL), the Digital Hadron Calorimeter (DHCAL), the Silicon-Tungsten Electronic Calorimeter (ECAL), and a joint ECAL-DHCAL in different facilities during the past decade. I will describe the inner workings of these prototypes, present event selection and particle identification processes, and explain the basic statistical methods that enable a comparison of different detectors' performances.

(10:15 – 10:30) ISOLATING THE SOUND OF DARK MATTER: OUR HELIOS SUSPENSION

Noah Baker[1], M. Hirschel[1], V. Vadakkumbutt[1], J. Manley[2], S. Singh[2], and J.P. Davis[1]
[1]*University of Alberta and* [2]*University of Delaware*

There are several candidates in the broad search for dark matter. Prevalent among them is an ultralight particle interacting via some scalar field, which would induce an isotropic strain on all condensed bodies. Our dark matter detector (HELIOS) aims to measure this effect in the 2 kHz frequency range, and thus requires strong vibration isolation in that range. We have created a new kind of vibration isolation suspension, which uses circular catherine-wheel springs cut out of oxygen-free copper sheets. These springs utilize significantly less vertical height, meaning more isolation stages can fit above the shell of our dilution refrigerator. This increases the overall attenuation. Since stainless-steel coil springs also have very poor thermal conduction, similar suspensions are generally thermally bypassed using copper wires or rods. This implementation is unnecessary with this new design, as the entire suspension is made out of copper. We verify the effectiveness of these new springs using Hooke's law measurements, and measure strong attenuation in the desired frequency range.

(10:30 – 10:45) Optimization of Detector Design for the MOLLER Experiment

M Tausif Tajwar Bhuiyan
Department of Physics and Astronomy, University of Manitoba

Only fundamental interaction that violates parity symmetry in nature is weak interaction. As a result, mirror image experiments produce asymmetric results. Therefore, the high-precision measurement, using electrons with rapidly flipping polarization as probes, can be used to test for Physics Beyond the Standard Model. The Measurement for Lepton-Lepton Electroweak Reaction (MOLLER) experiment is the flagship experiment that will use this technique using the state-of-the-art accelerator facility at Jefferson Lab, USA. There, an 11 GeV longitudinally polarized electron beam will be scattered from atomic electrons in a liquid hydrogen target and the scattered electrons will be guided by a novel spectrometer with full azimuthal coverage to an array of quartz Cerenkov detectors. The electroweak mixing angle value derived from the weak charge makes MOLLER sensitive to new physics in the MeV to multi-Tev range. The individual quartz Cerenkov detectors in the main detector array has 3 main sections:1) Quartz Piece 2) Reflector and Lightguide 3) PMT Housing. It arranged with 6 rings within the array with quartz pieces of different lengths. The talk details the results of recent optical simulations of GEANT4 and REMOLL performed on Open Science Grid and Beluga. The goal of the simulation was to optimize the dimension parameters of the reflector and lightguide to increase the efficiency in propagation of photons to PMT cathode for different rings. This study will modify the design of detectors for the MOLLER Experiment and precision measurement.

(10:45 – 11:00) Study of the Time Structure of S1 Signals from the Surface of DarkSide-20k

Khurshid Usmanov
Laurentian University, University of Waterloo, and SNOLAB

A preponderance of astrophysical evidence suggests that there is much more matter in the universe that can be explained by the Standard Model of particle physics. This “obscure” matter does not emit, scatter, absorb or interact with electromagnetic radiation and so stays unreachable from modern telescopes which motivated the physics community to coin it with the term “dark matter”. It is presumed, that a potential constituent of dark matter - a Weakly Massive Interactive Particle (WIMP) must interact through weak and gravitational forces. In order to test the WIMP hypothesis, the DarkSide-20k - a Liquid Argon Scintillation detector, is going to be assembled and commissioned by the Global Argon Matter Collaboration (GADMC) at the Gran Sasso National Laboratory in Assergi, Italy. An event in Dark Side-20k starts with a hypothetical dark matter particle interacting with the LAr atom and producing scintillation light and ionization, which correspond to S1 and S2 signals. In this talk, I discuss event reconstruction to reduce the number of accidental pile-up events that might occur close to the detector's inner surface and walls.

Session S3: Biomedical Physics

09:00 – 11:00 on Saturday October 30 in the Terrace Room at Delta Hotels Guelph

(09:00 – 09:15) EXAFS of Thin Solidified Canine Blood

Jordan Bischoff, Karen Kavanagh, Nicole Herbots
Simon Fraser University

Modern blood analysis techniques such as high-performance liquid chromatography can be effective methods for diagnosing health conditions with sufficient accuracy of <10% error. Major drawbacks of current techniques include the stability of samples at room temperature as well as the relatively large volume of blood required to be drawn (~10 mL per test). In this work, we introduce a new proprietary blood sample preparation technique that produces dried blood (μL) as a homogeneous thin (~10 μm) film that is stable without refrigeration. We performed energy dispersive spectroscopy (EDS) and extended x-ray absorption fine structure (EXAFS) analyses demonstrating sample compatibility in vacuum. The expected Fe blood composition (0.34 At. %) and hemoglobin structure (Fe-N nearest neighbour bond length 2Å) were obtained with equal or better accuracy and reproducibility compared to standard analysis techniques. Labour intensive sample preparation or hemoglobin separation were not required, with samples remaining viable for many weeks.

(09:15 – 09:30) Estimating the Asymptotic Characteristic Time Scales for Diffusion-Controlled Drug Release Systems Using Partially Sampled Data

Cédric Bohémier
University of Ottawa

Drug release experiments and numerical simulations only give access to partial release data (i.e., within a finite time range $t \in [0, t_f]$). In this article, we propose fitting-based procedures to estimate the asymptotic time scales of the release process, namely the global relaxation time τ^* and the longest (or terminal) relaxation time τ_0, from partially sampled data of diffusion- controlled drug release systems. We test these procedures on both synthetic and experimental data using, as an example, the well-known Weibull function. Our results show that the Weibull function must be used with great care because the values of the fitting parameters can vary significantly depending on the ratio t_f/τ_0. Beyond their practical simplicity, the usefulness of our procedures is evidenced by the fact that: 1) the initial loading profile does not need to be known and 2) the chosen fitting function does not require any physical basis. These two advantages allow us to determine the diffusion coefficient of the molecules directly from the characteristic time τ_0.

