Physics Department Seminar

Andrew Erlandson

Graduate Student
Physics Department, Carleton University

Date: Tuesday, September 27, 2016

Time: 3:30pm

Location: HP4351

Abstract:

Muon Computed Tomography: Putting muons to work for nuclear safety

High-energy muons generated from cosmic-ray particle showers have been shown to exhibit properties ideal for imaging the interior of large and dense structures. This talk explores the possibility of using a single portable muon detector in conjunction with image reconstruction methods used in nuclear medicine to reconstruct a 3-D image of the interior of critical infrastructure such as the zero-energy deuterium (ZED-2) research reactor at Canadian Nuclear Laboratories' (CNL) Chalk River site. The ZED-2 reactor core and muon detector arrangement are modeled in GEANT4 and Monte Carlo measurements of the resultant muon throughput and angular distribution at several angles of rotation around the reactor are generated. Statistical analysis is then performed on these measurements based on the well-defined flux and angular distribution of muons expected near the surface of the earth. The results of this analysis are shown to produce reconstructed images of the spatial distribution of nuclear fuel within the core for multiple fuel configurations. This muon computed tomography concept is currently an active area of research for CNL under Canada's Federal Science & Technology program.

Physics Department Seminar

Dr. Marcel-Cristian Voia

Associate Professor and Co-Director of the Center for Monetary and Financial Economics
Carleton University, Department of Economics

Date: Tuesday, October 4, 2016

Time: 3:30pm

Location: HP4351

Abstract:

Non-standard Confidence Sets for Ratios and Tipping Points with Applications to Dynamic Panel Data

We study estimation uncertainty when the object of interest contains one or more ratios of

parameters. The ratio of parameters is a discontinuous parameter transformation; it has been shown that traditional confidence intervals often fail to cover this true ratio with very high probability. Constructing confidence sets for ratios using Fieller's method is a viable solution as the method can avoid the discontinuity problem. This paper proposes an extension of the multivariate Fieller method beyond standard estimators, focusing on asymptotically mixed normal estimators that commonly arise in dynamic panel polynomial regression with persistent covariates. We discuss the cases where the underlying estimators converge to various distribution, depending on the persistence level of the covariates. We show that the asymptotic distribution of the pivotal statistic used for constructing a Fieller's confidence set remains a standard
Chi-squared distribution regardless of rates of convergence, thus the rates are being `self-normalized' and can be unknown. A simulation study illustrates the finite sample properties of the proposed method in a dynamic polynomial panel. Our method is demonstrated to work well in small samples, even when the persistence coefficient is unity.

Physics Department Seminar

Dr. Matthew Reece

Associate Professor
Harvard University

Date: Tuesday, November 1, 2016

Time: 3:30pm

Location: HP4351

Abstract:

“Particle Physics After the Higgs: What’s Next?”

The Large Hadron Collider's discovery of the Higgs boson in 2012 placed the capstone on the Standard Model of particle physics, from one point of view. But it leaves us with major unanswered questions, including: What is the underlying microscopic dynamics that turns on the Higgs field in our universe? What is the dark matter in our universe? Why is there more matter than antimatter? Do we live in a finely tuned universe? Run 2 of the LHC may help answer some of these questions. Others will likely require future colliders that are in the planning stages now. I will discuss how these experiments can be brought to bear in order to build a more fundamental theory of physics.

Physics Deaprtment Seminar

Dr. Barry Wood

NRC Fellow
National Research Council of Canada

Date: Tuesday, November 8, 2016

Time: 3:30pm

Location: HP4351

Abstract:

Putting Fundamental Constants to Work

It may not be generally known but near the end of 2018 a major change to the world's measurement system, the SI, is anticipated. This change was proposed by a number of scientists over a century ago and has been actively debated and experimentally tested particularly over the last decade. Despite this activity many scientists are unaware or unconcerned about these developments and this is at least in part by consecious design.

