VIRTUAL PHYSICS CONFERENCE

May 20th 2020

CONFERENCE PROGRAM

VPC 2020

Hosted on:
Virbela Open Campus

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THOMPSON RIVERS UNIVERSITY   UALBERTA PHYSICS   Canadian Association of Physicists / Association canadienne des physiciens et physiciennes   VirBELA

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SCHEDULE AT A GLANCE

Time	Auditorium Session	Theatre Session
PST	(5 plenary, 16 contributed talks, 9 am-2 pm)	(6 plenary, 14 contributed talks, 9 am-2 pm)
8:45:00 AM	**Opening Remarks**	
9:00:00 AM	Robin Kleiv (Particle, TRU)	Maria Drout (Astro, UofT)
9:10:00 AM		
9:20:00 AM	Daniel Durnford (Particle, UofA)	Michael Kinach (Astroparticle, UBC)
9:30:00 AM	Vasil Todorinov (Particle, ULethbridge)	Adaeze Ibik (Astro, UofT)
9:40:00 AM	Carl Rethmeier (Particle, CarletonU)	
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10:00:00 AM	Eldon Emberly (Biophysics, SFU)	Frank Hegmann (CMP, UofA)
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10:20:00 AM	Chelsea Dunning (Biophys, UVic)	Natascha Hedrich (CMP, UBasel)
10:30:00 AM	Mark Wright (Biophys, UofA)	Marianne Moore (CMP, UBC)
10:40:00 AM	Christoph Klein (Particle, CarletonU)	Timothy Branch (CMP, UBC)
10:50:00 AM	Matthias Danninger (Particle, SFU)	Alex Hill (Astro, UBCO)
11:00:00 AM		
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11:40:00 AM		
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12:00:00 PM	Marie-Cécile Piro (Particle, UofA)	Natasha Holmes (Physics Ed, Cornell)
12:10:00 PM		
12:20:00 PM	Dominique Trischuk (Particle, UBC)	Jake Bobowsk (Physics Ed, UBCO)
12:30:00 PM	Sudip Poudel (Particle, USouthDakota)	Vincent Daley (Physics Ed, TRU)
12:40:00 PM	Sumanta Pal (Particle, UofA)	Sabrina Madsen (Applied, UofT)
12:50:00 PM	Kelton Whiteaker (Particle, UBC)	Richard Taylor (Acoustics, TRU)
1:00:00 PM	Robin Hayes (Particle, UBC/TRIUMF)	
1:10:00 PM	**Coffee**	
1:20:00 PM	William Woodley (Particle, UofA)	Pramodh Senarath Yapa (CMP, UofA)
1:30:00 PM	John Keller (Particle, CarletonU)	Nikolai Lesack (AMO, UBC)
1:40:00 PM	Camille Belanger-Champagne (Applied, TRIUMF)	Matthias Le Dall (QC/Industry, ScotiaBank)
1:50:00 PM		
2:00:00 PM	**Closing Remarks**	

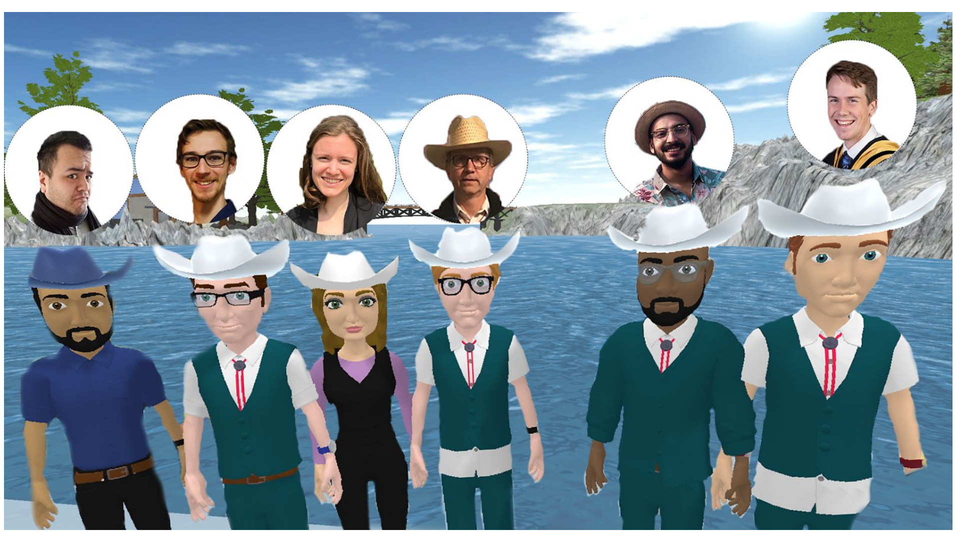
WELCOME

Welcome to the first ever **Virtual Physics Conference 2020**! VPC 2020 is a truly grassroots effort to provide graduate students and professional physicists with a chance to meet, share, and discuss their work in a welcoming, virtual environment.

We thank you for joining us in this experiment, and we hope that the conference not only fosters conversations across different sub-fields of Physics, but provides some insight into how academia can adjust to the new normal brought about by global disruption.

Organizing Committee

Mark Paetkau (TRU)
Owen Paetkau (UCalgary)
Dominique Trischuk (UBC)
Patrick O'Brien (UAlberta)
Brendin Chow (SFU)
Pramodh Senarath Yapa (UAlberta)



CODE OF CONDUCT

The Virtual Physics Conference will be supported by a two part Code of Conduct. This conference will adhere to the APS Meeting Code of Conduct and expectations for conduct in a virtual world. Violation of the code of conduct set here will be followed up with the violator's home institution.

APS Meetings Code of Conduct

It is the policy of the American Physical Society (APS) that all participants, including attendees, vendors, APS staff, volunteers, and all other stakeholders at APS meetings will conduct themselves in a professional manner that is welcoming to all participants and free from any form of discrimination, harassment, or retaliation. Participants will treat each other with respect and consideration to create a collegial, inclusive, and professional environment at APS Meetings. Creating a supportive environment to enable scientific discourse at APS meetings is the responsibility of all participants.

Participants will avoid any inappropriate actions or statements based on individual characteristics such as age, race, ethnicity, sexual orientation, gender identity, gender expression, marital status, nationality, political affiliation, ability status, educational background, or any other characteristic protected by law. Disruptive or harassing behavior of any kind will not be tolerated. Harassment includes but is not limited to inappropriate or intimidating behavior and language, unwelcome jokes or comments, unwanted touching or attention, offensive images, photography without permission, and stalking.

Violations of this code of conduct policy should be reported to meeting organizers, APS staff, or the APS Director of Meetings. Sanctions may range from verbal warning, to ejection from the meeting without refund, to notifying appropriate authorities. Retaliation for complaints of inappropriate conduct will not be tolerated. If a participant observes inappropriate comments or actions and personal intervention seems appropriate and safe, they should be considerate of all parties before intervening.

Conduct in a Virtual World

In a virtual setting, physical social cues and expectations are unavailable but must be followed. This includes presentation conduct in form of staying seated, muting your microphone as to stay silent and waiting to be called upon prior to asking a question. Be wary of personal space and don't walk through anyone!

Behaviour leading to the disruption of presentations or conference activities will not be tolerated.

Need to report something?