(09:30 – 09:45) Dying to be Beautiful: Analysis of 18th Century Lead Cosmetics

Taren Ginter[1], Shaelyn Horvath[2], Josephine La Macchia[1], Sonia Marotta[1], and Fiona McNeill[1]
[1]Department of Physics and Astronomy, McMaster University; [2]University of Toronto

The specific physical qualities and potential toxicity of 18th century white lead cosmetics remains largely unknown. Historically, these recipes have occasionally been attributed as the cause of death by lead poisoning; however, modern lead science suggests that they would not result in significant poisoning. I have been investigating the optical properties of white lead cosmetics and their potential toxicity from dermal absorption under Dr. Fiona McNeill. We have recreated historical recipes and using optical diffuse reflectance techniques observed light scattering properties that can be considered beautifying. We have employed a Franz cell system and diffusion models to predict and measure the ability of lead in cosmetics to pass through skin. Using the example of the historical recipe Laird's Bloom of Youth, I will discuss the development of the methodologies that have permitted us to study these cosmetics, the historical context of this work, and its relevance to modern physics.

(09:45 – 10:00) Matrix Probe Ultrasound Field Characterization

Jordyn Matthews, Kiyan Shapoori, and Roman Maev
Tessonics, Inc. and Institute for Diagnostic Imaging Research, University of Windsor

A custom-designed transcranial matrix probe is studied, and field characterization is reported. Ultrasound imaging is a low-cost and non-invasive method that allows real-time imaging. These qualities are useful but limited to soft tissue. When it comes to imaging through bone, e.g. transcranial imaging through skull, strong attenuation and acoustic impedance mismatch with the soft tissue causes severe distortion to the transmitting filed. A new and fully custom-designed transcranial ultrasound matrix probe has been developed at Tessonics Inc., Windsor, Ontario, which allows for skull-induced attenuation and phase aberration correction for diagnosis of Intracranial Hemorrhages within the brain tissue. Experimental ultrasound field characterization and comparison with simulation results is provided in this work.

(10:00 – 10:15) Rheology of Charge-Modified, Soft Phytoglycogen Nanoparticles

Ricky Summerlin, Hurmiz Shamana, and John Dutcher
Department of Physics, University of Guelph

Phytoglycogen (PG) is a natural polysaccharide produced in the form of 42 nm diameter, electrically neutral nanoparticles in the kernels of sweet corn. Its highly branched structure and compressible nature leads to useful properties that make the particles ideal as additives in personal care, nutrition, and biomedical formulations. We consider the effect of covalently attaching positively charged glycidyltrimethylammonium chloride (GTAC) chemical groups to PG on the rheology of the particles, focusing on the zero-shear viscosity of GTAC-modified PG dispersed in water at different concentrations C. Dispersions of GTAC-modified PG were significantly more viscous than those of native PG and showed a much steeper increase in the zero-shear viscosity with increasing C. Additionally, the viscosity of GTAC-modified PG dispersions was sensitive to the addition of salts and decreased significantly with added NaCl. These results show that electrostatic interactions have a significant effect on the interactions between the particles.

(10:15 – 10:30) Abdominal Organs Auto-Segmentation to Reduce Patient-Wait Times in Radiation Oncology Treatment Starts

Udbhav Ram[1,2], Jeffrey Peacock[2], and Carlos E. Cardenas[2]
[1]McMaster University and [2]The University of Alabama at Birmingham

We evaluate MONAI's deep learning framework to achieve high-quality auto-contouring to develop an automated segmentation solution for abdominal normal tissues on computed tomography (CT) images for use in radiotherapy. We used the Medical Open Network for Artificial Intelligence (MONAI) framework on the Abdominal Multi-Organ Segmentation (AMOS) dataset. This dataset provides manual-annotations of 15 organs on 500 CT scans. We explore the 3D-UNETR architecture and evaluate performance using the Dice Similarity Coefficient (DSC), an overlap metric that measures similarity between ground-truth and prediction. Average DSC value across all organs was 0.665±0.288 demonstrating good overlap between auto-segmentations and ground-truth. We found the highest/lowest average DSC values for stomach (0.905±0.024) and left-adrenal (0.368±0.211). Deep learning as a method of accelerating planning workflows shows promise for radiotherapy. Future work will focus on architecture design and training towards making auto-segmentations clinically-acceptable without edits.

(10:30 – 10:45) Investigating Age-Related Changes in Molecular Collagen

Daniel Sloseris and Nancy Forde
Department of Physics, Simon Fraser University

Advanced Glycation End Products or AGEs are a group of potentially harmful crosslinks and adducts that are formed through non-enzymatic glycation between sugars and proteins, lipids or nucleic acids known as the Maillard reaction. These non-reversible end products have been associated with increased levels of oxidative stress, inflammation and apoptosis (cell death). AGEs are consumed from cooked foods or formed in the body. However, AGEs are only removed by catabolism and therefore accumulate on proteins with slow turnover rates such as collagen. AGE accumulation on collagen has been associated with tissue stiffening and decreased turnover rate in collagen fibrils; leading to tissue deterioration and slowed wound healing, among other traditional age-related health effects. In this investigation we probe the mechanical properties of molecular collagen after inducing ageing *in vitro*. Using Atomic Force Microscopy (AFM) we quantify collagen molecule flexibility and find a decrease in flexibility, suggesting AGE play a role in changing collagen's molecular flexibility. Further, we find that glycation affects collagen's triple helical structure, thermal stability and ability to form higher-order structures (fibrils), by measuring glycated molecules and their assembly using Circular Dichroism (CD) spectroscopy, protease digestion, and optical density measurements.