I will outline the orgins and structure of the SI system of units and trace the evolution of the SI incorporating fundamental physical constants. I will breifly review fundamental physical constants, their interrelationships and the most accurate experimental determinations of their values. I will conclude with a short survey of where we are, what is expected to happen at the end of 2018 and why, if all goes well, almost no one will notice the biggest measurerment change in a century.

Physics Department Seminar

Dr. Guillaume Giroux

Research Associate
Queen's University

Date: Tuesday, November 15, 2016

Time: 3:30pm

Location: HP4351

Abstract:

The Search for Dark Matter with the PICO Bubble Chambers

Arguably the most pressing question in modern physics arises from the growing evidence that dark matter constitutes the vast majority of the universe's content. The PICO collaboration searches for dark matter in the form of Weakly Interacting Massive Particles (WIMPs) using superheated fluid

detectors, or “bubble chambers”, that are operated in thermodynamic conditions where they are insensitive to gamma and beta radiation. The additional background suppression required to obtain sensitivity to the elusive dark matter signal is achieved with the acoustic signature of the bubble nucleation that allows the identification of alpha particles. The PICO-2L and PICO-60 detectors were recently deployed at the SNOLAB deep underground laboratory, in Sudbury, Canada. In this seminar I will present the latest results of the PICO experiment that set the most stringent constraints on the dark matter signal in the spin-dependent sector. I will also give a sneak preview of PICO-60’s data, our largest bubble chamber to date.

Physics Department Seminar

Dr. Jeff Smith

Associate Professor
Chemistry Department, Carleton University

Date: Tuesday, November 22, 2016

Time: 3:30pm

Location: HP4351

Abstract:

Isotopically-labelled TrEnDi: new technology to increase the sensitivity and selectivity of MS-based lipid analysis of complex biological samples

Trimethylation enhancement using diazomethane (TrEnDi) is a chemical derivatization strategy that results in the complete and concomitant methylation of phosphate moieties, carboxylic acids and primary amines, rendering phosphatidylethanolamine (PE), phosphatidylcholine (PC), and phosphatidylserine (PS) glycerophospholipids, as well as the sphingolipid sphingomyelin, permanently positively charged. Modified lipids demonstrate enhanced sensitivity via mass spectrometry (MS) analysis, particularly in MS^2 experiments where ion fragmentation is consolidated to only one or two channels. One challenge initially encountered by this technique was the conversion of PC and PE molecules of identical chain length to identical (isobaric) lipids. To overcome this, a novel method to synthesize ^{13}C-labelled diazomethane has been developed. Here we demonstrate the sensitivity gains of using isotopically-labelled TrEnDi on complex lipid mixtures.

Physics Department Seminar

Dr. Marcin Kuzniak

Researcher

Carleton University

Date: Tuesday, November 29, 2016

Time: 3:30pm

Location: HP4351

Abstract:

The Search for Dark Matter

From astronomical observations it is established that most of existing matter is dark matter, which accounts for 23% of the mass-energy density of the observable Universe (while the ordinary matter accounts for only ~5% and the remainder is attributed to dark energy). However, the exact nature of dark matter is still unknown and its origin is one of the most important questions in physics. The search for Weakly Interacting Massive Particles (WIMPs), the leading dark matter particle candidate, is now in a decisive phase. This talk will present a brief history of this dynamically evolving field, overview of the main dark matter searches and the status of the currently leading experiments. Special attention will be given to the DEAP-3600 experiment, located at SNOLAB, which is currently taking physics data. It is a single-phase detector, which searches for WIMP interactions with 1-tonne fiducial mass of liquid argon target. The sensitivity of DEAP-3600 is competitive with other current searches, offering a real discovery potential. Finally, perspectives and limitations for future dark matter searches with very large next generation detectors will be discussed. The single-phase liquid argon approach is easily scalable to very large detector masses and liquid argon is a superior target for heavy WIMPs, which are favored by the existing data.