Contact a member of the organizing committee or send an email to mpaetkau@tru.ca with any concerns.

CONFERENCE PROGRAM

Auditorium Talks

8:45 AM - 11:30 AM Pacific Standard Time (PST)

Plenary & Student Talks - Morning Session

8:45 - **Opening Remarks**

Particle Physics Session

9:00 - **Robin Kleiv (Thompson Rivers University)**

Doubly-heavy Constituent Diquark Masses from QCD Sum Rules

9:20 - Daniel Durnford

9:30 - Vasil Todorinov

9:40 - Carl Rethmeier

9:50 - Coffee Break

Biophysics Session

10:00 - **Eldon Emberly (Simon Fraser University)**

Using Neural Networks to Learn the Folding of DNA inside Cells

10:20 - Chelsea Dunning

10:30 - Mark Wright

10:40 - Christoph Klein

Particle Physics Session

10:50 - **Matthias Danninger (Simon Fraser University)**

The Pacific Ocean Neutrino Explorer

11:10 - Patrick O'Brien

11:20 - Tom Steele

11:30 AM - 12:00 PM

Lunch break

12:00 PM - 2:10 PM

Plenary & Student Talks - Afternoon Session

Particle Physics Session

12:00 - **Marie-Cécile Piro (University of Alberta)**

Dark Matter: The Hunt for the Unknown

12:20 - Dominique Trischuk

12:30 - Sudip Poudel

12:40 - Sumanta Pal

12:50 - Kelton Whiteaker

1:00 - Robin Hayes

1:10 - Coffee Break

Particle & Applied Physics Session

1:20 - William Woodley

1:30 - John Keller

1:40 - **Camille Belanger-Champagne (TRIUMF)**

Particle Accelerators' Role in Building Better Electronic Components

2:00 - **Closing Remarks**

Theatre Talks

9:00 AM - 11:30 AM Pacific Standard Time (PST)

Plenary & Student Talks - Morning Session

Astronomy & Astrophysics Session

9:00 - **Maria Drout (University of Toronto)**
Multi-Messenger Gravitational-Wave Astrophysics
9:20 - Michael Kinach
9:30 - Adaeze Ibik
9:40 - None
9:50 - Coffee Break

Condensed Matter Physics Session

10:00 - **Frank Hegmann (University of Alberta)**
Exploring the Ultrafast Nanoworld
10:20 - Natascha Hedrich
10:30 - Marianne Moore
10:40 - Timothy Branch

Astronomy & Astrophysics Session

10:50 - **Alex Hill (University of British Columbia Okanagan)**
The Near and Far universe with CHIME
11:10 - Adam Dong
11:20 - Matthew Lundy

11:30 AM - 12:00 PM

Lunch break

12:00 PM - 2:10 PM

Plenary & Student Talks - Afternoon Session

Physics Education & Applied Physics Session

12:00 - **Natasha Holmes (Cornell University)**
The Trouble with Traditional Labs: Structure versus Confirmation
12:20 - Jake Bobowsk
12:30 - Vincent Daley
12:40 - Sabrina Madsen
12:50 - **Richard Taylor (Thompson Rivers University)**
Loudspeaker Line Arrays for Acoustic Diffusion
1:10 - Coffee Break

Condensed Matter Physics & Industry Session

1:20 - Pramodh Senarath Yapa
1:30 - Nikolai Lesack
1:40 - **Matthias Le Dall (Scotiabank)**
How a Century-old Theory is about to Revolutionize the World (Again)
2:00 - **Closing Remarks**

PLENARY ABSTRACTS

Auditorium Plenary Talks

Prof. Robin Kleiv
Thompson Rivers University

Robin Kleiv completed his BSc at the University of the Fraser Valley and his PhD in theoretical particle physics at the University of Saskatchewan. In August 2019 he became a tenure-track assistant teaching professor in the physics department at Thompson Rivers University in Kamloops, BC. His research uses QCD sum rules to study exotic hadrons. His hobbies include camping, hiking, fly-fishing and amateur astronomy.

Doubly-heavy constituent diquark masses from QCD Sum Rules

Particle Physics

Experiments have found evidence for strongly interacting particles (hadrons) which do not seem to fit into either of the two established hadronic families: baryons and mesons. Baryons, such as the proton or neutron, are composed of three quarks, and mesons, such as the pion, are composed of a quark and an antiquark. Some of these newly discovered hadrons have been interpreted as four-quark states which contain two quarks and two anti-quarks. Four-quark states can be modelled as diquark-antidiquark bound states: a diquark is a cluster of two quarks (or two antiquarks for an antidiquark) that exists within a hadron. A crucial input to the diquark-antidiquark model is the constituent diquark mass, which can be calculated using QCD sum rules. We have calculated the masses of diquarks composed of two charm quarks or two bottom quarks using QCD sum rules. Using these diquark masses as inputs for the diquark-antidiquark model, we predict masses for several different tetraquarks and discuss the implications of our results for experimental searches for these states.

Dr. Eldon Emberly
Simon Fraser University

Using neural networks to learn the folding of DNA inside Cells

Biophysics

DNA is meticulously packaged into a structure known as chromatin within the small volume of the nucleus of a cell. This packaging is highly regulated and depends on the binding of many proteins that interact to compact the DNA and help it form looped structures. Predicting how DNA folds inside a cell is currently an unsolved problem. In this talk, I will show how dense neural networks can be trained to solve for the local folding of chromatin, connecting structure, represented as a measured contact map, to the sequence of measured bound proteins. We can also train a network to solve the inverse problem: given structural information in the form of a contact map, predict the likely distribution of proteins that generated it. Amazingly, we find that these networks are able to learn physical insights that are informative and intuitive about this complex polymer folding problem

Prof. Matthias Danninger
Simon Fraser University

Professor Matthias Danninger is leading searches for unconventional exotic signals, such as Long-Lived Particles, in ATLAS. Matthias is also working on improving the track reconstruction performance of the ATLAS Inner Detector. In addition, he is involved in global statistical fits for New Physics (GAMBIT) and the Pacific Ocean Neutrino Explorer, a new initiative to construct one of the world's largest neutrino detectors in the deep Pacific Ocean off the coast of British Columbia, Canada.

The Pacific Ocean Neutrino Explorer

Particle Physics

The Pacific Ocean Neutrino Explorer (P-ONE) is an initiative to construct one of the world's largest neutrino detectors in the deep Pacific Ocean off the coast of British Columbia, Canada. Located in the Cascadia Basin region of the Ocean Networks Canada, P-ONE builds on a number of key strengths within the Canadian astroparticle physics and oceanographic communities. P-ONE consists of cutting-edge photosensors arranged in a three-dimensional array along 10 cables (strings). Each string extends a kilometre upwards from the ocean floor instrumenting more than a 1/8 km3 volume. This provides sensitivity to very high-energy neutrinos originating from some of the most extreme astrophysical processes in the Universe. P-ONE represents a crucial next step for the rapidly emerging field of neutrino astronomy, opening a new window onto the Universe while also probing the Standard Model of particle physics at unprecedented energies. I will present an overview of ongoing activities and status of the project.