(10:45 – 11:00) Association of Computed Tomography Total Airway Count (TAC)/ Total Vessel Count (TVC) with Lung Function Measures in Chronic Obstructive Pulmonary Disease and Asthma Patients

Neha Nasir[1], Ehsan Haider[,3], Colm Boylan[,3], Carmen Venegas[4], Shaista Riaz[2], Suad Al Duwaiki[2], Moustafa Yehia[2], Terence Ho[4,5], Parameswaran Nair[4,5], Sarah Svenningsen[4,5], Miranda Kirby[1,6]
Department of Physics, Toronto Metropolitan University; [2]Department of Radiology, McMaster University; [3]Department of Diagnostic Imaging, St Joseph's Healthcare, Hamilton, Canada; [4]Department of Medicine, Division of Respirology, McMaster University; [5]Firestone Institute for Respiratory Health, St Joseph's Healthcare, Hamilton, Canada; [6]Institute for Biomedical Engineering, Science and Technology (iBEST), St. Michael's Hospital, Unity Health Toronto, Toronto, Canada

Computed tomography (CT) total airway count (TAC) decreases with increasing disease severity in chronic obstructive pulmonary disease (COPD) and asthma. We hypothesize that reduced TAC due to airway obstruction has preserved vasculature (total vessel count (TVC)), and a reduced TAC/TVC ratio. Our objective was to determine the relationship between TAC/TVC and airway obstruction/destruction measures in COPD/asthma patients. 35 patients (n=19/16 COPD/asthma) underwent CT at St. Joseph's Healthcare Hamilton. TAC, TVC, emphysema quantified as a percentage of low-attenuation-areas below −950HU (LAA950) and average wall-area-percent (WA%) (VIDA Diagnostics). Radiologists generated airway mucus scores. There were no significant differences for TAC/TVC between high/low groups (based on median threshold) for LAA950 ($p=0.35$) or WA% ($p=0.95$), but TAC/TVC was significantly reduced in the high mucus score group ($p=0.03$). TAC/TVC was reduced in patients with high mucus scores suggesting airways are predominantly obstructed on CT by mucus plugs.

Poster Session Abstracts

13:00 – 15:00 on Saturday October 30 in Peter Clark Hall - University Centre, University of Guelph

P1: Isolating the Sound of Dark Matter: Our HELIOS Suspension

Noah Baker[1], M. Hirschel[1], V. Vadakkumbutt[1], J. Manley[2], S. Singh[2], and J.P. Davis[1]
[1]University of Alberta and [2]University of Delaware

There are several candidates in the broad search for dark matter. Prevalent among them is an ultralight particle interacting via some scalar field, which would induce an isotropic strain on all condensed bodies. Our dark matter detector (HELIOS) aims to measure this effect in the 2 kHz frequency range, and thus requires strong vibration isolation in that range. We have created a new kind of vibration isolation suspension, which uses circular catherine-wheel springs cut out of oxygen-free copper sheets. These springs utilize significantly less vertical height, meaning more isolation stages can fit above the shell of our dilution refrigerator. This increases the overall attenuation. Since stainless-steel coil springs also have very poor thermal conduction, similar suspensions are generally thermally bypassed using copper wires or rods. This implementation is unnecessary with this new design, as the entire suspension is made out of copper. We verify the effectiveness of these new springs using Hooke's law measurements, and measure strong attenuation in the desired frequency range.

P2: SEAQUE (Satellite Entanglement and Annealing QUantum Experiment)

Nouralhoda Bayat, Joanna Krynski, Nigar Sultana, Paul Godin, Zhenwen Wang, Thomas Jennewein, Kelsey Ortiz, Spencer Johnson, Liam Ramsey, Matteo Stefanini, Tiphaine Kouadou, Logan Power, Richard Eason, Qi Lim, Subash Sachidananda, Daniel Pardo Suarez, Josh Aller, Bradley Slezak, Phil Battle, Alexander Ling, Michael Lembeck, Makan Mohageg, Paul Kwiat
CSA, NSERC, CFI, ORF, IQC, University of Waterloo, University of Illinois Urbana Champaign, National University of Singapore, AdvR Inc., NASA, and JPL

In order to set up the stage for a global quantum network, an infrastructure for quantum computers and quantum sensors to communicate securely is required. The critical stepping stone to this infrastructure is establishing a free-space quantum light-based communication system. SEAQUE (Satellite Entanglement and Annealing QUantum Experiment) is the first collaborative North American mission to demonstrate two communication technology tests from space. The milk-carton-size device will be installed on Nanoracks Bishop Airlock on the International Space Station, exemplifying the viability of orbiting nodes connecting quantum transmitters and receivers over a great distance. The payload will contain an entanglement source based on integrated optics to produce photon pairs used to communicate with the ground and test the bell's inequality. The SEAQUE mission will also test a self-healing method to demonstrate the extension of the lifetime of devices like itself by relieving the radiation-caused degradation of the photon detectors via laser annealing the detectors using a bright laser.

P3: Data Analysis and Detection Systems in the Neutron-Rich Region

Madeleine Bérubé, R. Caballero-Folch, I. Dillmann, et al.
TRIUMF and University of Waterloo

Nuclear structure properties of many isotopes in the neutron-rich region are still unknown. Detection systems that focus on this region are an important part of nuclear physics studies. At TRIUMF, the gamma-decay spectroscopy GRIFFIN facility, and its ancillary detectors, such as the neutron-tagging DESCANT detector, allows the study of many of these nuclei. From these studies, we can learn about the r-process nucleosynthesis and better understand the nuclear structure of exotic isotopes. This poster will show the current maintenance process of DESCANT. This work is important to preserve the performance of the 70 detectors that make up the array and its future experiments. In addition, the status of the analysis of a GRIFFIN experiment aiming to determine 148-150Ba properties using Cs beams will be reported.

P4: MATHUSLA: The Search for Long-Lived Particles

Lana Bozanic
University of Toronto and CERN

The Large Hadron Collider (LHC) at CERN has the world's most sophisticated equipment for its task of observing exotic particles that help us unlock a better understanding of our universe. However, despite its best efforts, there are still some mysterious, strange particles that have been evading detection; Long-Lived Particles. These particles, some theorists say, could be the key to understanding many fundamental theories about the universe, with one of its most promising deliverables being the probe for dark matter. The search for these particles requires a much larger and more robust detector than the ones currently available. That's why CERN, in collaboration with many universities across the globe, have decided to collaborate on MATHUSLA (Massive Timing Hodoscope for Ultra Stable neutraL pArticles), a detector designed to look for these very particles. This presentation features the prototyping stages of MATHUSLA@UofT, and the search for long-lived particles.

