Physics Department Seminar

Dr. Pierre Gorel

Research Scientist
SNOLAB

Date: Tuesday, September 18, 2018

Time: 3:30pm

Location: HP4351

Abstract:

NEWS-G @ SNOLAB: Looking for Weakly Interacting (not so) Massive Particles with a Spherical Proportional Counter

One of the oldest tool for detecting ionizing particles, gas detectors still have a wide range of applications. Gas ionization requires little energy, typically few tens of electron-volt. Thus it is an attractive technology to look for the elusive dark matter, which is thought to be 5 times more abundant than baryonic matter in the Universe.

The Weakly Interacting Massive Particles (WIMP) with a mass higher than 10’s GeV/c2 has been a favoured candidate for dark matter. It is in part because they are predicted by popular extensions of the Standard Model, the Super Symmetry (SUSY) models. But decades of search for WIMPs and SUSY particles have yet to give positive results. So the hunt has been extended to lower masses with a new generation of detectors aiming at sub-GeV WIMPs.

In this field, NEWS-G proposes to use a Spherical Proportional Counter (SPC) of large diameter. Thank to its geometry, such detector has a very low intrinsic electronic noise and high gain capability due to the avalanche mechanism. It maximizes the low threshold potential of the gas detector. The SEDINE detector (60 cm diameter) has been running at the Laboratoire Souterrain de Modane for the past few years, providing worldwide leading sensitivity at sub-GeV dark matter mass. Using the gathered experience, a 1.4 m diameter detector is now under construction. To maximize the sensitivity to a light WIMP interaction, the sphere will be filled with light gases mixtures (Ne, He or H-based). It will be deployed at SNOLAB (Sudbury, ON), where the 2 km of rock overburden will provide adequate shielding against cosmic rays.

In this talk, I will introduce the principle of the SPC and give an overview of the dark matter question. I will then describe the results provided by the SEDINE detector. I will end with a full description of NEWS-G at SNOLAB and its physics program.

Physics Department Seminar

Dr. Giovanni De Lellis

Professor
University of Naples

Date: Tuesday, September 25, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Directional detection of Dark Matter with a nuclear emulsion based detector: the NEWSdm experiment

The nature of Dark Matter is one of the fundamental questions to be answered. Direct Dark Matter searches are focussed on the development, construction, and operation of detectors looking for the scattering of Weakly Interactive Massive Particles (WIMPs) with target nuclei. The measurement of the direction of WIMP-induced nuclear recoils is a challenging strategy to extend dark matter searches beyond the neutrino floor and provide an unambiguous signature of the detection of Galactic dark matter. Current directional experiments are based on the use of gas TPC whose sensitivity is strongly limited by the small achievable detector mass. NEWSdm is an innovative directional experiment proposal based on the use of a solid target made of newly developed nuclear emulsion films and read-out systems achieving an unprecedented position accuracy, better than 10 nm. We describe the proposed apparatus and its expected performance.

Physics Department Seminar

Physics Department Faculty Members

Physics Faculty Members
Carleton University

Date: Tuesday, October 2, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Two-minute presentations

Physics Department Seminar

Dr. Karl Landheer

Postdoctoral Fellow, Biomedical Engineering
Columbia University

Date: Tuesday, October 9, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Magnetic resonance spectroscopy: From basic physics to novel data acquisition strategies

Proton magnetic resonance spectroscopy (MRS) is a powerful noninvasive technique used to measure spatially localized concentration of biomarkers within the brain and body. This technology can be used to map the in vivo metabolic changes across a variety of diseases, such as cancer, multiple sclerosis, and virtually all psychological disorders, making it of use for both basic science researchers and for differentiating between pathologies within the clinic. Although the technology for in vivo MRS has existed for thirty years there is still a need for technical innovations to improve data acquisition and data processing.

This talk will encompass the basic physics of MRS, which differs from magnetic resonance imaging (MRI) because unlike the uncoupled spins which generate signal in MRI, MRS obtains signal from spins within metabolites that are coupled, necessitating the use of the quantum mechanical density matrix formalism. Dr. Landheer's research on software algorithm improvements in data processing, pulse sequence design and novel data acquisition strategies will be discussed, concluding with some applications of MRS and currently unsolved limitations.

Physics Department Seminar

Dr. Mustafa Bahran

Scholar at Risk Faculty Member
Carleton University

Date: Tuesday, October 16, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Carleton Physics Education: A Way Forward

The Carleton University (CU) Physics Education Academic Program is an essential and integral part of the Department of Physics academic program servicing CU students and hence the community at large. Based on more than 30 years long physics teaching career including recent 18 months at the University of Oklahoma (OU), an overview of a typical physics education program will be made. An initial review of CU physics education program will be made parallel to that of OU and ideas towards progress will be proposed concentrating on General Physics Labs and Physics for Non-Science Majors such as BIT courses. An emphasis will be given to the curriculum based on comparison covering a number of physics departments (mainly in the US), current trends and the answer to the fundamental question: Why do we teach? Also, an emphasis will be given to the status and possible future of the Labs; structure, content, approach and methods. A proposal will be made in this regard. This talk will be guided by available/current research as well as excellent conversations with colleagues who have taught these courses at OU and here at CU.