Prof. Marie-Cécile Piro
University of Alberta

Marie-Cécile Piro is a french-italo-canadian who grew up in a tiny french island in the Caribbean the Guadeloupe. She moved in Montreal for her undergraduate and graduate studies at Université de Montréal and received her PhD in 2012 in experimental particle physics in the PICASSO collaboration using superheated liquid detectors for the search of dark matter. She continued her quest for dark matter as a postdoctoral associate in France within the EDELWEISS group working with High Purity Germanium (HPGe) bolometer. After some research work in Japan, she moved to the US to work as a research associate with the XENON1T experiment and spent two years in Gran Sasso in Italy for the complete commissioning of the detector, as expert on-site of the purification system and slow control for the experiment. Marie-Cécile is now an Assistant professor at the University of Alberta in Edmonton since 2017 and she continues her search as a leader in the dark matter searches within several experiments in order to push the limit of the detection at theoretical and experimental levels. For more info: https://sites.google.com/ualberta.ca/pirolab/

Dark Matter: The Hunt for the Unknown

Particle Physics

Despite all of our advancements in science, physics, and astronomy, we still try to understand what approximately 80%-90% of the content of the Universe is. However, astronomical and cosmological observations strongly suggest the presence of a new form of matter different from the ordinary matter that surrounds us and which would be five times more abundant named “Dark Matter”. The only visible effects of its existence are its gravitational influence on ordinary matter composing galaxies but it may be detectable in particle physics experiments. But, at present, it is still invisible and undetectable. Does it exist or not? Do we need to change our theories and create new ones? This makes it one of the greatest unsolved mysteries of our universe. Currently many experiments around the world are searching for dark matter and we hope that in the near future we will solve this mystery and understand its properties. After reviewing in detail why dark matter matters and the strong evidence of its existence, I will give an overview of the numerous direct dark matter searches with emphasis in our involvement in Canada and the challenge we are now facing by reaching such unprecedented levels of sensitivity that never-before-seen background signals must be now considered.

Dr. Camille Bélanger-Champagne

TRIUMF

Camille Bélanger-Champagne completed her PhD at the University of Uppsala, Sweden, working on the D0 experiment at Fermilab and the ATLAS experiment at CERN. During her postdoc at McGill University, she started dipping her toes in detector development and testing, and she never looked back. She spent a few years in Helsinki, Finland developing detector systems for nuclear safeguards and nuclear safety. Since 2018, she is the coordinator for TRIUMF’s Irradiation Facilities in Vancouver.

Particle Accelerators’ Role in Building Better Electronic Components

Applied Physics

Electronic components in all applications from the Mars rovers to the cell phone in your pocket are continually bombarded by cosmic radiation. Components can exhibit performance degradation from the long-term accumulation of radiation damage, or undergo spectacular local failures arising from a single high-energy radiation interaction. In this talk I will give an overview of radiation effects on electronics components and highlight how accelerator laboratories, with their high-energy, high-intensity particle beams provide unique testing capabilities. Time permitting, I will highlight some recent dosimetry developments at PIF & NIF, TRIUMF’s facilities for irradiation tests.

Theatre Plenary Talks

Prof. Maria Drout
University of Toronto

Maria Drout is an Assistant Professor in the Department of Astronomy and Astrophysics at the University of Toronto. She is an observational astronomer who studies the evolution and death of massive stars and the origin of peculiar astronomical explosions. She was part of the team that discovered the first optical counterpart to a gravitational wave source detected by LIGO/Virgo, shedding light on the origin of heavy elements. Dr. Drout is also committed to effective science communication, and has co-founded multiple outreach/education initiatives, including Astrobites.org and the Communicating Science Workshop (ComSciCon.com). She was previously a NASA Hubble Fellow at Carnegie Observatories in Pasadena. received her Ph.D. from Harvard, M.A.St from the University of Cambridge, B.Sc. from the University of Iowa, and is originally from Eau Claire, Wisconsin.

Multi-Messenger Gravitational-Wave Astrophysics
Astronomy

On August 17th, 2017, the field of multi-messenger, gravitational-wave, astronomy was born. On this date, Advanced LIGO and Advanced Virgo observed gravitational waves from the merger of two neutron stars and counterparts were subsequently identified across the entire electromagnetic spectrum. Now, in May 2020, LIGO/Virgo recently. completed their third observing run, with many more gravitational wave detections. In this talk, I will give a broad overview of discovery and localization of electromagnetic emission associated with gravitational wave events, review the extensive follow-up observations obtained for the binary neutron star merger GW170817, and place these observations in context. I will discuss the implications of these observations on our understanding of topics ranging from the origin of heavy elements in the universe to the neutron star equation of state. Finally I will give future prospects for the field of multi-messenger astronomy.

Prof. Frank Hegmann
University of Alberta

Frank Hegmann received his PhD in Physics from McMaster University in 1994 and then worked as a postdoctoral researcher at the Center for Terahertz Science and Technology at the University of California, Santa Barbara. In 1997, he started as an Assistant Professor in the Department of Physics at the University of Alberta studying ultrafast dynamics in materials using time-resolved terahertz pulse spectroscopy. He is currently a Professor in Physics and AITF Strategic Chair in Terahertz Science and Technology with research interests in ultrafast spectroscopy, ultrafast carrier dynamics and transport in nanomaterials, terahertz photonics, ultrafast imaging, terahertz scanning tunneling microscopy, intense THz pulse generation and nonlinear dynamics, and biological effects of intense THz pulses. He also loves skiing. He really really loves skiing.

Exploring the Ultrafast Nanoworld

Condensed Matter Physics

Nature is full of processes that occur over very short times and distances down to the atomic scale. In materials and device technologies, fundamental excitations such as the generation of free charge carriers by the absorption of light (like in solar cells), the transport of electrons (like in semiconductor transistors), and quantum dynamics (like in superconductors, magnetic materials, and quantum nanostructures) occur over picosecond time scales and nanometer length scales. Therefore, if we can see how nature works over ultrafast time scales and nanometer length scales, then we obtain a wealth of information on why materials work the way they do and how fast devices can operate, which then leads the way for designing better materials and new device technologies. However, directly observing ultrafast processes on the nanoscale in various materials and devices has been quite challenging, and is the focus of research in many labs around the world. Recently, a new ultrafast scanning tunneling microscope (STM) technique that couples terahertz (THz) pulses to the scanning probe tip of an STM was demonstrated (THz-STM), showing photoexcitation dynamics of a single semiconductor nanodot with simultaneous 0.5 ps time resolution and 2 nm spatial resolution under ambient conditions. Operation of THz-STM in ultrahigh vacuum now makes it possible to spatially-resolve subpicosecond dynamics of single molecules and silicon surfaces with atomic precision. This talk will discuss how THz-STM works and how it can provide unprecedented new insight into ultrafast quantum dynamics in materials down to the atomic scale.

Dr. Alex Hill

University of British Columbia Okanagan

Alex Hill is an astronomer at UBC Okanagan and the Dominion Radio Astrophysical Observatory and an expert on interstellar gas and magnetic fields in the Milky Way galaxy. He received his BA at Oberlin College and his PhD at the University of Wisconsin-Madison in 2011 and held postdoctoral research positions at CSIRO's Australia Telescope National Facility in Sydney and Haverford College near Philadelphia before moving to DRAO in 2017. He then joined UBC Okaganan's faculty in 2019. He uses radio and optical telescopes as well as numerical simulations to explore the dynamic environment of our Galaxy.