P5: Modelling Formaldehyde Emission Toward Young Stellar Objects

Julian Caza
Department of Physics, Engineering Physics & Astronomy, Queen's University

Stars are born in dense, gaseous cores. Properties of these young stellar objects (YSOs) can be determined by studying the chemistry of the gases that surround them. Formaldehyde is one such molecule that is a good tracer of gas temperature, and determining its abundance alone can reveal information about the YSO. This project's intention was to compare how the gas temperature and formaldehyde abundance varied with the evolutionary stage and number of YSOs within each core. To do so, formaldehyde line transitions were modelled using a line fitting program which assumes that sources are in local thermal equilibrium (LTE). This program did not yield good fits, however, which indicates that the sources studied likely are not in LTE. Future work with non-LTE codes will test this assumption and, if confirmed, will reveal the desired properties of the cores.

P6: Libration Induced Energy Dissipation of the TRAPPIST-1 Planets

Hannah Christie[1] and Mathieu Dumberry[2]
[1]*Department of Physics and Astronomy, McMaster University;* [2]*Department of Physics, University of Alberta*

The seven planets orbiting the ultra cool star, TRAPPIST-1, have physical sizes similar to Earth and have star-to-planet mass ratios of around 0.02 percent. Further, given the planets' non-zero eccentricities, a periodic gravitational torque is applied to the planet, resulting in the longitudinal libration of the outer shell above a liquid region (for example, a subsurface ocean or fluid core). The libration induced motion in the fluid region results in viscous friction between the core and the crust, leading to the dissipation of orbital and rotational energy deposited in the fluid core. Using the measured parameters for the planets' mass, radius, density and orbital geometry, we constructed a model of the interior layers of the seven TRAPPIST-1 planets. We found the density of each layer, as well as the layer's ellipticity, and thus were able to build a prediction of the libration amplitude and the resulting energy dissipation. We found that a non-zero amount of energy is dissipated due to the viscous friction at the core-mantle boundary. This energy is converted to other forms, including heating, which may help prevent freezing in liquid regions or, in the core, may also be converted to magnetic energy, both of which would increase the potential for habitability of the TRAPPIST-1 planets.

P7: Machine Learning for the Identification of Emerging Jets at the ATLAS Experiment

Robert Owen Darragh, Jesse Heilman and Kevin Graham
Carleton University and ATLAS Canada

Of the known universe only 4.9% is made of baryonic matter, while 26.8% is made of dark matter; which we know very little about. Physicists have been trying to understand dark matter for decades and some models for dark matter postulate the existence of a "Hidden Valley" where dark physics may occur, including the creation of stable dark matter. One possible consequence of this kind of Beyond the Standard Model physics could be the production of so-called emerging jets in collisions at the Large Hadron Collider. A search for this type of signature is ongoing within the ATLAS collaboration using the Run2 dataset. Now that Run3 has begun, efforts are being made to expand the current analysis with improved tools that focus on using machine learning and simulated events to identify emerging jets.

P8: Four-Wave Mixing for Charge and Spin Transport

Lilly Daw, Liam Morrison, Grant Wilbur, and Kimberley Hall
Department of Physics & Atmospheric Science, Dalhousie University

Four-Wave Mixing (FWM) spectroscopy is a non-linear optical technique used to measure charge and spin transport of semiconductors. Specifically, transient grating FWM can measure carrier diffusion and carrier lifetimes. It uses two coincident optical pulses to excite a transient absorption grating in the material, creating a modulation of carrier density. A third pulse is used to determine the amplitude of the carrier grating in the material as a function of time. A FWM set-up was built as a summer research project, to later be used to study charge and spin transport in 2D materials, including TMDCs. This poster will discuss FWM as an experimental technique and provide details about the in-lab set-up.

P9: Study of Neutrino Emission Spectra from Neutron Star Mergers

Paul Deguire
Department of Physics, University of Guelph

Neutron stars are very dense objects that result from the death of a main-sequence star with an original mass between 8 and 25 solar masses. Studying their interior can help us to understand the behaviour of ultra-compact matter. During the merger of a binary neutron star system, part of the gravitational energy is transferred to neutrinos that escape the stellar matter. Some of these neutrinos are possibly detected on the Earth. They carry information about the equation of state of neutron stars, and their detection in neutrino observatories can be compared to theoretical predictions. The latter depend, among other things, on models of the expansion of the Universe and its composition, the number of neutrinos produced during a merger, and of the merger rate in the Universe across time. Several sources can contribute to the spectrum of neutrinos, in the MeV energy range, detected on earth. Some sources are black hole accretion disks, supernovae and neutron star mergers. I will present the contribution from binary neutron star mergers to the neutrino spectrum, which is in order to understand the behaviour of compact matter.

P10: Calibration of Charged & Neutral Particle Tissue Equivalent Proportional Counter by Proton Edge Technique

Larysa Duda
Department of Physics and Astronomy, McMaster University

As interest in human space exploration grows, it is critical to consider the health risks associated with extended exposure to the radiation environment in space. The McMaster Interdisciplinary Satellite Team aims to further the understanding the radiation dose contributions in low-Earth orbit through the Neutron Dosimetry & Exploration (NEUDOSE) CubeSat Mission, with the development of a Charged & Neutral Particle Tissue Equivalent Proportional Counter (CNP-TEPC). This work details the process of lineal energy calibration of the TEPC. In order to convert detected pulse height spectra into microdosimetry spectra, the TEPC was irradiated in a neutron field at the McMaster 1.25 MV Tandetron Accelerator. The spectrum produced by the neutron field contains a characteristic proton edge region with a defined lineal energy value from which the spectrum was calibrated.

P11: Can deep learning help us create better Point Spread Functions, faster?

Ashley Ferreira[1] and Wesley Fraser[2]
[1]University of Waterloo and [2]NRC Herzberg/University of Victoria

This project uses data from the Hyper Suprime-Cam (HSC) on the Subaru telescope to train a 2D Convolutional Neural Network. The purpose of this deep learning model is to pick the optimal stars from cutouts of all sources in an image to use for Point Spread Function creation, a necessary step in many astronomy data processing pipelines. Although this approach does not yet consistently perform as well as the usual method it completes the task in only 6% of the time. Next steps are outlined which can hopefully improve the performance of this deep learning model such that it can consistently outperform previous approaches and can be extended to work on images from other telescopes. Hopefully, this project can serve as an additional example of how we can harness deep learning to help process the quickly increasing volume of astronomy data we have access to.