Physics Department Seminar

Dr. Alberto Tonero

Postdoctoral Fellow
Carleton University

Date: Tuesday, October 30, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Effective searches for New Physics at LHC

In October 2018 the Large Hadron Collider (LHC) has entered the final days of a four-year-long run (Run 2). The next hadrons will collide at CERN only in the spring of 2021, after a long technical shut down. During almost a decade of operation, the LHC experiment has given a magnificent contribution to fundamental research by testing the Standard Model of elementary particles and by finding its last missing piece, the famous Higgs boson, in 2012. However "not all promises have been kept", because no new physics particle has been discovered yet, contrary to what expected (or hoped) by the particle physics community. Therefore, the possibility that new particles lie at a energy scale outside the reach of the LHC is gaining more and more consideration. In this case, new physics is best described in a model independent way by an effective lagrangian that contains higher-dimensional operators made of Standard Model particle fields. In this colloquium I will present the status of current searches for these effective operators at LHC and discuss future perspectives and implications.

Physics Department Seminar

Dr. Kenneth Clark

Assistant Professor
Queen's University

Date: Tuesday, November 6, 2018

Time: 3:30pm

Location: HP4351

Abstract:

PICO

Bubble chambers have a long history of use in particle physics, starting with being used for particle discovery in the 1950s and moving through to their use in dark matter search experiments today. The many different target fluids which have been used have provided great flexibility in the use of this technology. In this talk I will start with a very brief history of these detectors and quickly move on to their use in the PICO experiment. After discussion of the stages and plans for that collaboration, a possibility of future improvements to the bubble chamber will be presented.

Physics Department Seminar

Dr. Amina Mire

Assistant Professor
Carleton University

Date: Tuesday, November 13, 2018

Time: 3:30pm

Location: HP4351

Abstract:

The Leaky Pipeline or Embracing Femininity in the STEM Fields?

In the Western countries, including Canada, women and girls who enter in the STEM fields often suffer from what is known as the leaky pipeline. The leaky pipeline addresses a social phenomenon in which women and girls enter the STEM fields enthusiastically and then steadily leave them. Some researchers working in the Western academia and media pundits have linked the leaky pipeline to biologically determined factors which supposedly shape gendered ways of learning. If this was the case, there would have been similar patterns of women and girls leaking out from Science, Technology, Engineering and the Math fields in large numbers around the world. But the available empirical data show this is not the case. There is large data which show that women’s success in the STEM fields varies radically. For example, available data shows that in the Europeans continent, women in Eastern Europe and Central Asia (former Soviet Republics) do well in the STEM fields. Women also do well in the STEM fields in Asian countries such as India and China. This lecture

reveals how nineteenth century Victorian era construction of women as frail shaped and continue to frame women as too “weak” to cope with the challenging demand of strenuous mental activities. Embracing Femininity in the STEM Fields can be critically important strategy to subvert Western modernist construction of the ‘frail’ female subject. In this way, femininity can be deployed creatively to entice girls to the STEM fields. Embracing femininity can also be critical important way of overcoming image of the few “hard” women in the STEM fields; women as anomy figures in physics and engineering fields. In this lecture, I propose embracing femininity in the STEM as part of broader theoretical and empirical project that seeks to uncover how women have been systematically removed from popular symbolic imaginary and material progress of technological modernity in the West.

Physics Department Seminar

Dr. David Curtin

Assistant Professor
University of Toronto

Date: Tuesday, November 20, 2018

Time: 3:30pm

Location: HP4351

Abstract:

Particle Physics at the Lifetime Frontier

We think of particle physics as making progress when we probe smaller and smaller size scales, but sometimes new signatures can show up far away from highly energetic particle collisions. I explain why Long Lived Particles (LLPs) could be the harbingers of new physics beyond the Standard Model, and why they are motivated by some of the most fundamental mysteries in particle physics today, like the Matter-Antimatter Asymmetry of the Universe, Dark Matter, and the Hierarchy Problem. LLP signatures can be spectacular but are easily missed in standard searches, which could be the reason that we have not yet seen new physics at CERN's Large Hadron Collider. Exploring this Lifetime Frontier requires new capabilities. I will introduce the MATHUSLA proposal that aims to build a large but relatively simple detector on the surface at CERN to catch these elusive LLPs, and also discuss other detector proposals that MATHUSLA has inspired. Together, these new experiments may hold the key to discovering the missing puzzle pieces of new physics that could be hiding at the Lifetime Frontier.