The Near and Far universe with CHIME

Astronomy

The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is Canada's newest major telescope and one of the largest telescopes in the world. Located at the Dominion Radio Astrophysical Observatory near Penticton, it is designed to measure the expansion history of the Universe by detecting extremely faint radio signals from atomic hydrogen. To do so, CHIME must look through our own Galaxy, which is up to 100,000 times as bright as the cosmological signal, which provides a unique opportunity to understand the magnetic fields which shape interstellar gas. I will present an overview of CHIME and a status report on the cosmology and Milky Way science efforts.

<u>Prof. Natasha Holmes</u>
Cornell University

Natasha G. Holmes is the Ann S. Bowers assistant professor in the Department of Physics at Cornell University, with the Laboratory of Atomic and Solid State Physics. Prof. Holmes received her BSc.(Hons) in physics from the University of Guelph and her MSc and PhD in physics at the University of British Columbia, and was a postdoctoral researcher at Stanford University working with Prof. Carl Wieman. Her research group studies many aspects of student learning attitudes, and skill development from hands-on laboratory experiences, with a focus on critical thinking and experimentation. They also study how we know what outcomes are being achieved (how do you measure critical thinking?) and aim to probe the mechanisms responsible for those outcomes.

The Trouble with Traditional Labs: Structure versus Confirmation

Physics Education

When you ask physicists to reflect on their intro labs, responses include “boring”, “forgettable”, or “cookbook.” What is so wrong with the traditional lab? In this talk, I’ll present our work that differentiates the role of structure from the role of confirmation, exploring student learning and behaviors in multiple types of labs. We’ll end with implications for designing introductory labs (and maybe even what it all means for online labs!).

<u>Prof. Richard Taylor</u>
Thompson Rivers University

Richard Taylor is an Associate Teaching Professor at Thompson Rivers University, where he has taught mathematics and physics since 2005. He holds a Ph.D. in Applied Mathematics from the University of Waterloo, Canada. His research interests include physical acoustics, loudspeaker arrays, digital signal processing, dynamical systems, and scientific computing and modeling.

Loudspeaker Line Arrays for Acoustic Diffusion

Acoustics

A "diffuse" sound source is one that decorrelates the audio signals radiated in different directions. In sound reproduction and reinforcement in enclosed rooms, these can be used to mitigate the effects of constructive and destructive interference, improving speech intelligibility, reducing echo, and promoting a diffuse sound field that enhances the perception of envelopment -- acoustical benefits that can otherwise be achieved only with large and expensive wall and ceiling coverings. There has been little theoretical work on diffuse sources; to date there are no analytical models suitable for optimizing their diffusive properties. Here we develop a diffusion theory for loudspeaker line arrays, in which each loudspeaker is driven with a different amplitude and polarity. If the amplitude/polarity sequence has flat Fourier spectrum then the array radiates omni-directionally. We derive a simple formula that characterizes the diffusivity (polar cross-correlation) of such an array, and we use this formula to design several arrays optimized for diffusion.

Dr. Matthias Le Dall
Data Science and Analytics Lab, Scotiabank

I started my PhD as a theoretical particle physicist, studying the evolution of the matter content in the Universe through various theories of Neutrino physics. I then transitioned to theoretical condensed matter physics, to study the interaction between localized magnetic spins and Type-I superconductors — specifically, I looked at the implications for noise in SQUID-based quantum bits. I graduated from my PhD in 2017.

Now, as a Data Scientist in capital markets, I mine various financial and non-financial data to predict future market moves by leveraging techniques from Machine Learning and Quantum Computing.

How a Century-old Theory is about to Revolutionize the World (Again)

Condensed Matter Physics and Industry

At more than 100 years-old, the theory of quantum mechanics remains widely elusive to our intuition, harboring predictions that are stranger than science fiction. Yet, it is also one of the most accurate theories of the microscopic world, and is behind some of the most revolutionizing technologies of the 20th century. Quantum mechanics has not said its final words, however, as it is behind yet another emerging technology promising to revolutionize the world: quantum computers.

The power of quantum computers lies in their ability to handle problems whose combinatorial complexity explodes exponentially with their size. The Traveler's Salesman Problem is a famous example of this, and most relevant to the transportation industry, but other industries also have their own flagship problems, such as portfolio optimization in finance. Alongside the growing demand for quantum solvers, a plethora of big and small companies have been democratizing the technology by providing easy-to-use software tools allowing anyone to access quantum hardware.

In this talk, I will describe the basic quantum principles that make quantum computers so powerful and show how the widely available open-source quantum software packages can be leveraged today to impact various industries.

CONTRIBUTED SPEAKER ABSTRACTS

Auditorium Talks

Measurement of the single electron response of Spherical Proportional Counters for the NEWS-G light dark matter search experiment

Daniel Durnford
University of Alberta, Edmonton, Alberta
Particle Physics

The NEWS-G collaboration employs Spherical Proportional Counters (SPCs) to search for low-mass dark matter. Their excellent sensitivity to the minute energy depositions expected from light dark matter scattering make SPCs fundamentally well-suited for this task, but demands exquisite understanding of the detector response at the level of single electron/ion pair events. A novel UV laser calibration system has been developed to address this need, allowing for precision measurements of the single electron response of SPCs. Additionally, this calibration system is shown to be ideal for several other key tasks, including measuring the trigger efficiency of SPCs, and monitoring detector stability in real time. The UV laser was also used together with a low energy Ar-37 source to measure the mean ionization energy in a Ne + 2% CH_4 gas mixture, demonstrating its future applicability for measuring fundamental gas properties. This UV-laser calibration system has been used in the commissioning of a new 140 cm SPC, and will play a crucial role in the next phase of the NEWS-G experiment at SNOLAB.

Quantum gravity effects on scattering amplitudes

Vasil Todorinov
University of Lethbridge, Lethbridge, Alberta
Particle and Nuclear Physics

Theories of Quantum Gravity predict a minimum measurable length and a corresponding modification of the Heisenberg Uncertainty Principle to the so-called Generalized Uncertainty Principle (GUP). Most theories considering this modification do so in a non-relativistic framework, which means the minimum length they provide is not Lorentz invariant. In our previous work we formulated a Relativistic Generalized Uncertainty Principle (RGUP), resulting in a it Lorentz invariant minimum measurable length.Through the modified Klein-Gordon (KG) and Dirac equations, we reconstruct the Lagrangians for scalar and spinor Quantum Electrodynamics. We write the Feynman rules and calculate RGUP corrections to the scattering amplitude of a muon and an electron. We find that for the Dirac field, there is a term in the scattering amplitude that does not depend on the angle, but only on the rest mass fundamental constants, and the Planck length. We believe that this result can provide a potential method to measure minimum length effects using heavy ions scattering experiments.

5.5 MeV Solar Axion Search with DEAP-3600

Carl Rethmeier
Carleton University, Ottawa, Ontario
Particle Physics

DEAP-3600 is a liquid argon (LAr) based spin-independent direct dark matter search experiment. It is designed to detect nuclear recoils induced by the elastic scattering of weakly interacting massive particles (WIMPs) on argon nuclei. In addition, its large target mass and excellent ability to distinguish between electronic and nuclear recoils makes it well-suited for the detection of 5.5 MeV solar axions, which would produce electronic recoils in the LAr, at higher energy than most backgrounds. In this talk I will discuss the various components of the 5.5 MeV solar axion search analysis, including the calibration of the energy response function on AmBe neutron calibration data, development of the Monte Carlo based background and signal models, the algorithm developed to fit the MC model to the data, the methods used to evaluate the sources of uncertainty, and the approach that will be used to calculate the final result. The projected sensitivity for various axion interaction channels will also be shown.