P12: Monte Carlo Calculation of Cloud Layer Reflectance for Isotropic, Rayleigh & Forward Scattering

Aayush Gambhir and William van Wijngaarden
Department of Physics and Astronomy, York University

Scattering occurs when cloud particles interact with incoming radiation. Rayleigh & isotropic scattering applies for small particles. Mie scattering which is predominantly in the forward direction occurs for larger particles. Photons scatter numerous times in the cloud before exiting from top or bottom. The reflectance was found for different incident angles for the case of zero cloud absorption. Photons incident at near horizontal trajectory are less likely to be transmitted through the cloud than those incident perpendicularly. Reflectance is lower for forward scattering than for isotropic or Raleigh scattering.

P13: Using Atomic Force Microscopy to Measure the Stiffness and Radius of Acid Hydrolyzed Phytoglycogen

Ashley Geddes, Benjamin Baylis, Yasmeen El-Rayyes and John Dutcher
Department of Physics, University of Guelph and Mirexus Biotechnologies Inc.

Scattering occurs when cloud particles interact with incoming radiation. Rayleigh & isotropic scattering applies for small particles. Mie scattering which is predominantly in the forward direction occurs for larger particles. Photons scatter numerous times in the cloud before exiting from top or bottom. The reflectance was found for different incident angles for the case of zero cloud absorption. Photons incident at near horizontal trajectory are less likely to be transmitted through the cloud than those incident perpendicularly. Reflectance is lower for forward scattering than for isotropic or Raleigh scattering.

P14: Life at the Resolution Limit: Using Confocal Microscopy to Detect Bicoid Transcriptional Condensates

Lydia Hodgins, Lili Zhang, and Cécile Fradin
Department of Physics and Astronomy, McMaster University

Bicoid (Bcd) is a transcription factor found in fly embryos. Recently it has been shown that Bcd has multiple diffusing populations and can be spatially clustered. This, added to the fact that Bcd is composed of intrinsically disordered regions, supports the hypothesis that this protein forms transcriptional condensates, membrane-less compartments formed through liquid-liquid phase separation. The predicted size and lifetime of transcriptional condensates, however, is near the resolution limit of many imaging modalities. I have investigated the possibility to observe Bcd condensates using confocal microscopy. Image series were captured under various conditions to identify the set of parameters which represent the best comprise between maximizing signal and minimizing acquisition time, detector noise and photobleaching. My analysis revealed high intensity regions which can be tracked between frames, corresponding to localized high Bcd concentration regions. This offers insight into the mechanisms by which transcription factors locate and bind to specific promoters.

P15: Measurement of the Standard Model top quark and Higgs Boson Pair Production

Harsh Jaluka, Pekka Sinervo, Sahibjeet Singh, Angela Xiang, and Joel Foo
Department of Physics, University of Toronto

The Higgs boson interacts with all massive particles and the strength of this interaction (‘Yukawa coupling’) can be measured experimentally by different types of decays involving the Higgs. One such decay is the $pp \to tH$ decay predicted by the Standard Model (SM), where two protons collide and decay into a top quark and Higgs boson pair. A measurement of this decay is currently being conducted at the ATLAS experiment in the boosted (i.e., high momentum in the transverse plane) all-hadronic final state. To effectively identify tH events, topological and kinematic properties were used to filter for potential tH events and simulations were generated for the tH signal and each type of background that is expected. These samples are based on the SM and act as models for the experimental data. Moreover, numerous ‘tagging’ algorithms have been developed to efficiently identify particles from detector data. In particular, the ‘DL1’ and ‘DL1r’ algorithms to tag bottom quarks, the ‘contained’ and ‘inclusive’ algorithms to tag top quarks and the ‘boosted $H \to b\bar{b}$’ algorithm to tag Higgs bosons are considered in this study. Each of these algorithms have different ‘working points’, which each provide a different signal to background rejection rate. To see which choices of algorithms and working points provides the most sensitive measurement of the tH pairs, the

efficiency of each combination was studied. The simulations generated using the SM will be used as a comparison to the experimental data from the ATLAS detector. The degree of correspondence between the two will test how well the theory predicts reality, provide a measurement of the production rate of tH pairs and ultimately the Yukawa couplings.

P16: Analysis of Selenium and Zinc in Mother and Infant Nail Clippings from a Population in New Zealand Using X-Ray Fluorescence

Michaela Kaiser[1], David Fleming[1], and Louise Brough[2]

[1]Department of Physics, Mount Allison University and [2]School of Food and Advanced Technology, Massey University, New Zealand

Zinc and selenium are micronutrients that play an important role in many biological processes. The status of these micronutrients is especially vital in postpartum women. In New Zealand, there has been a concern for low selenium content in the soil for over four decades. To look at the long-term status of trace element concentrations in humans, toenails have been shown to be a successful biomarker. This study uses X-ray fluorescence (XRF) spectrometry as a means of investigating zinc and selenium levels in the toenails of mothers and their infants from New Zealand. Two sets of samples from eighteen mother-infant pairs are being compared to see the changes in concentration over time as well as determining any relationship between mother and infant concentrations.

P17: Active Magnetic Field Compensation System in One-Axis

Yeh-In Kang, Arina Tashchilina, Lindsay J. Leblanc, and Jacob Byers

Department of Physics, University of Alberta

Variations in the background magnetic field may cause inconsistency in the number of atoms present in a Magneto Optical Trap (MOT), which are commonly used in Bose-Einstein Condensate (BEC) apparatuses. To remedy this a magnetic field compensation system is sometimes used. This project consisted of a magnetic field compensation system in one-axis. It was designed to compensate effects from uniform near DC fields such as the Earth's magnetic field. Greater consistency in the MOT would maximise the number of atoms trapped thus increasing the robustness of experimental conditions. The system consists of 2 magnetoresistive sensors that sit opposite to each other at the edges of a control zone that is contained between a pair of Helmholtz coils. The field generated by these coils are controlled using the sensors and an analog proportional controller. The system was able to achieve compensation on the order of -15.8 dB.