2-min Presentations

Physics Department Faculty

Physics Department, Carleton University

Date: Tuesday, December 6, 2016

Time: 3:30

Location: HP4351

Abstract:

2-min presentations on research endeavors by the Physics Department faculty

Physics Department Seminar

Dr. Benjamin Spencer

Researcher
University of California - Davis Medical Center

Date: Thursday, January 5, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Dynamic PET imaging using the Kernel Method

Dynamic PET imaging monitors the spatiotemporal distribution of a radiotracer in the human body in vivo and has the ability to quantitatively characterize the radiotracer kinetics of the underlying molecular process. This requires the tracer activity within each image voxel to be accurately measured during multiple short time frames - which, however, suffers from high noise due to low counts that can be acquired in short scan durations. The kernel-based dynamic (KBD) image reconstruction has been recently proposed by our group to conquer this high-noise problem in dynamic PET. KBD improves image reconstruction of low-count data by incorporating prior information derived from high-count composite data of many time frames using machine learning. The method has been shown to provide a stark improvement to the quality of dynamic PET activity images. This presentation will focus on the evaluation of a new kernel type which has been designed to improve region of interest (ROI) quantification in dynamic PET images.

Physics Department Seminar

Dr. Shaun Lovejoy

Professor
McGill University

Date: Tuesday, January 17, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Why the warming can’t be natural: the nonlinear geophysics of climate closure

Claims with extraordinary consequences require extraordinary evidence. It is not sufficient to prove that the warming is "extremely likely" to be anthropogenic: to achieve "climate closure", we must also

disprove the converse theory that it is a natural fluctuation. This disproof requires an understanding of the strongly nonlinear atmospheric variability: since the 1980's this understanding is one of the important contributions of nonlinear geophysics to the atmospheric sciences. Atmospheric variability spans twenty orders of magnitude in time and ten in space, but it can be tamed with the help of emergent high-level turbulent laws and their anisotropic and multifractal generalizations.

We take a voyage through scales and with the help of some new fluctuation analysis tools, we review the arguments and evidence for wide scale range space-time scaling: high level turbulent laws. We examine the consequences for the extreme fluctuations ("grey swan", "black swan" events) and we apply this to estimating the probabilities and return times of extreme centennial, global scale temperature fluctuations. Even with conservative assumptions, the natural, the natural warming hypothesis can be rejected with >99% confidence.

Physics Department Seminar

Dr. Jacob Krich

Assistant Professor
University of Ottawa

Date: Tuesday, January 24, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Intermediate band solar cells and the path to high efficiency

Intermediate band (IB) materials are a novel class of materials that, like semiconductors, have a band gap but also have an extra set of allowed electronic levels entirely contained inside the semiconductor band gap. Solar cells made from such materials have the potential to radically improve photovoltaic efficiencies. Current intermediate band devices are made from three classes of materials: quantum dots, highly-mismatched alloys, and hyperdoped semiconductors. None has simultaneously achieved high sub-gap absorption and sufficient carrier lifetime. I will describe theoretical and experimental work to understand carrier lifetimes and their impact on device efficiencies. I will introduce a figure of merit, which predicts the potential effectiveness of candidate IB materials in advance of device fabrication. This figure of merit captures in a single parameter the inherent tradeoff between enhanced absorption and enhanced recombination within an IB material,

and it suggests a path toward efficient IB materials. I will give examples of measurements of the figure of merit and theoretical predictions for new systems.

Physics Department Seminar

Dr. Albert Stolow

Canada Research Chair in Molecular Photonics
Departments of Chemistry & Physics, University of Ottawa

Date: Tuesday, January 31, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Molecules in Laser Fields: Non-adiabatic Dynamics, Quantum Control, Strong Field Physics

The most general cases of molecular dynamics are non-adiabatic processes involving the coupled flow of both electronic charge and vibrational energy - i.e. the failure of the Born-Oppenheimer approximation. Experimental methods such as Time-Resolved Photoelectron Spectroscopy are powerful probes of these ultrafast non-adiabatic dynamics in molecules. The most information, however, obtains by observing such dynamics from the Molecular Frame of reference, avoiding loss of information due to orientational averaging. Borrowing techniques from particle physics, Time-Resolved Coincidence Imaging Spectroscopy observes the kinematically complete 3D momentum recoil vectors of emitted molecular fragments and electrons - in coincidence and as a function of time. This allows for study of the time evolution of both scalar and vector correlations during molecular processes. One important Molecular Frame vector correlation permits imaging of electronic wavefunction evolution during dynamic processes. An alternative method, based on using the non-resonant Dynamic Stark Effect to align molecules in space, also permits direct time-resolved imaging of electronic dynamics in the Molecular Frame.