Design of a Combined X-ray Fluorescence Computed Tomography (CT) and Photon-Counting CT Table-top Imaging System

<u>Chelsea Dunning</u>

University of Victoria, Victoria, British Columbia

Biophysics

This paper demonstrates the capability of a table-top x-ray imaging system to simultaneously image a small animal phantom loaded with Gd and Au contrast agents with photon-counting computed tomography (PCCT) and x-ray fluorescence CT (XFCT). Our table-top system consisted of a diagnostic x-ray tube, translation and rotation stages, a 330 um-pitch cadmium zinc telluride (CZT) photon-counting detector with six energy bins, and two CdTe spectrometers which detected fluorescent x-rays in 0.5 keV bins. The energy bin thresholds on the CZT detector matched the contrast agent K-edge energies, enabling K-edge PCCT. A 3 cm-diameter phantom containing vials of 1% and 5% Gd and Au solutions by weight, including a mixed 1% Gd/Au vial, was scanned with 0.5 mm Cu-filtered 120 kVp x-rays at 2 mA. A pencil beam geometry was used with 33 translation and 30 rotation steps to form XFCT and K-edge PCCT images. A cone beam geometry with 180 rotation steps was used to form higher-resolution K-edge PCCT images. Three mice were each injected post-mortem with 0.2 mL of 5% Gd, Au, or mixed Gd/Au solutions in the upper torso and imaged similarly to the phantom. The lowest detectable concentration based on the Rose criterion for Gd and Au phantom data was 0.75% and 3.0% for XFCT, 0.81% and 0.82% for pencil beam K-edge PCCT, and 0.79% and 1.5% for cone beam K-edge PCCT. However, cone beam K-edge PCCT images have a much higher spatial resolution than the pencil beam images. The mixed 1% Gd/Au signal was diminished in the K-edge PCCT phantom images. Preliminary mouse images of Gd and Au among the imaging techniques were similar in image quality as the phantom images. This is the first demonstration of simultaneously-acquired XFCT and PCCT of both Gd and Au in a phantom on a table-top imaging system. On our system, cone beam PCCT is best for imaging Gd, pencil beam PCCT is best for imaging Au, and pencil beam XFCT is better suited toward resolving mixtures of contrast agents.

Time Domain Principal Component Analysis for Rapid, Real-Time MRI Reconstruction from Undersampled Data

<u>Mark Wright</u>

University of Alberta, Edmonton, Alberta

Biophysics

To create a temporally-robust MRI reconstruction method using Principal Component Analysis (PCA) suitable for real-time imaging and tumour contouring for Linac-MR.Methods: This project builds on past work in which PCA was used to reconstruct undersampled MRI dynamic frames based on a series of ~30 fully-sampled frames at the beginning of the session. While the previous technique was capable of reconstructing images from undersampled data, it was found that the reconstruction artifacts increase over time, as the principal components (PCs) were calculated based on the initial fully-sampled data. The work presented here introduces a method by which PCs can be calculated and updated based on a moving database of core k-space data. This core k-space data refers to central k-space (low-frequency) data that is acquired every frame (and never undersampled). The high frequency data can be undersampled in multiple ways. The higher-frequency k-space can be sub-sampled both across the phase-encode (PE) dimension and through time at regular intervals (Case A). In an attempt suppress artifacts; two cases of randomized undersampling schemes were tested. In Case B randomized schemes were applied in the PE direction while the time dimension was sampled at regular intervals. For Case C randomized undersampling was applied in both the PE and time dimension. In all cases, undersampling was performed in such a way as to generate a complete set of k-space every four frames (intermittently complete in the case of time-randomization). After each undersampled frame is acquired, the core data from the most-recent 60 frames is used to create a series of PCs that represent the time-dependent modulation of k-space. The most relevant PCs, typically between 2 and 7 PCs, are kept and then projected onto the sparsely-populated high-frequency data to fill in unsampled phase encodes for the most-recent frame by extrapolation. Results: By calculating the artifact level in retrospectively undersampled lung images, the new reconstruction method results in images that better maintain their fidelity over time (2-4x smaller mean artifact level after two minutes), an improvement over the previous method. However, there are occasional spikes of high artifact which we are currently working on overcoming. Normalised Mean Square Error (NMSE) is one method used to compare the different cases of undersampling patterns and distributions. For Case A the average NMSE among the patients was found to be approximately 0.023 when two PCs are kept and approximately 0.020 when seven PCs are kept. Similarly for Case B the average NMSE amongst all patients was found to be 0.017 and 0.014 for two and seven PCs kept respectively. For Case C the averages were found to be 0.017 and 0.018 for two and seven principal components respectively. We saw that when more were PCs kept the NMSE tended to be smaller; however this also corresponded to much larger NMSE spikes. Based on these results Case B will be pursued further. Conclusion: This method of MRI reconstruction appears to be robust over time, but further investigation will be needed to assess the cause of intermittent artifact spikes.

Investigation of performance and the influence of environmental conditions on strip detectors for the ATLAS ITk Upgrade

Christoph Klein
Carleton University, Ottawa, Ontario
Particle Physics

With the upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC) scheduled to become operational in 2027, the Inner Detector will be replaced with the new all-silicon ATLAS Inner Tracker (ITk) to maintain tracking performance in this high-occupancy environment and to cope with the increase of approximately a factor of ten in the integrated radiation dose.The outer four layers in the barrel and six disks in the end-cap region will host strip modules, built with single-sided strip sensors and glued-on hybrids carrying the front-end electronics necessary for readout.The outer four layers in the barrel and six disks in the end-cap region will host strip modules, built with single-sided strip sensors and glued-on hybrids carrying the front-end electronics necessary for readout. The strip sensors are manufactured as n-in-p strip sensors from high-resistivity silicon, which allow operation even after the fluences expected towards the end of the proposed lifetime of the HL-LHC.Prototypes of different sensor designs have been extensively tested electrically as well as in testbeam setups, yielding generally satisfactory results, but also revealing ongoing challenges. During electrical sensor evaluation many prototype sensors have been found to not comply with specifications for stable long-term operation. This outcome was attributed to the influence of humidity, which has been subsequently investigated in great detail and will have lasting consequences for sensor production and module assembly. Repeated measurements on continuously biased sensors revealed a decrease in tracking performance and increased charge-sharing due to the accumulation of charges in the Si-SiO2 interface. The dynamics of this effect and how it will affect operation of the finished ITk have been examined with a novel approach using the time-development of inter-strip quantities and trap energy level characterisation in SiO2 with Deep-level Transient Spectroscopy (DLTS).