P18: Contact Drawing of Zein Fibers

Gavin Kerr and Laurent Kreplak

Department of Physics & Atmospheric Science, Dalhousie University

Zein is a protein which is a waste product from the corn industry. It has a molecular weight of 22 to 27 kDa and is soluble in a mixture of ethanol and water at concentrations of 55% to 90% ethanol. The study of zein is an important area of research as it has a wide variety of applications, including the development of gluten free foods, textile fibers and 3D printing ink. This project focuses on the area of textile fibers. The current most prevalent method of zein fiber fabrication is electrospinning. Electrospinning uses a charged polymer solution to pull fibers onto an oppositely charges collection plate. This method has significant drawbacks as it requires the use of volatile solvents. Another popular method is wet extrusion. This method is also not ideal as it does not allow the user to make a large volume of fibers quickly. Contact drawing is another method of creating fibers from a polymer solution. It uses a needle attached to a motorized stage. The fiber is pulled by moving the needle into a reservoir containing a polymer solution, then pulling the needle out of the solution at a controlled velocity. This created a liquid bridge between the tip of the needle and the solution. After the liquid bridge dries, a fiber is produced between the reservoir and the needle tip. This method is advantageous compared to the previously discussed methods as it allows the use of additives, does not require the use of volatile solvents and allows the user to manufacture a large volume of fibers. The objective of this project is to better understand under what conditions zein polymer solutions will be pulled into fibers. It also aims to understand how these conditions affect the diameter as well as the uniformity of the diameter along the fiber. Pull time, as well as the concentrations of the zein polymer solution are the parameters being optimized to determine how to consistently make fibers with a uniform diameter. Three types of data are being measured while changing these parameters: failure rate, dry fiber diameters and the change in diameters over time while the fiber is being pulled. Preliminary data indicates that fibers pulled with a higher concentration of zein at faster pulling velocities, have smaller and more uniform diameters with lower failure rates.

P19: Measurement of t-channel single top-quark cross-section at $\sqrt{s} = 5.02$ TeV

Kelvin Leong, Pekka Sinervo, and Sahibjeet Singh
Department of Physics, University of Toronto; ATLAS Collaboration

This presentation reports the analysis progress on a measurement of the t-channel single top-quark cross-section at a centre-of-mass energy of $\sqrt{s} = 5.02$ TeV using 257 pb^{-1} of proton-proton collision data collected in 2017 by the ATLAS experiment at the LHC. This measurement is the first measurement of its kind at $\sqrt{s} = 5.02$ TeV and can increase our understanding of the proton parton distribution functions. The main challenge in this measurement arises from the low cross-section at $\sqrt{s} = 5.02$ TeV, which necessitates a dedicated region to increase the signal-to-background ratio. Furthermore, a boosted decision tree (BDT) is being implemented to further differentiate signal events from background since one can obtain a better statistical significance on the cross-section by fitting to the BDT output. The measurement is on track to be published by early 2023.

P20: Accelerated Ageing Study of Different Formulations of PEX-a Pipe

Hugh MacFarlane, Joseph D'Amico, Jonathan Quintal, Michael Grossutti, and John Dutcher
Department of Physics, University of Guelph

Cross-linked polyethylene (PEX) pipes are being used more frequently instead of metal pipes in both homes and industrial settings. This is mainly due to their cost-effective manufacturing process and ease of installation compared to that of metal pipes. However, PEX pipes can degrade due to oxidation, causing the pipes to become brittle and resulting in premature pipe failure. To counteract this, stabilizing additives are included in the pipe formulations to reduce oxidation, but eventually these additives are depleted with use. By performing FTIR microscopy measurements on two different PEX pipe formulations that were subjected to accelerated ageing at high temperature, we were able to track the progression of oxidation across the pipe wall thickness by measuring the area of the carbonyl IR absorption peak. This IR peak provides a unique window on both the polyethylene and the stabilizing additives. We determined that one of the formulations was more stable with respect to oxidation than the other, indicating that it should have a longer in-service lifespan.

P21: Cosmic Ray Simulations for the JWST FGS

Dia Martinez Gracey and Neil Rowlands
Honeywell Aerospace and NSERC NTCO-CREATE Training Program

This poster explores the impact of cosmic rays on the pointing of the James Webb Space Telescopes' Fine Guidance Sensor (JWST FGS). Cosmic rays are simulated in test images for the JWST FGS Data Acquisition and Handling System at various intensities, locations, and patterns, and their impact on the calculated stellar centroid is recorded. Based on this information, a cosmic ray detection flag is created to find and remove comic rays from the stellar centroid. Finally, this flag's effectiveness is tested, and it is recorded which intensities and patterns are not flagged, and therefore have the greatest impact on the centroid. It is determined that with this flag, cosmic rays will not have significant impact on the pointing on the JWST.

P22: Capture of Asymmetric Dark Matter in Stars

Madelynn Mast
Department of Physics, Engineering Physics & Astronomy, Queen's University

Asymmetric Dark Matter (ADM) could be trapped in the sun and other stars. In the past two heat transport formalisms were developed to explain how this ADM could alter temperature gradients in stars, which could in turn alter key components such as neutrino flux, astero seismological signatures, and so on. More recent articles have developed a recalibrated form of the transport formalism from Spergel & Press that would also allow the ADM cross sections to be momentum or velocity- dependent. This new formalism has been validated for instantaneous "snaphsots" of a star's structure but has not been implemented in stellar evolution simulations. My summer project is to perform this implementation in a Fortran-based simulation code that can utilize these new formalisms to model theoretical effects of dark matter in stars that can later be compared to real life asteroseismology data.

P23: Polarization-Entangled Photon Sources for Quantum Communication

Fraser McCauley
Department of Engineering Physics, McMaster University

Polarization-entangled photon pairs are an important resource for quantum cryptography and other emerging communications technologies. A simple quantum key distribution protocol using polarization-entangled photons is presented to show the high-level application of these sources. An important physical mechanism for pair generation, spontaneous parametric down conversion, is described, with a focus on how the phase matching conditions can impact photon entanglement characteristics. To demonstrate how these techniques can be implemented, source devices using bulk β-Barium Borate and periodically poled Lithium Niobate crystals are introduced. Issues with these current devices are discussed, along with the figures of merit that will be used to evaluate the next generation of photon pair sources.