As laser fields get stronger still, a new laser-matter physics emerges for polyatomic systems wherein the approximations implicit in standard atomic strong field ionization models can fail dramatically. A new Nonadiabatic Multi-Electron dynamics emerges and has important consequences for all strong field processes in polyatomic molecules, including high harmonic generation and attosecond spectroscopy. An experimental method, Channel-Resolved Above Threshold Ionization, directly unveils the multiple electronic continua participating in the attosecond molecular strong field response.

Physics Department Seminar

Dr. Andrew Speirs

Assistant Professor
Department of Mechanical & Aerospace Engineering, Carleton University

Date: Monday, February 6, 2017

Time: 3:30pm

Location: HP4351

Abstract:

TBD

Physics Department Seminar

Dr. Nedeltchko Kandev

Hydro Quebeq

Date: Tuesday, February 7, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Electromagnetic DC Pump for Liquid Metal: Numerical Simulation and Experimental Study

Results will be presented of 3D numerical magneto-hydrodynamic (MHD) simulation of an electromagnetic direct current (DC) pump for liquid metal using a rectangular metal flow channel subjected to an externally imposed transversal inhomogeneous magnetic field.
A prototype of direct current electromagnetic pump for liquid aluminum was built and characterized under different operation conditions. The results of the experimental study will be also discussed.

Physics Department Seminar

Dr. Caio Licciardi

Research Associate
Physics Department, Carleton University

Date: Tuesday, February 14, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Neutrinoless Double Beta Decay Search with EXO-200 and nEXO

The collaboration is probing for the nature of neutrinos with liquid xenon. The EXO-200 detector consists of an ultra-low background time projection chamber which contains ~150 kg of LXe enriched to 80% in Xe-136. Using the first two years of data, EXO-200 has produced important physics results including a lower limit on the 0vbb half-life of 1.1x10^{25} years, at 90% C.L., as well as stringent limits for exotic physics, such as the 0vbb decay with emission of Majoron particles. The experiment has recently restarted data taking with important hardware upgrades. This talk will cover the physics involved in 0vbb searches, focusing on results from EXO-200, detector updates and an overview of the future nEXO experiment, a 5-tonne detector proposed as part of the next generation of searches for 0vbb.

Physics Department Seminar

Dr. Ravi Bhardwaj
Associate Professor
University of Ottawa

Date: Tuesday, March 7, 2017

Time: 3:30pm

Location: HP5345

Abstract:

Ultrafast photonics – nanoscale manipulation of materials

Ultrafast photonics is enabled by highly nonlinear interaction of intense femtosecond light pulses with matter. It allows fabrication of novel photonic devices and sensors by controlled manipulation of material properties on nanoscale in three dimensions. Three applications of ultrafast laser processing of materials will be discussed. (1) Ultra-high density 3D optical data storage in common inexpensive plastics with a storage capacity that is ten times higher than a standard Blu-ray disc. (2) Selective cell patterning in biocompatible polymers by altering the wetting properties of its surface. (3) Fabrication of nanostructures in silicon using non-gaussian beams and the role of transient plasmonics.

Physics Department Seminar

Dr. Antonio Delgado
Associate Professor
Notre Dame University

Date: Tuesday, March 14, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Dark Matter

It has been established that 21% of the energy budget of the universe comes in form of Dark Matter. How do we know that? What evidence do we have? What is Dark Matter? Can we detect it? I will try to answer

these questions and maybe more…..