Radon mitigation for the NEWS-G dark matter detector

Patrick O'Brien
University of Alberta, Edmonton, Alberta
Particle Physics

Over the last several decades, dark matter detectors have reached unprecedented levels of sensitivity, such that new and rare background signals must be considered. Radioactive contaminants such as radon, which constitutes the largest background, must be removed to create high purity and low noise detectors. This technical constraint is important to overcome in the New Experiments With Spheres - Gas (NEWS-G) dark matter detector. NEWS-G requires a very pure mixture of gases which are required in directly detecting low mass Weakly Interacting Massive Particles (WIMPs), a well-known candidate for dark matter. The challenges of removing radon from these gas mixtures and the characterization of different materials to remove radon being studied at the University of Alberta will be presented.

Universal scale factors relating mesonic fields and quark operators

Tom Steele

University of Saskatchewan, Saskatoon, Saskatchewan

Particle Physics

Scale factor matrices relating mesonic fields in chiral Lagrangians and quark-level operators of QCD sum-rules are shown to be constrained by chiral symmetry, resulting in universal scale factors for each chiral nonet. Results are presented for the scale factors relating the a_0 isotriplet and K^*_0 isodoublet scalar mesons to their underlying quark composite fields , confirming the universality property and validating the scale-factor connection between chiral Lagrangians and QCD. This connection can contribute to our understanding of low-energy QCD and the physics of scalar mesons.

Search for Displaced Heavy Neutral Leptons

Dominique Trischuk

University of British Columbia, Vancouver, British Columbia

Particle Physics

Introducing a right-handed sterile neutrino with a mass below the electroweak scale is one extension to the Standard Model that could help explain problems with neutrino masses, matter anti-matter asymmetry and dark matter. At the LHC, heavy neutral leptons (HNLs) could be produced via mixing with muon or electron neutrinos. Using proton-proton collision at the LHC, the leptonic decays of W bosons are studied to search for HNLs. This presentation will focus on the search for the displaced leptonic decays of HNLs conducted using the ATLAS detector. Published results consist of an HNL signature that includes a prompt muon from the W boson decay and a dilepton vertex (either 2-muons or 1-muon and 1-electron) displaced between 4-300 mm from the initial interaction point. More recently, work is ongoing to improve the analysis and extend it to include the prompt electron signature in order to also search for HNLs that couple to electron neutrinos.

CDMSlite LIPs search analysis

Sudip Poudel

University of South Dakota, Vermillion, USA

Particle Physics

While the Standard Model does not anticipate the existence of free particles with a fractional electric charge, these fractionally charged particles (FCPs) have not been experimentally excluded. The Standard Model of particle physics does have quarks and antiquarks with ±2e/3 and ±e/3 charges, but their strong interaction binds them inside unit-charged hadrons. Free fractionally charged particles are a feature of viable extensions to the Standard Model with extra U(1) gauge symmetries. CDMSlite Run 2 Period 1 data is used to search for cosmogenic FCPs with sensitivity to far smaller electric charge than any prior search. These results are the first to consider cosmogenic FCPs with a wide range of masses and velocities.

Search for dark matter and neutrinos with the Scintillating Bubble Chamber (SBC)

Sumanta Pal

University of Alberta, Edmonton, Alberta

Particle Physics

Search for dark matter and neutrinos with the Scintillating Bubble Chamber (SBC) Sumanta Pal, Marie-Cécile Piro University of Alberta, On behalf of the SBC collaboration. The Scintillating Bubble Chamber (SBC) experiment is a novel low-background technique used to directly detect low-mass WIMP interactions and coherent elastic neutrino nuclear scattering of reactor neutrinos (CEvNS). The detector combines the strengths of bubble chambers with those of scintillation detectors. By adding a scintillation detection channel, the SBC detector aims to detect 100 eV nuclear recoils and significantly increase the background rejection for electron recoils. The motivation of such new technology and an overview of the collaboration’s plans for the SNOLAB installation/operation and the reactor CEvNS search will be presented. In addition, the current status of the ongoing construction and commissioning at Fermilab will be discussed.

Accessing the ALPs: Reconstructing merged two-photon decays in the Belle II detector

Kelton Whiteaker
University of British Columbia, Vancouver, British Columbia

Particle Physics

Axion-like particles (ALPs) are proposed to mediate interactions between dark matter and the Standard Model. The Belle II detector at the SuperKEKB electron-positron accelerator in Japan is well-suited to search for an ALP to two-photon decay; however, a large fraction of possible two-photon ALP decays, and even a large fraction of Standard Model two-photon decays, remain unresolvable in the detector due to the small opening angle between their daughter photons. This project explores various methods of classification, including a machine learning algorithm, to enable Belle II users to manually distinguish between a single photon and two merged photons. It is found that the machine learning algorithm presented is able to distinguish the two cases to a high degree of accuracy, but even without its implementation, tools already available at Belle II that can help with this problem are identified.

Testing the Standard Model with the Higgs Boson at the LHC

Robin Hayes
University of British Columbia and TRIUMF, Vancouver, British Columbia

Particle Physics

Characterizing the Higgs Boson at the Large Hadron Collider As the most recently-discovered particle of the Standard Model, the Higgs boson is fundamental to our understanding of particle physics and is the focus of much attention at CERN'S Large Hadron Collider (LHC). The Higgs boson's couplings to other particles are predicted by the Standard Model (SM), so performing precise measurements of these couplings can probe for discrepancies and constrain theories beyond the SM. This talk will present ongoing work by the ATLAS experiment at CERN to characterize the newly-discovered Higgs boson by measuring its coupling to W bosons using data collected at the LHC from 2015-2018. It will explore the anticipated role of the vector boson fusion (VBF) production channel in achieving new levels of precision and rigorously testing the SM. Recent improvements to the VBF H->WW* analysis will be highlighted, particularly in the area of background treatment.

Propagation of Muon Fluxes to Simulate the Expected External Neutron Background in PICO

William Woodley
University of Alberta, Edmonton, Alberta

Particle Physics

Propagation of Muon Fluxes to Simulate the Expected External Neutron Background in PICO. PICO is a direct Dark Matter detection experiment installed 2 km underground at SNOLAB in Sudbury, Ontario, searching for WIMPs (Weakly-Interacting Massive Particles) using superheated liquid technology. With this technology, we expect to detect WIMPs by seeing single bubbles in the liquid of the detector. Neutrons, however, can also produce single bubbles, which would be indistinguishable from those created by WIMPs. For this reason, neutrons are one of the main backgrounds for PICO, and must be well-understood in order to ensure WIMP detection is feasible. One source of external neutrons is from interactions between cosmogenic muons and the rock above the detector. This presentation will focus on the work being done to simulate the propagation of cosmogenic muons from the exosphere to the SNOLAB cavern using a new method with high precision. This will provide full information on the muon spectrum underground, which will be used in Monte Carlo simulations in Geant4 to calculate the expected external neutron rate entering the PICO detector.

Testbeam studies for the ATLAS ITk Inner Tracker strips upgrade

John Keller
Carleton University, Ottawa, Ontario
Particle Physics

Testbeam studies for the ATLAS Inner Tracker strips upgradeThe ATLAS experiment at the Large Hadron Collider (LHC) is preparing upgrades to be able to cope with the increased demands of the High-Luminosity LHC (HL-LHC). The current Inner Detector will be replaced with a fully silicon-based Inner Tracker (ITk), consisting of pixel and strip subsystems. In order to exploit the physics potential of the HL-LHC, the ITk must maintain or improve the tracking performance of the Inner Detector, while dealing with vastly increased charged particle occupancy and radiation damage. To be confident that these goals will be met, the ITk strips project has in recent years tested a series of prototype detector modules at the DESY-II testbeam facility. The tests use electron beams with energy up to 5 GeV, with tracking provided by EUDET-style pixel telescopes. Modules are tested before and after exposure to radiation, with particular attention given to charge collection, noise occupancy, tracking performance, and inter-strip behavior. The results give confidence that the ITk strip detector will meet the requirements of the ATLAS experiment, at the beginning and end of its lifetime.