P24: Constraining the Secret Histories of Stars Using Circumbinary "Tatooine" Planets

Niharika Namulla[1], J.J. Zanazzi[2,3], Janosz Dewberry[2,4], Gwendolyn Eadie[5], Kanah Smith[6]
[1]*Department of Physics and Astronomy, Trent University;* [2]*Canadian Institute for Theoretical Astrophysics, University of Toronto;* [3]*The Department of Astronomy, University of California Berkeley;* [4]*The Division of Physics, Astronomy and Mathematics, California Institute of Technology;* [5]*David A. Dunlap Department of Astronomy & Astrophysics, University of Toronto;* [6]*Department of Astronomy & Astrophysics, University of Toronto*

A binary star system consists of two stars orbiting a common center of mass. Although once believed to be a work of fiction, it is now known that roughly half of Sun-like stars exist in multiples, with one-third existing in binaries. Additionally, with the help of the Kepler and TESS survey missions, over a dozen planets orbiting eclipsing binaries have thus far been discovered. The stability of these planets orbiting binary stars on an eccentric orbit is generally calculated numerically, wherein the planet is treated as a massless test particle. Typically, the survival times of test particles under various orbital constraints are then used to estimate regions of stability and instability in phase space. In this project, a similar approach was utilized, however with improved computing power to replicate the results of previous studies. Consequently, the presence of a critical semi major axis beyond which most test particles appeared to have long term stability has been confirmed. However, most studies have thus far utilized linear regression models for data analysis, lacking to account for right censorship caused by limited simulation time. In this work, the statistical method known as "survival analysis", which accounts for right censorship when performing survival regression, is used to calculate the stability boundary for planets orbiting eccentric binary stars. An extension of the classical survival model known as the Cure Model is fit to the data with emcee, a Markov Chain Monte Carlo (MCMC) ensemble sampler.

P25: Quantum Information Labs for High School Students

Jamiel Nasser, Azzam Bin Aamir, Hannah Gallop, and John Donohue
Institute for Quantum Computing, University of Waterloo

Quantum key distribution (QKD) is one of the key technologies of quantum information science. Over the course of many workshops for high-school students, undergraduates, and educators, we have consistently found that the ideas behind QKD are best communicated with hands-on demonstrations that mimic the real-world setup. Since single-photon sources and detectors are inaccessible to most educators, a demonstration was developed with laser pulses that communicates the key ideas of quantum bits, measurement bases, and quantum cryptography in a hands-on, interactive manner.

P26: Ultracold Neutron Detection with Scintillating ZnS and 6Li Detectors

Igal Press
University of Winnipeg, TUCAN, and MITACS

Ultracold neutron (UCN) detectors are needed for a variety of projects including the TUCAN (TRIUMF Ultra Cold Advanced Neutron) experiment at TRIUMF (Canada's particle accelerator center, in Vancouver, BC). Two UCN detectors were tested at the Japan Proton Accelerator Research Complex (J- PARC, Tokai, Japan). The different detector technologies tested were made of (1) scintillating glass containing 6Li atoms, and (2) a phosphorescent screen of ZnS that was coated with 10B. The 6Li and ZnS detectors were characterized using both cold and ultracold neutrons and compared to two reference detectors. A 3He detector operating at 10 atm was used to characterize the CN runs and the DUNia-10 detector operating near atmospheric pressure with a 3% partial pressure of 3He was used to characterize UCN runs.

P27: ASSEMBLING CONFIGURATIONS OF ATOMS WITH ARBITRARY GEOMETRY

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Transformative Quantum Technologies (Institute for Quantum Computing, University of Waterloo)

Our quantum simulator exploits configurations of neutral atoms individually trapped in large arrays of optical traps whose arrangement reproduce the geometry of synthetic quantum materials. By preparing large configurations of atoms assembled along any arbitrary geometries, it is possible to reliably access controllable quantum many-body systems that act as testbeds for quantum experiments. Using our simulator, early adopters would be able to: 1) assemble large synthetic quantum materials expected to exhibit interesting physical phenomena with programmable geometry 2) use the configuration in many-body simulator to model interactions and behaviours for real-world applications 3) replace missing or lost atoms at a specific location, as well as displace atoms to engineer any desired interaction between any two atoms.

P28: ADJUSTABLE MICROWAVE RESONATOR FOR WARM 87RB FREQUENCY CONVERSION

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For information to be collectable and processable, a quantum realization needs to be calibrated over a specific range to achieve certain degrees of steadiness and constancy. In the 87Pb vapor cell system, large tunability between the conversion of microwave and optical signals can be achieved with the assistance of the Doppler effect and the relevant laser techniques. To make this nonlinear optics system more controllable, the microwave resonance adjustment can be coupled with the doppler effect to gain another dimension of freedom in the atomic states side to affect the output of optical channels.

P29: RHEOLOGY OF CHARGE-MODIFIED, SOFT PHYTOGLYCOGEN NANOPARTICLES

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Phytoglycogen (PG) is a natural polysaccharide produced in the form of 42 nm diameter, electrically neutral nanoparticles in the kernels of sweet corn. Its highly branched structure and compressible nature leads to useful properties that make the particles ideal as additives in personal care, nutrition, and biomedical formulations. We consider the effect of covalently attaching positively charged glycidyltrimethylammonium chloride (GTAC) chemical groups to PG on the rheology of the particles, focusing on the zero-shear viscosity of GTAC-modified PG dispersed in water at different concentrations C. Dispersions of GTAC-modified PG were significantly more viscous than those of native PG and showed a much steeper increase in the zero-shear viscosity with increasing C. Additionally, the viscosity of GTAC-modified PG dispersions was sensitive to the addition of salts and decreased significantly with added NaCl. These results show that electrostatic interactions have a significant effect on the interactions between the particles.