Physics Department Seminar

Dr. Maxim Pospelov

Professor
University of Victoria / Perimeter Institute

Date: Tuesday, November 27, 2018

Time: 4:00pm

Location: HP4351
Abstract:

Infrared frontier of fundamental physics

Light weakly coupled states are predicted in many extensions of the Standard Model. I will review some efforts in detecting new light weakly coupled states, such as axions, dark photons and light dark matter. I will describe some of my recent work that relates to the cosmological manifestations of light particles, including a possible connection to the physics of the 21 cm line.

Physics Department Seminar

Dr. Thomas Koffas
Associate Professor
Carleton University

Date: Tuesday, December 4, 2018

Time: 3:30pm

Location: HP4351
Abstract:

How hard can light punch?

Reaching for the brightest light and the physics that can be done with it

Modern Quantum Electrodynamics (aka QED) has been extremely successful in describing the interactions of light with matter as long as the fields involved remain weak. But nature tends to be much more exciting than that and ultra-strong electromagnetic fields do exist. They can be found in the interior of large planets or white dwarfs. They form the central engines of supernovae and gamma ray bursts and of the energy extraction from black holes. They appear in inertial confinement fusion implosions and in the lattices of highly compressed solids. In short, ultra-strong fields pop-up everywhere, however, their effects remain poorly understood due to the lack of laboratory-based experiments. This is about to change with the advent of high-intensity lasers that can produce light pulses with focused intensities greater than that at the center of the sun and which can deliver peak powers of almost 100 times that of the world’s consumption rate.

So, how hard can these bright light pulses punch? What can we learn by using them? This talk will attempt to answer these questions and highlight the beginnings of a new exciting era in physics research.

Physics Department Seminar

Dr. Jeff Kinder

Executive Director, Science and Innovation
Institute on Governance

Date: Tuesday, January 8, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Title: Integrating Science and Policy: What Role Will You Play?

Speaker: Jeff Kinder, PhD, a physicist turned science policy wonk

Abstract: Curious about science policy? Whether trying to demonstrate impact to funders or contribute to the solution of societal grand challenges, the need to engage effectively with policy-makers is increasingly part of the research endeavour. But even many of the most experienced research faculty find it difficult to navigate the barriers to bringing their research evidence to the decision-table. This colloquium will provide a gateway into the world of science policy, exploring what science policy is, how it works and how you can effectively position yourself in relation to policy and politics.

Physics Department Seminar

Dr. Ksenia Dolgaleva

Assistant Professor
University of Ottawa

Date: Tuesday, January 15, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Material Candidates for Nonlinear Photonic Devices

Rapid development of nanofabrication has stimulated the growth of the field of nonlinear photonics. Nonlinear photonic devices are finding their applications in more and more areas, including (but not limited to) classical and quantum communications. The material platforms used for nonlinear photonics on-a-chip range from transparent

dielectrics with a relatively weak nonlinearity to semiconductor materials with strong nonlinear interactions. Among the materials for nonlinear photonics, III-V semiconductors stand out due to the large variety of compounds suitable for different spectral ranges that can be realized. There is, however, very little information available on the nonlinear optical performance of various III-V semiconductor compounds. There are very few representatives assessed for their nonlinear optical performance (e.g., AlGaAs), and many more materials offering a variety of operation ranges and applications that have never been studied for that role.

In this presentation, I propose the approach towards identifying interesting material candidates suitable for nonlinear photonics, and present the results of some experimental studies performed in this direction. More specifically, I will talk about our studies of GaN waveguides with wide electronic bandgap, suitable for the applications in the visible and near-infrared spectral ranges. I will also present the results of our experimental realization of passive InGaAsP waveguides that have potentials of being used for wavelength conversion to beyond 2 micrometers, thus expanding the operation range of well-established InGaAsP laser sources to the longer wavelengths.

Physics Department Seminar

Dr. Kristine Spekkens

Associate Professor
Royal Military College of Canada

Date: Tuesday, January 22, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Atomic Gas and the Cosmology of Extreme Dwarf Galaxies

Understanding the diversity of nearby galaxies within the cosmological framework that describes the large-scale structure and evolution of the universe is an important research driver in extragalactic astronomy. In that context, the properties of the smallest and faintest ("dwarf") galaxies, which are both hard to observe and susceptible to a variety of competing physical processes because of their shallow gravitational potential wells, are the most challenging to explain. In this talk, I will describe how atomic gas observations with current and future radio telescopes can constrain the origin of some of the most extreme dwarfs known today. I will first focus on how sensitive single-dish observations of ultra-diffuse galaxies are a powerful tool for measuring their structure and distinguishing between competing formation models. Then, I will describe how a widefield atomic gas survey soon to be undertaken with a new radio

interferometer in the Australian outback will allow for the first spatially resolved populations studies of the smallest field dwarfs for comparison with cosmological predictions.