Theatre Talks

A Numerical Study of Q-ball Dynamics

Michael Kinach
University of British Columbia, Vancouver, British Columbia
Astrophysics and Particle Physics

A Numerical Study of Q-ball Dynamics Q-balls are non-topological solitons that arise in complex scalar field theories with a global or gauge U(1) symmetry. These solitons have relevance for supersymmetric models and systems governed by non-linear Schrodinger equations. In this talk, I will present results from numerical experiments involving relativistic collisions of Q-balls in 2+1 dimensions. We find that the system exhibits complex dynamics, such as fission, right-angle scattering, and interference behaviour, that depend on the collision velocity. I will also discuss the stability of gauged U(1) Q-balls against dynamical perturbations in an axisymmetric model.

Constraining the mass loss rates of interacting superluminous supernova

Adaeze Lorreta Ibik
University of Toronto, Toronto, Ontario
Astrophysics

The interacting superluminous supernova is a type of stellar explosion with a luminosity greater than 10 times that of standard supernovae with narrow hydrogen lines in their spectra which is an evidence of their interaction with a circumstellar material (CSM). Some members of this class of supernova seems to explode into a very dense material located close to their star. These materials are thought to be several solar masses worth probably released in eruptive mass loss episodes by the parent star slightly before the explosion. As a result of this material, the supernova can be very bright compared to a traditional supernova. However, the usual model of stellar evolution does not predict this phenomenon and as such, the progenitor stars, mass-loss mechanism, and the full power source of the supernova are debated. For some of these supernova, the total radiated energy exceeds 10^{51} ergs, and thus an exotic type of explosion may be necessary to create them. In this study, we assessed the post explosion behaviour of some PANSTARRS interacting supernovae and their pre-explosion mass loss history. The optical light from the supernova was used to probe the density of the CSM out to radii of a few times 10^{16} cm. In particular, our models probed either a thin dense shell for PS1-11aop (one of the supernova) or a thick shell with lasting interaction few years before core collapse. The late time radio study reveals high mass loss rate that happened some years before the core collapse which is similar to the winds of luminous blue variable stars.

Extreme Sensing with Point Defects in Diamond

Natascha Hedrich
University of Basel, Basel, Switzerland,
Condensed Matter Physics

In the search for more efficient, non-volatile magnetic memory storage systems, spintronics, where bits are encoded by the material's spin structure, has drawn a lot of attention. Antiferromagnetic spintronics in particular, support fast dynamics while being robust to external fields [1]. Many studies have therefore focused on manipulating and reading out the domain structure of antiferromagnets such as Cr_2O_3 [2,3,4]. However, one critical aspect, specifically the interface between two oppositely oriented domains, or domain wall, has been neglected thus faInvestigating such structures is not an easy task though, as it requires high purity materials and nanoscale resolution to isolate single domain walls. We address this knowledge gap using a technique known as nitrogen-vacancy (NV) magnetometry, which makes use of a single-atom defect in diamond (the NV center) as a magnetic sensor [5]. Specifically, we utilize the electronic spin-1 ground state of this defect to detect the local magnetic field through the Zeeman splitting of the NV's energy levels, yielding a field sensitivity of ~ 3uT/√Hz. Furthermore, we work with all-diamond scanning probes, hosting a single defect, which limits our resolution only to the distance between the NV and the sample, namely < 50 nm [6]. These are ideal conditions for measuring the very small stray fields resulting from the domain wall of antiferromagnetic Cr_2O_3. Here, we demonstrate nanoscale imaging of individually nucleated domain walls in a single crystal Cr_2O_3 using NV magnetometry and present a method of domain wall manipulation based on local sample heating. To our knowledge, this is the first such demonstration, and represents a key step towards a better understanding of domain walls and the role they can play in spintronic applications. 1. V.Baltz, et.al., Rev. Mod. Phys. 90, 015005 (2018).2. T. Kosub, et.al., Nat. Comm. 8, 23985 (2017).3. P. Appel, et.al., Nano Lett. 19, 3 (2019).4. M. Fiebig, et.al., Appl. Phys. Lett. 66, 2906 (1995).5. L.Rondin, et.al., Rep. Prog. Phys. 77, 56503 (2014). 6. N.Hedrich, et.al., arXiv:2003:01733 (2020).

Electronic Viscosity in Semimetals

Marianne Moore
University of British Columbia and TRIUMF, Vancouver, British Columbia
Condensed Matter Physics

Contemporary Quantum Materials studies have featured an explosion of interest in exotic electronic dispersions, both in 2D and 3D. Even more recently, topological signatures in physical properties have been a central theme of research. Simple thermodynamic and transport probes, such as the specific heat and the compressibility, however, typically face difficulties in extracting topological features. In this talk, I will discuss how the electronic dynamic shear viscosity can be a powerful probe into the topology of a material. I will show that a topology-dependent frequency power-law scaling can be extracted from this viscosity, describing in a unified picture a large class of nodal semimetals. Such a class embraces both isotropic and anisotropic systems with examples including multi-layer graphene, multi-Weyl semimetals, and critical topological insulators.

Hydrodynamic electron flow in PdCoO2

Timothy Branch
University of British Columbia, Vancouver, British Columbia
Condensed Matter Physics

Evidence in support of hydrodynamic electron flow, in which electronic viscosity-like effects influence transport properties, has been observed in the DC resistance of PdCoO2 [1]. Hydrodynamic effects are predicted to influence the AC electromagnetic response in ultrapure metals [2, 3], but experimental evidence to confirm this is lacking. In these predictions, the electronic viscosity changes the way electromagnetic fields penetrate into the material. Using microwave spectroscopy, the electromagnetic response near the surface of the sample can be probed as a function of frequency and temperature, and can serve as a test of these predictions. In this talk, we briefly introduce the existing models for hydrodynamic electron flow. The hydrodynamic AC electromagnetic response predicted by these models will be compared to the response in conventional metals. The fundamentals of cavity perturbation, the technique we plan to use, will be summarized. Experimental outlook will be outlined. [1] Moll et al., Science 351 6277 (2016) [2] Gurzhi, Sov. Phys. Usp. 11 255 (1968) [3] Forcella et al., Phys. Rev. B 90 035142 (2014)

Finding Pulsars with CHIME

Adam Dong
University of British Columbia, Vancouver, British Columbia

Astrophysics

When a star several times more massive than the Sun comes to the end of its life it will explode in a spectacular way. The star then proceeds to contract until it is held up by only degeneracy pressures due to Pauli's exclusion principle. One might erroneously think of these as failed black holes, however, because of the contraction and angular momentum conservation they can spin at breakneck speeds. As these objects rotate, they emit intense radiation from their magnetic poles, and if we're lucky, the misalignment of the spin and magnetic axes means that those radiation beams sweep over the Earth, much like a lighthouse. These objects are called pulsars and are some of the best Galactic laboratories for studying a wide range of fundamental physics, from general relativity to the nuclear equation of state.The Canadian Hydrogen Intensity Mapping Experiment was originally built to observe the hydrogen gas existing in the Universe. However, due to the nature of the telescope, it is also particularly effective at detecting transient events, such as the relatively new phenomenon, Fast Radio Bursts (FRBs). Fortuitously, it turns out that the very distant FRBs have characteristics similar to those of some nearby pulsars. The CHIME FRB backend is extremely good at detecting particular kinds of pulsars, those that show strong one-off bursts, and thus we preferentially find rotating radio transients (RRATs) and also giant pulse emitters. I will present a machine-learning approach to finding pulsars within the huge CHIME FRB archive and then describe our follow up procedure with the CHIME pulsar backend.