Physics Department Seminar/ CAP Lecture

Dr. Randy Lewis

Professor

Department of Physics & Astronomy, York University

Date: Tuesday, March 21, 2017

Time: 3:30pm

Location: SP303 (St. Patrick)

Abstract:

Exotic Hadrons

After several decades of discovering many mesons (made of two quarks) and baryons (made of three quarks), experiments are beginning to detect "exotic" hadrons that are neither. Are they tetraquarks, pentaquarks or something else? Theoretical calculations and supercomputer studies performed at York University and elsewhere are providing insights and predictions for future experimental searches. An overview of the present situation will be given.

Physics Department Seminar

Dr. Josh Ruderman

Assistant Professor

Department of Physics, New York University

Date: Tuesday, April 4, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Dark Matter at the Higgs Scale and Below

Dark matter is believed to make up most of the matter of our Universe, but its particle origin remains a mystery. A promising possibility is that dark matter is composed of a new particle that was thermally produced in the early Universe, and has a mass near the mass of the recently discovered Higgs boson. As I will review, a diverse set of experiments are now searching for dark matter candidates at the Higgs scale. These experiments have great potential to discover dark matter, but the allowed parameter space is rapidly closing. An alternative possibility, that is receiving growing attention, is that dark matter is thermally produced but has a mass that is significantly lighter than the Higgs boson. I will present an overview of recent theoretical and experimental progress exploring light dark matter candidates.

Special Physics Department Seminar

Dr. Marcin Kuzniak

Research Associate
Carleton University

Date: Thursday, April 27, 2017

Time: 3:30pm

Location: RB1200

Abstract:

Search for Dark Matter with Liquid Argon Detectors

Although the existence of Dark Matter is well established based on astronomical observations, its nature remains one of the most pressing and exciting questions in physics, with Weakly Interacting Massive Particles (WIMPs) still among the top Dark Matter candidates.

This talk will discuss WIMP detection based on liquid argon, which is complementary and provides certain advantages over more established xenon technology (currently dominating the field). I will describe the DEAP-3600 detector, which searches for dark matter particle interactions with 3.6 tonnes of liquid argon contained in an ultrapure acrylic vessel viewed by 255 photomultiplier tubes. It is located 2 km underground at SNOLAB, in Sudbury, Ontario, and currently taking data, aiming to reach a competitive sensitivity (or discover WIMPs) after 3 years of running.

I will also discuss DarkSide-20k, a larger 20 ton detector planned for the future, as well as prospects for a global collaborative effort to build a multi-hundred ton scale instrument, capable of reaching the

ultimate sensitivity available to WIMP searches. I will highlight the role of the planned cryogenic test facility at Carleton in this context, and present details of the proposed R&D to be performed there.

Special Physics Department Seminar

Dr. Masayuki Wada

Dicke Fellow, Associate Research Scholar
Princeton University

Date: Thursday, May 4, 2017
Time: 2:15pm
Location: 238 Tory Building

Abstract:

DarkSide-50: A Liquid Argon Detector for WIMP Searches

DarkSide-50 is a liquid argon based experiment searching for Weakly Interacting Particles (WIMPs), a well-motivated candidate for Dark Matter. DarkSide-50 is designed to be a background-free WIMP search using a two-phase argon TPC that is operated inside an active veto at the LNGS underground laboratory in Italy. A blind analysis of more than one year of DarkSide-50 data is currently underway. I will describe the DarkSide-50 detector and discuss in detail event reconstruction methods and their impact on our understanding of the background for the blind analysis.

Special Physics Department Seminar

Dr. Marie-Cecile Piro

Research Associate
Johnsson Rowland Science Center, Rensselaer Polytechnic Institute

Date: Tuesday, May 9, 2017
Time: 3:00pm
Location: TB238

Abstract:

Towards solving the dark matter puzzle and beyond

Understanding the nature of Dark Matter is the Holy Grail for many physicists. While the answer to this fundamental question still eludes the scientific community, it could well result in unique proof of physics beyond the Standard Model. Direct detection searches are currently the most powerful way

to solve this long lasting mystery.

Over the last decade, dark matter detection techniques have been improving drastically, pushing the sensitivity to unprecedented levels. These great technical successes have brought new challenges. In particular, the intrinsic experimental background is becoming increasingly important and the purification of the materials used is now crucial. In addition, the "solar neutrino floor", the irreducible background that will limit the next generation of experiments , must be fully studied and understood.