P30: GAIN-COMPENSATED PLASMON MODES

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We introduce a rigorous mode theory for gain compensated plasmonic dimer modes, and show how to use a quasinormal mode theory to model and describe the system. Through this quasinormal mode theory, we see that the system is much better described this way than through any previous mode descriptions. Full three-dimensional calculations are presented for gold dimers in a finite-size gain medium. We show how the Purcell factor can be described with two different methods and show excellent agreement, and we show that the mode distribution and effective mode volume remain similar for a system with no gain versus the gain compensated system.

P31: TIPSY CONES: OPTICAL CONDUCTIVITY OF TILTED DIRAC CONES WITH VARYING PSEUDOSPIN

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The conduction electrons in two-dimensional 'Dirac materials' like graphene exhibit exotic low-energy behaviour, with a 'cone-like' energy dispersion analogous to massless spin-1/2 particles in relativistic quantum mechanics. These materials are useful both as a solid-state system for the relativistic Dirac equation of high-energy physics and in technological applications like digital screens and solar cells, where a detailed understanding of their optical properties is key. Some Dirac materials attracting recent attention have 'tilted' Dirac cones, introducing additional directionality into the electronic response. Dirac materials with behaviour analogous to higher-spin (spin > 1/2) massless particles have also been investigated. We have predicted the low-energy interband optical conductivity of materials with tilted spin-1 and spin-3/2-type Dirac cones. Our results generalize previous spin-1/2 results and underscore the key physics at work. Understanding the optical response of these materials may have wide-reaching implications in materials science and technological design.

P32: Low-Latency Control System for Quantum Experiments

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Manipulating the information encoded in quantum mechanical systems before they lose their quantum features or are lost all together is challenging. This arises due to environmental interactions, which manifest in a decoherence time for the system and limit the ability to control the system. Therefore, when looking to achieve a specific operational goal, errors must be quickly identified and corrected. A high-speed feedback control system for a Rydberg atom array quantum simulator is presented that can extract information from the Rydberg atoms, process the information, and issue control pulses to perform reconfiguration. The peripherals of the control system are controlled by a CPU, but there are also plans to cross-benchmark the current system with a version that is augmented by the addition of a GPU.

P33: Interacting Galaxy Pairs in IllustrisTNG

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Within current models of the universe, an important role in the formation and evolution of galaxies is attributed to interactions and mergers of galaxies, but the universe evolves so slowly that we cannot track a single galaxy and watch how it evolves. Cosmological simulations like IllustrisTNG model the formation and evolution of galaxies from soon after the Big Bang until the present day, taking galaxy formation physics into account (Nelson et al. 2019). We can use this to look at how galaxy systems evolve through time. Pairs of galaxies in the IllustrisTNG cosmological simulations have been identified and numbered in terms of their closest separation from each other in any snapshot (Patton et al. 2020), and from these there has been a subsequent reconstruction of their orbits using mathematical interpolation (Patton et al. in prep.). During our summer research, we manipulated data from TNG regarding pair separation to project the motion of a system into their shared orbital plane. We also used the pericenters and apocenters of interacting pairs to approximate their expected orbital path between the pericenter and apocenter (or apocenter and pericenter). We found that for pairs that were well isolated from other galaxies, this approximation worked very well, though the accuracy of the approximation was significantly worse for pairs in denser environments.

P34: Characterization of Extreme Tip Jets off Cape Farewell, Greenland

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Greenland's topography prevents winds from travelling over its surface. Instead, they speed up along its coast. The tip jet off Cape Farewell on August 19, 2022, at 12H is of particular interest, appearing more extreme than seen before. Using satellite data and numerical weather prediction models, we characterize this event. Both point and area-based statistics are used to find that the event consists of high percentile winds in an uncommon contiguous region of roughly 395,402 square kilometers. 181,248 hourly samples of winds in this region were analysed by computing the fraction of points whose speed met or exceeded the 98th percentile at that point. Full coverage was found only on the event of interest, while 60 samples had coverage at or above 90%, and 855 had coverage at or above 50%.

P35: MEASUREMENT OF STANDARD MODEL HIGGS BOSON WITH ASSOCIATED TOP QUARK PRODUCTION IN THE BOOSTED ALL-HADRONIC FINAL STATE USING THE ATLAS DETECTOR: TRIGGER STUDY

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Between the years of 2015-2018, there were ~14 quadrillion proton-proton collisions in the LHC, the ATLAS detector recorded only ~19 billion events. To decide which events to save, the ATLAS detector implements a trigger system to select the most interesting ones. It is important to an analysis to understand the effects of the trigger on the physics processes being studied. The production of a Higgs bosons with an associated single top quark (tH) is a rare process predicted by the standard model (SM) with an estimated cross-section of 74.3 fb in the t-channel. For this analysis, it was important to know the efficiency of triggers on SM tH events to ensure the accuracy of event yields. Triggers that have higher efficiency at lower transverse momentum (pT) were studied to maximize the number of observed tH signal events in the high pT regime. It was found that di-jet triggers performed better than single-jet triggers, allowing for full efficiency down to 340 GeV while the best single-jet triggers were fully efficient only down to 390 GeV.

P36: STREAMLINING THE TESTING PROCESS OF PHOTONIC CHIPS

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The Shastri lab focuses on generating advanced photonic chips for signal processing and computing by combining artificial intelligence (AI) and photonics. These chips are utilized in neuromorphic silicon photonics which has various applications such as improving computational efficiency in AI and neuromorphic computing hardware. One of our advanced chips can be divided into three physical components: receiving a light signal, modulating the signal, and lastly detecting the signal with a photodetector on chip. Prior to utilizing these chips for experiments, it is vital to ensure that all components are functioning correctly. My work focused on streamlining the testing process of the photodetector by improving the signals used within the process. In order to test the photodetector, the light entering must be modulated externally using a Mach-Zehner Modulator (MZM). The MZM takes in a light signal and splits it into two where they experience a phase shift and when the two are recombined create a modulated signal. The signal's modulation is determined by changing the radio frequency (RF) signal sent from a driver into the modulator. Another aspect of my work was enhancing the control of the RF signal produced by the driver. The driver requires specific positive and negative voltages to generate ideal frequencies which are supplied by a unique power source. The voltage source was designed to ensure that the driver never received a damaging current or voltage and had a user-friendly interface to control the modulation of the signal.