Physics Department Seminar

Dr. John Kildea

Associate Professor
McGill University

Date: Thursday, January 31, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Opal - Empowered Patients, Informed Research

Opal (**opalmedapps.com**) is a person-centered patient portal smartphone app that was built at and has been released to cancer patients at the McGill University Health Centre in Montreal. Opal was designed with two goals in mind: (1) to empower patients, and (2) to inform research.
Opal empowers cancer patients with access to their electronic medical records (appointment schedules, lab results, clinical notes, etc) and automatically-personalized educational material tailored to their disease and phase of treatment. For example, it can automatically advise a patient on how to prepare for an upcoming appointment, provide a map of where to go, and facilitate appointment check-in and call-in so that the patient does not need to wait in the waiting room. It can also display the radiotherapy treatment planning process and let patients follow the progress of their treatment plans.

As a research tool, Opal is designed to collect patient-reported outcomes. It is also designed to operate in a multi-institutional context so that patients can communicate with and access all of their data from multiple hospitals at once. With their multi-institution data in hand, consenting patients can donate them to research studies, facilitating patient-powered multi-institutional data linkage for real-world evidence research.

This presentation will describe the history of the Opal project, the technology behind it, the stakeholder co-design process that was used to build it, and the research projects that are now forming around it.

Physics Colloquium: John Kidea

Prof. John Kildea
Opal - Empowered Patients, Informed Research
McGill University

Date: Thursday, January 31, 2019

Time: 15:30

Location: Herzberg building, room HP4351

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Physics Department Seminar

Dr. Nikita Bernier

Research Assistant
TRIUMF

Date: Tuesday, February 5, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Decay Spectroscopy of Neutron-Rich Cadmium Around the N = 82 Shell Closure

The neutron-rich cadmium isotopes around the well-known magic numbers at Z=50 and N=82 are prime candidates to study the evolving shell structure observed in exotic nuclei. Additionally, the extra binding energy observed around the nearby doubly-magic Sn-132 has direct implications for in astrophysical models, leading to the r-process abundance peak at A~130 and the corresponding waiting-point nuclei around N=82. The beta-decay of the N=82 isotope Cd-130 into In-130 was investigated in 2002, but the information for states of the lighter indium isotope In-128 is still limited.

Detailed beta-gamma-spectroscopy of Cd-128,131,132 was accomplished using the GRIFFIN facility at TRIUMF. In In-128, 32 new transitions and 11 new states have been observed in addition to the four previously observed excited states. The Cd-128 half-life has also been remeasured via the time distribution of the strongest gamma-rays in the decay scheme with a higher precision. For the decay of Cd-131,132, results are compared with the recent EURICA data. These new results are compared with recent shell model and IMSRG calculations, highlighting the necessity to re-investigate even "well-known" decay schemes for missing transitions.

Physics Department Seminar

Dr. Raphael Galea

Research Officer
National Research Council

Date: Tuesday, February 12, 2019

Time: 3:30pm

Location: HP4351

Abstract:

The Magic and Mystery of Manganese

In the year of the periodic table (150 years old since its inception), it is only fitting to look inside it and marvel at its beauty. Right in the centre of the table are the transition metals and one particular column contains Mn, Tc and Re. Tc and Re are medical isotopes and somewhat useful but to metrologists Mn is like Au. Mn is crucial to the absolute standardization of the emission rate of neutron sources. The aptly named Manganese Salt Bath method is currently the only method used at National Metrology Institutes around the world, and NRC has revived this technique last used in the 1960s in Canada. This talk will briefly outline the method but will focus more on the radionuclide standardization and more specifically the radiochemistry magic used to produce a pure Mn56 standard for the calibration of the salt bath. While the Szilard-Chalmers effect used in isotope separation was named after chemists, it was based on pioneering experiments and follow-up studies by physicist Enrico Fermi. In a similar manner, we will explore physics, chemistry and the psychology of a metrologist through this presentation.

OMPI Seminar: Tong Xu and James Renaud

Date: Thursday, February 28, 2019
Abstract:

Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.

Location: National Research Council, Kelvin Room (M36)

Presentations:

1) Calorimetry-based clinical reference dosimetry of a 1.5T MRI-linac in water and solid phantoms using Aerrow

By: **James Renaud**, PostDoctoral Candidate, National Research Council (NRC)

Supervisor(s): Bryan Muir and Malcolm McEwen.

Abstract: Calorimeters are used as primary standards for absorbed dose measurements in ionizing radiation. Due to the complexity of the systems, and the time required to obtain measurements, they have remained in the standards laboratory and are rarely seen in end-user situations, such as cancer centres. However, calorimetry offers some significant advantages over secondary dosimeter systems and a clinical implementation of a calorimeter would provide new measurement capabilities for the medical physicist.

In this talk, an introduction to Aerrow, a probe-format graphite calorimeter, is provided along with a detailing of its use to perform clinical reference dosimetry in the high-energy photon beam of a 1.5T MRI-linac. Response perturbations due to the presence of the magnetic field, as well as detector orientation dependence – in both water and solid phantoms – are investigated.