After describing the diverse experimental detection techniques for dark matter, I will present the new challenges we are facing and demonstrate how we can address them to solve some of the great puzzles of physics.

Special Physics Department Seminar

Dr. Simon Viel

Chamberlain Research Fellow
Lawrence Berkeley National Lab

Date: Thursday, May 11, 2017

Time: 3:30pm

Location: 238 Tory Building (TB)

Abstract:

Dark matter particles and where to find them

Dark matter is one of the most fundamental questions of our time. Observed via gravitational effects, it may also weakly interact with ordinary matter and be detectable in particle physics experiments. Two planned searches for dark matter will be discussed: a collider search with the upgraded ATLAS detector at CERN, and a direct detection search with the next-generation DEAP experiment at SNOLAB.

Special Physics Department Seminar

Dr. Mark Ward

Research Associate
Royal Holloway University of London

Date: Thursday, May 18, 2017

Time: 3:30pm

Location: 5345 HP (Herzberg Building)

Abstract:

Detectors and Dark Matter

The history of particle physics is owed to both the development of theoretical models and to the detector technology that allows these models to be tested. One of the major open questions that has been puzzling physicists for the last 80 years is the nature of dark matter, which is thought to make up 26.8% of the universe. One of the favoured candidates for dark matter are Weakly Interacting Massive Particles (WIMPs), which by their nature will be extremely difficult to detect. However, as technology has developed, it has opened up the possibility to search for WIMP interactions within a vast array of different detector types. This search is currently lead by liquid Nobel detectors, which have now entered the multi-ton era. During this seminar, the design and status of one such experiment; DEAP-3600 will be presented along with a possible avenue in which detector technology could be developed in order to improve upon the current generation.

Special Physics Department Seminar

Dr. Fabian Kruger

Research Associate
CERN

Date: Tuesday, May 23, 2017

Time: 3:30pm

Location: HP4351

Abstract:

Development and Optimization of (Micromegas) Gaseous Detectors

Since several decades Gaseous Detectors are the first choice to equip large detector volumes like for example muon systems high energy physics experiments. With the evolution in photolithographical and microprocessing techniques Micro Pattern Gasous Detectors (MPGD) are becoming mature to sucessively replace the frist gerneration of parallel plate or dirft tube based detector systems.

To prepare the transition from small laboratory prototypes to large size MPGD based detector systems, like the Micromegas for the ATLAS New Small Wheel upgrade, intense research & development efforts and optimization programs have been performed. This resulted in an increased

understanding of the technology and its processes of signal formation.

In this seminar a systematic approach on detector R&D is presented and illustrated with some exemplary studies on signal formation processes in Micromegas detectors. The impact of these studies on the ATLAS NSW Micromegas will be discussed as well as the possible extention of the R&D approach to other process or technologies.

Special Physics Department Seminar

Dr. Gordan Krnjaic

Fellow Theoretical Physics Division
Fermi National Laboratory

Date: Monday, August 14, 2017

Time: 3:45pm

Location: HP4351

Abstract:

Discovering or Falsifying Light Thermal Dark Matter

This talk covers the theoretical features and experimental status of thermal dark matter (DM) with mass below the electroweak scale (M_DM << 100 GeV). In this class of models, dark and visible matter are initially in thermal equilibrium during the early universe when the DM is relativistic (T_photons >> M_DM). During this epoch, dark and visible matter annihilate into each other at equal rates and both number densities are calculable from equilibrium thermodynamics. However, as Hubble expansion cools the universe, the annihilation rates fall out of equilibrium and the co-moving DM number density becomes fixed to its value when equilibrium is lost. Thus, these models predict a firm relationship between the dark-visible annihilation rate and the cosmic DM abundance, which implies a sharp sensitivity target for a variety of novel, accelerator based search techniques. It is found that a small set of future experiments based on these new techniques can decisively discover or falsify nearly all predictive models of thermal DM below the electroweak scale.