Gamma-ray and Optical Observations of Repeating Fast Radio Bursts with VERITAS

Matthew Lundy
McGill University, Montreal, Quebec

Astrophysics

Gamma-ray and Optical Observations of Repeating Fast Radio Bursts with VERITAS. VERITAS (Very Energetic Radiation Imaging Telescope Array System) is a gamma-ray telescope operating in the 100 GeV – 50 TeV range. The observatory, located on Mt. Hopkins, AZ, is composed of four 12 m diameter telescopes. Traditionally, the telescopes have operated using the imaging atmospheric Cherenkov technique, but several recent upgrades to the VERITAS camera backend have allowed for a new series of rapid optical photometric observations. This new style of multi-wavelength observing has allowed for a series of novel programs to launch at VERITAS. One such program is the search for multi-wavelength counterparts to fast radio bursts (FRBs). FRBs are high energy millisecond pulses of radio emission from multiple unknown extragalactic sources. In this talk, I will summarize the results of our search for FRB counterparts, as well as outlining the new capabilities of our optical system.

Engaging Students in Authentic Experimental Physics Practices in Advanced Labs

Jake Bobowski
University of British Columbia Okanagan, Kelowna, British Columbia

Physics Education

It is now well established that prescribed experiments in instructional labs designed to confirm concepts from the lecture do not enhance student learning. Nevertheless, there is no doubt that experimentation and measurement are of critical importance in physics. Therefore, lab exercises must be restructured and their purpose reimagined. Traditional labs often provide students with a detailed set of instructions to guide them through a sequence of steps that lead to a predetermined result. These structured experiments give students an inauthentic lab experience in which all of the important decisions have been made ahead of time by the laboratory instructor. In our senior physics lab courses at UBC Okanagan, we have been introducing open-ended lab projects that emphasize the experimental process rather than specific physics concepts. In this talk, I briefly describe some of the most successful experimental physics projects developed (with substantial student contributions) within our instructional labs over the past several years. I also discuss some of the unanticipated benefits as well as some of the challenges faced.

Computerized tomography imaging system using a laser pointer

Vincent Daley
Thompson Rivers University, Kamloops, British Columbia
Physics Education

Computed tomography (CT) has long been used to detect and diagnose various injuries and ailments. CT scanners are teeming with interesting physics, but due to their bulk, cost and safety, hands on experience with a medical CT scanner is unrealistic for undergraduate students. Therefore, operationally similar, yet simplified, model CT scanners are desirable teaching tools. This project details the development of a novel model CT scanning apparatus. The scanner employs a laser and photodiode and it images a transparent material while avoiding loss of intensity through refraction. Coloured Pyrex glass was chosen as the scan object. To minimize refraction from interaction between the laser and glass, the glass was bathed in mineral oil, which has a similar index of refraction to Pyrex. Image reconstruction was accomplished by a back-projection algorithm written in R, an open source programming language. The input to the program is the intensity of the transmitted light throughout the scan. The back-projection algorithm then sifts through the data and colours areas of high absorption white, and those of low absorption black. The result is a 2-D cross section of the scan object. Data collection and image reconstruction is accomplished in less than 30 minutes

Permeability of Arrays of Split-Ring Resonators

Sabrina Madsen
University of Toronto, Toronto, Ontario
Industrial and Applied Physics

We present measurements of the relative permeability of split-ring resonator (SRR) arrays used in metamaterials designed to have negative permeability over a narrow range of microwave frequencies. The SRR arrays were loaded into the bore of a loop-gap resonator (LGR) and reflection coefficient measurements were used to determine both the real and imaginary parts of the array's effective permeability. Data were collected as a function of array size and SRR spacing. The results were compared to those obtained from continuous extended split-ring resonators (ESRRs). The arrays of planar SRRs exhibited enhanced damping and a narrower range of frequencies with negative permeability when compared to the ESRRs. The observed differences in damping, however, were diminished considerably when the array size was expanded from a one-dimensional array of N SRRs to a 2 x 2 x N array. In future measurements, we hope to use our experimental design to measure the permeability of metamaterial structures that have been reported to exhibit a so-called anti-resonant response in which, surprisingly, the imaginary part of the permeability is negative over a narrow range of frequencies.

Superfluid 3-He: Within the Confines

Pramodh Senarath Yapa
University of Alberta, Edmonton, Alberta
Condensed Matter Physics

The element Helium has two naturally-available stable isotopes, known as Helium-3 (3He) and Helium-4 (4He). Both these isotopes are the only known substances which do not freeze even when cooled through to 0 Kelvin. Below certain critical temperatures, both 4He and 3He become superfluids - a quantum phase of matter which is most notable for having zero viscosity or zero resistance to movement. I will outline our current theoretical models of superfluid 3He, and recent progress made in identifying a brand new phase of superfluid 3He when it is confined to a nanometre-scale slab.

Comparison of electroabsorption detection via Franz-Keldysh effect to electrooptic detection

Nikolai Lesack

University of British Columbia, Vancouver, British Columbia

Atomic, Molecular, and Optical Physics

In this work, a comparison between terahertz (THz) time-domain spectroscopy performed via electroabsorption sampling and electrooptic sampling is presented. A brief comparison of the methods for deriving the optical absorption coefficient of both ideal and nonideal semiconductors is presented and this theory is utilized in conjunction with the Franz-Keldysh effect to derive an expression for the electroabsorption signal strength of a THz system. A THz electroabsorption detection system that uses only a single wavelength laser beam and an electroabsorption detector design consisting of a biased semiconductor are presented. The theoretical performance of the presented THz electroabsorption system is compared to that of conventional THz electrooptic systems utilizing ZnTe electrooptic crystals. This comparison is made for both GaAs and InP based electroabsorption systems. The values at which GaAs and InP electroabsorption detectors are expected to surpass ZnTe electrooptic detectors is presented allowing for the prescription of conditions in which electroabsorption detection methods are favored. It is found that GaAs and InP THz electroabsorption detection systems should outperform THz electrooptic detection system for both large THz electric fields and large semiconductor bias voltages. Due to the growing THz electric field strengths being generated, this work illustrates that electroabsorption sampling has the potential to outperform contemporary electrooptic sampling methods.

tips + tricks for interacting in the virtual world

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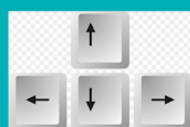

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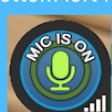

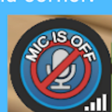

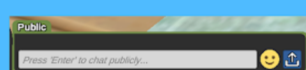

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