2) "A generalized MLC simulation method designed for GPU"

By **Tong Xu**, Carleton University and NRC

Graphics Process Units (GPU) are very attractive for parallel computing thanks to their low cost per processing core and the ability of integrating thousands of cores in one desktop computer. This talk will start with a brief introduction of a GPU implementation of EGSnrc (GEGS) and some basic benchmarking against EGSnrc. Then a framework for multi-leaf-collimator (MLC) simulation designed for GPU will be introduced. This new framework is designed to minimize the code divergence in GPU. It also allows the simulation of MLCs of arbitrary shapes, which makes it possible to be adopted for MLC from different manufacturers. Some examples of simulated MLC fields will be presented.

Canadian Association of Physicists Lecture

Dr. Bhavin J. Shastri

Assistant Professor
Queen's University

Date: Tuesday, March 5, 2019

Time: 3:30pm

Location: HP4351
Abstract:

Neuromorphic Silicon Photonics

Artificial Intelligence (AI) is transforming our lives in the same way as the advent of the Internet and cellular phones. AI is revolutionizing the healthcare industry with complex medical data analysis, actualizing self-driving cars, and beating humans at strategy games such as Go. However, it takes thousands of CPUs and GPUs, and many weeks to train the neural networks in AI hardware. Over the last six years, this compute power has doubled every 3.5 months. Traditional CPUs, GPUs, and neuromorphic (i.e., brain-inspired) electronics such as the IBM TrueNorth and Google TPU will not be powerful enough to train the neural networks of the near future. There is a global race to solve this challenge. My research group is developing the next generation of AI hardware with neuromorphic photonics processors that use light instead of electric signals. By combining the high bandwidth and efficiency of photonic devices with the adaptive, parallelism and complexity similar to the brain, our processors have the potential to be at least ten thousand times faster than state-of-the-art electronic processors while consuming less energy. In this lecture, I will describe our work on building processors on a silicon photonics platform which enables large-scale integration of optical and electronic devices on the same substrate. I will demonstrate how our photonic neural networks can solve coupled ordinary differential equations (such as a Lorenz attractor or a nonlinear optimization problem) a thousand times faster than conventional CPUs. In summary, I will take a look at some of the traditional challenges of photonic information processing, describe the photonic neural-network approaches being developed by our lab and others, and offer a glimpse at the future outlook for this emerging field.

Biography: Dr. Bhavin J. Shastri is an Assistant Professor of Engineering Physics at Queen's University, Canada. He was an Associate Research Scholar (2016-2018) and Banting and NSERC Postdoctoral Fellow (2012-2016) at Princeton University. He received the Ph.D. degree in electrical engineering (photonics) from McGill University in 2012. Dr. Shastri is a co-author of the book, *Neuromorphic Photonics* (Taylor & Francis, CRC Press). He is a recipient of the 2014 Banting Postdoctoral Fellowship from the Government of Canada, the 2012 D. W. Ambridge Prize for the top graduating Ph.D. student, an IEEE Photonics Society 2011 Graduate Student Fellowship, a 2011 NSERC Postdoctoral Fellowship, a 2011 SPIE Scholarship in Optics and Photonics, a 2008 NSERC Alexander Graham Bell Canada Graduate Scholarship, including the Best Student Paper Awards at the 2014 IEEE Photonics Conference, 2010 IEEE Midwest Symposium on Circuits and Systems, the 2004 IEEE Computer Society Lance Stafford Larson Outstanding Student Award, and the 2003 IEEE Canada Life Member Award.

Physics Department Seminar

Dr. Oleg Kamaev

R&D Scientist
Canadian Nuclear Laboratories

Date: Tuesday, March 12, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Canadian Nuclear Laboratories' Initiatives in Application of Cosmic Ray Muons to Nuclear Security and Safeguards

Nuclear technologies bring a variety of benefits to our lives such as power generation, radiation therapy, and many industrial applications. While the world relies on continuous carbon-free energy generated by 454 civil nuclear power reactors currently in operation (World Nuclear Association, **http://www.world-nuclear.org**), it's critical to ensure that nuclear materials are secure and are used only by authorized persons and only for peaceful purposes. Canadian Nuclear Laboratories (CNL) has extensive past and on-going experience in the development of technologies

to strengthen nuclear safety and security. This experience includes development of high-sensitivity non-degradable detectors for border security, studies of active interrogation methods using neutrons or gamma-rays, and employment of stand-off radiation detectors to locate special nuclear materials, monitor reactors from a distance, and to intercept any diversion operations.

One of the emerging techniques for passive non-destructive detection of shielded illicit nuclear materials in large-volume objects is muon tomography. It uses naturally occurring cosmic-ray muons to determine the presence of high-density/high-Z materials such as uranium or plutonium. Muons are much more deeply penetrating than x-rays, neutrons, or gamma-rays, and cannot be easily shielded, making them particularly attractive to nuclear security and safeguards verification activities. A unique medium-scale muon tomography prototype with a capability of measuring muon momentum, the Cosmic Ray Inspection and Passive Tomography (CRIPT) detector, is in operation at CNL (initially constructed at Carleton). In addition, a portable muon tomography system suitable for rapid detection and response in the event of a nuclear or radiological emergency is undergoing construction and verification.

In this talk I will give an overview of CNL with an emphasis on our nuclear safety & security program and discuss recent work in the development of an integrated detection system based on muon tomography for nuclear security.

Physics Department Seminar

Dr. Evan Rand

Applied Physicist
Canadian Nuclear Laboratories

Date: Tuesday, March 19, 2019

Time: 3:30pm

Location: HP4351

Abstract:

High-performance computation and the simulation of (pesky) cosmic-ray and gamma-ray induced secondary neutrons

Simulation is now an integral part, and undeniably vital scientific-tool, in all areas of physics. The most widely applied simulation method within the nuclear and particle physics community is the Monte Carlo method. Monte Carlo simulation allows researchers to “solve” complex problems which

are analytically intractable or simply too time-consuming or costly to perform in the laboratory. In this talk I present two such cases on the simulation of secondary neutrons and illustrate how high-performance computation can be applied to investigate quantities that are typically too difficult to extract from experimentation.

The first case examines cosmic-ray induced neutrons within the DEAP-3600 experiment, a state-of-the-art dark matter detector comprising of 3600 kg of liquid argon. The detector is located 2 km below the surface of the earth at the SNOLAB facility in Sudbury, Ontario. At this depth, background events originating from cosmic-rays are significantly reduced, therefore enabling the measurement of extremely rare interactions; such as the interactions theorized between ordinary matter and dark matter. To achieve this level of sensitivity, the detector is housed within a large ultra-pure water tank which serves as a radiation shield and a Cerenkov veto detector for cosmic-ray muons. Although rare, secondary neutrons are produced within the water tank and surrounding rock via cosmic-ray muon interactions. These secondary neutrons can mimic dark matter interactions within liquid argon, and therefore understanding their impact is paramount. In this work we characterize the efficiency of the DEAP-3600 cosmic-ray muon veto system and calculate the probability of these secondary neutrons to enter the liquid argon detector.

The second case studies the dynamic behaviour of heavy-water reactors through the lens of photoneutrons, secondary neutrons produced via photonuclear interactions between deuterium and high-energy gamma-rays from the beta decay of fission products. The production of these neutrons are “delayed” with respect to the initial fission event and generate a time-dependence in the neutron flux. Understanding and predicting this time-dependence and the dynamic behaviour of reactors in general is critical for reactor safety. In this work we apply the Geant4 toolkit and recent nuclear data to calculate the photoneutron yield from the thermal fission of 233,235U and 239Pu within a quasi-infinite bath of D2O. Large discrepancies were observed between the simulation results and the recommended 235U photoneutron yields used in reactor kinetics calculations and applications. The results raise concerns on the validity of the yields derived from experimental data. In this talk I will present our results and discuss possible explanations for the observed disagreement with historical data.

Special Physics Department Seminar

Dr. Joshua Berger

Samuel P. Langley PITT PACC Fellow
University of Pittsburgh

Date: Monday, March 25, 2019

Time: 3:00pm

Location: HP5345

Abstract:

Dark Matter: New Avenues to Detection

Understanding the nature of dark matter, which does not fit into the standard model, is key to making progress on the big questions in particle physics. I discuss two classes of models that are provide important next steps in the search for dark matter. The first, Boosted Dark Matter, extends simple dark matter models in well-motivated ways that lead to signals in neutrino detectors while evading direct detection searches. A relativistic flux of dark matter is produced by non-standard annihilations of dark matter captured in the Sun. Data from Super-Kamiokande have sensitivity to these models and future projects like DUNE will extend the reach significantly. New computational tools are required in order to perform an in depth study of Boosted Dark Matter. The second, portal mediators to the dark sector, encompasses models in which the dark matter interacts with the standard model via a weakly mixed mediator. Given a small mixing, the best probes require either a high intensity beam or cosmology and astrophysics. The short baseline liquid argon detectors at Fermilab offer a particularly promising route to discovering such mediators. Furthermore, cosmological probes from distortions of big bang nucleosynthesis and the cosmic microwave background and astrophysical signals from indirect detection can offer further approaches to discovering an even more weakly coupled mediator.

Physics Department Seminar

Dr. Adina Luican-Mayer

Assistant Professor
University of Ottawa

Date: Tuesday, March 26, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Custom low-dimensional material systems explored at the atomic scale

Innovative technologies have a history of capitalizing on the discovery of new physical phenomena, often at the confluence of advances in material characterization techniques and innovations in design and controlled synthesis of high-quality materials. Pioneered by the discovery of graphene, atomically thin materials (2D materials) hold the promise for realizing physical systems with distinct properties, previously inaccessible.

In this talk I will describe experiments that seek to uncover the novel physical phenomena in 2D materials by using scanning tunneling microscopy and spectroscopy (STM/STS). STM allows us to spatially resolve both the local electronic and structural properties of materials down to atomic scale. In particular, I will discuss consequences of twisting graphene layers, which leads to the formation of Moiré patterns and results in a system with extraordinary electronic properties tuned by the twist angle. I will then focus on the 1T polymorph of TaS_2, which has one of the richest phase diagrams among the layered transition metal dichalcogenides. Using a combination of scanning probe microscopy, electrical and optical characterization, we address the question of how the transition from bulk to few layers affects the different charge density wave phases in this material. Lastly, I will describe our atomic-scale characterization of the in-plane anisotropic 2D semiconductor ReS_2. We demonstrate that rhenium atoms form diamond-shaped clusters, organized in disjointed chains, and characterize the semiconducting electronic band gap by STS. By spatially mapping the local density of states around defects in ReS_2, we explore their origin and electrostatic nature.

Adina Luican-Mayer started as an assistant professor in the Physics Department at uOttawa in January 2016. She received her undergraduate degree from Jacobs University Bremen in Germany (2006) and her PhD in Physics from Rutgers University (2012). Prior to joining uOttawa, she was the Alexei Abrikosov postdoctoral fellow at the Center for Nanoscale Materials at Argonne National Laboratory outside Chicago. Her research group focuses on uncovering the novel electronic properties of low-dimensional systems custom made by stacking atomically thin sheets of van der Waals materials using scanning probe microscopy and supporting spectroscopic techniques.

Special Physics Department Seminar

Dr. Yue Zhang

Research Associate

Fermi National Accelerator Laboratory

Date: Thursday, March 28, 2019

Time: 3:00pm

Location: HP4351

Abstract:

How to Discover Dark Matter (again)

The recent discoveries of the Higgs boson and gravitational waves marked the triumph of two cornerstones of modern physics, the standard model of elementary particles and Einstein’s theory of gravity. However, overwhelming evidence from cosmology suggests that the standard model is inadequate for understanding our universe. There is stuff gravitating that we cannot see with light. In particular, dark matter comprises eighty-percent of the matter in the universe. In this talk, I will present the exciting quest to probe the nature of dark matter in our laboratories, from traditional approaches to new ideas and directions. I will highlight how new dark sector theories are driving us to new frontiers of dark matter searches.

Special Physics Department Seminar

Dr. Yuhsin Tsai

Postdoctoral Research Associate
University of Maryland

Date: Monday, April 1, 2019

Time: 3:00pm

Location: HP5345

Abstract:

Cosmological Probes of the Invisible Universe

In the next decade, precision cosmological data from Cosmic Microwave Background and Large Scale Structure observations will improve in sensitivity by more than an order of magnitude. In addition, gravitational wave signals may allow us to see through the plasma background to study the universe at the very earliest times, immediately after the Big Bang. I will discuss the prospects for using these cosmological signals to study the invisible universe, including the properties of neutrinos and dark sector particles, and quantum fluctuations in the primordial dark age.

Physics Department Seminar

Dr. Daniel La Russa

Medical Physicist
The Ottawa Hospital

Date: Tuesday, April 2, 2019

Time: 3:30pm

Location: HP4351

Abstract:

Automation in radiation oncology treatment planning processes at The Ottawa Hospital

In radiation oncology, it is well understood that automation improves quality and reduces errors attributable to human factors. At *The Ottawa Hospital* (TOH), several pre-treatment workflows in external beam radiation therapy have been automated or semi-automated using machine learning methods and purpose-built software applications. Following an introduction to the radiation therapy treatment infrastructure at TOH, the main software-driven processes in development and/or in use within the radiation medicine program will be presented and discussed, with emphasis placed on applications for assessing treatment plan quality and deliverability.

Special Physics Department Seminar

Dr. Nirmal Raj

Postdoctoral Researcher
TRIUMF

Date: Thursday, April 4, 2019

Time: 3:00pm

Location: HP5345

Abstract:

The Reverse Rutherford Era of Dark Matter

Dark matter -- the mysterious, invisible substance that makes up four-fifths of all matter -- is ubiquitous, yet efforts to identify its microscopic nature have proven elusive. As it is known to move at high speeds, a promising approach to detect it is to observe unusual effects of its scattering on well-understood stationary targets, essentially the Rutherford scattering experiment in reverse. I will outline two experiments for the near future: (1) Through scattering, dark matter could set ancient neutron stars on fire, which may be observed by upcoming infrared telescopes such as James Webb and the Thirty Meter Telescope; this would be the most extensive method to date for detecting dark

matter. (2) One reason for why dedicated detectors on Earth looking for dark matter particles have found none so far could be that these particles are very rare, at least kilometres apart. If so, even bigger detectors, such as the liquid scintillator-based neutrino detectors BOREXINO, SNO+, and JUNO, may be repurposed to catch these rare particles.

Special Physics Department Seminar

Dr. Seyda Ipek

UC President's Postdoctoral Fellow
University of California Irvine

Date: Tuesday, April 9, 2019

Time: 3:00pm

Location: HP4351
Abstract:

Why Are We Here?
Matter — Antimatter Asymmetry Of The Universe

Everything around us, cookies, rocks, stars, galaxies, etc. is made up of "matter" and not "antimatter". We know that if antimatter comes close to matter, they annihilate each other leaving only energy behind. That we are here means there is no antimatter to annihilate with us. But what happened to the antimatter in the Universe? Where did it go? How did it disappear? Why/how did matter stay behind? I will talk about this mystery and possible ways around it which requires new physics beyond the Standard Model of particle physics.

Particle Seminar

Date: Thursday, April 18, 2019
Abstract:

Speaker: Kevin Earl

Time: 2:30PM -- 3:30PM

Location: HP 4351

Title: Investigating baryonic R-parity violation at the LHC

Abstract: The ATLAS and CMS collaborations have performed multiple searches for possible Minimal Supersymmetric Standard Model (MSSM) signatures. Many of these searches focus on R-parity conserving (RPC) models of supersymmetry and typically require large missing transverse

momentum (MET). Alternatively, R-parity may be violated (RPV) and this removes MET but opens new signatures like multiple leptons or large numbers of jets. Multiple ATLAS and CMS searches have looked for these types of signatures too and have produced impressive bounds. In this talk, I will consider one of the last few unconstrained RPV signatures: electroweak production of neutralino and chargino pairs which decay promptly due to the RPV lambda'' UDD superpotential operator. The idea will be to consider the production of same sign tops and four jets. The same sign tops can lead to same sign leptons and by recasting a recent CMS search looking for same sign leptons and b-jets it will be shown that this parameter space is starting to be constrained. Additionally, the production of same sign tops has a few subtleties which will be discussed in detail. While not directly a concern for the RPVMSSM, these subtleties play an important role in R-symmetric models of supersymmetry where the R-symmetry is identified with baryon number.

Particle Seminar

Date: Thursday, April 18, 2019
Abstract:

Speaker: Kevin Earl

Time: 3:00 PM -- 4:00 PM

Location: HP 4351

Title: Investigating baryonic R-parity violation at the LHC

Abstract:

The ATLAS and CMS collaborations have performed multiple searches forpossible Minimal Supersymmetric Standard Model (MSSM) signatures. Many of these searches focus on R-parity conserving (RPC) models of supersymmetry and typically require large missing transverse momentum (MET). Alternatively, R-parity may be violated (RPV) and this removes MET but opens new signatures like multiple leptons or large numbers of jets. Multiple ATLAS and CMS searches have looked for these types of signatures too and have produced impressive bounds. In this talk, I will consider one of the last few unconstrained RPV signatures: electroweak production of neutralino and chargino pairs which decay promptly due to the RPV lambda'' UDD superpotential operator. The idea will be to consider the production of same sign tops and four jets. The same sign tops can lead to same sign leptons and by recasting a recent CMS search looking for same sign leptons and b-jets it will be shown that this parameter space is starting to be constrained. Additionally, the production of same sign tops has a few subtleties which will be discussed in detail. While not directly a concern for the RPVMSSM, these subtleties play an important role in R-symmetric models of supersymmetry where the R-symmetry is identified with baryon number.

Particle Seminar

Date: Thursday, April 25, 2019
Abstract:

Speaker: Duarte Azevedo

Time: 3:00 - 4:00 PM

Location: HP 4351

Title: Scalar vs. vector dark matter.

Abstract:

Two of the simplest models of dark matter (DM), in the context of scalar extensions of the Standard Model (SM), will be presented. A scalar DM and a vector DM model. These models require two physical Higgs bosons, h1 and h2, which arise from mixed components of the SM doublet and an additional complex singlet S. In the scalar case, we impose a dark charge symmetry Z2 (S→S*) which forces stability on the imaginary component of the singlet (A→-A), the dark matter candidate. We also demand explicit breaking, albeit softly, of the U(1) symmetry for a massive DM. In the vector case, an additional U(1) symmetry is broken by the vacuum of the singlet. This leads to a massive gauge boson X_\mu which is stable because of an analogous dark charge conjugation symmetry (S→S*, X_\mu → -X_\mu) and, thus, a DM candidate.

Special Physics Department Seminar

Dr. Alan Nahum

Visiting Professor
University of Liverpool

Date: Monday, June 10, 2019

Time: 10:00am

Location: HP5345

Abstract:

Bragg-Gray breakdown in small megavoltage photon fields

Ionization chambers in 'small' i.e. sub-CPE beams/fields (of megavoltage photons) can require huge 'perturbation factors' i.e. their response deviates significantly from 'Bragg-Gray'. And yet the contribution to the ionization from photon interactions in the gas cavity is as negligible as it is in 'large fields'. What is going on?
