The 8th annual PHAS symposium

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phas dga

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A special thanks to the furry research assistants of PHAS

Organizing Committee

The Physics and Astronomy (PHAS) Departmental Graduate Association (DGA) is comprised of graduate students to represent students' interests for the Graduate Student Association (GSA). One of our goals is to foster an inclusive and welcoming environment for the diverse group of graduate students within the department. The PHAS DGA organizes social and academic activities throughout the year, the PHAS Symposium being one of many. Additionally, the PHAS DGA works to recognize students' accomplishments within the department. Please visit the [PHAS DGA website]() for more information concerning the upcoming events and the PHAS DGA.

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Leili Esmaeilifar
Member at Large

Mahdi Bornadel
Member at Large

Schedule

TIME	EVENT
9:00 - 9:15 am	Check in
9:15 - 9:30 am	Opening Remarks
9:30 - 10:30 am	Keynote Speaker – Claudia Gomes da Rocha
10:30 - 10:45 am	Coffee Break
10:45 am - noon	Session 1 (6 talks)
12:00 - 1:00 pm	Lunch
1:00 - 2:15 pm	Session 2 (6 talks)
2:15 - 3:00 pm	Keynote Speaker – Anna Danko
3:00 - 3:15 pm	Coffee Break
3:15 - 4:45 pm	Session 3 (7 talks)
5:30 pm	Social Event at LDL (prizes announced)

PHAS grads in the wild

PHAS graduate students hike in Kananaskis Fall 2022

DGA Skating Social December 2022

Keynote Speaker → 9:30 – 10:30 am

Dr. Claudia Gomes da Rocha

Assistant Professor, Department of Physics and Astronomy, University of Calgary

As a faculty member of the Department of Physics and Astronomy, University of Calgary, Dr. Rocha leads the Complex Nano Materials group whose research targets problems in theoretical condensed matter physics and computational nanoscience realms. Dr. Rocha received her MSc (2001) and PhD (2005) degrees in Physics from the Fluminense Federal University (FFU) in Rio de Janeiro, Brazil. There followed a series of postdoctoral experiences in Europe: research fellow at Trinity College Dublin (TCD), Ireland, (2005-2008); Alexander von Humboldt Fellow at Dresden University of Technology, Germany (2008-2011); independent researcher at the University of Jyväskylä, Finland (2011-2014); and senior research fellow at TCD, Ireland (2014-2018).

Research at the Complex Nano Materials Group

Abstract: The research line of the Complex Nano Materials Group (CNMG) concentrates on state-of-the-art theoretical condensed matter physics, computational nanoscience, and complex systems, but it also assumes an interdisciplinary character touching the boundaries of materials sciences, nanotechnology, and neuroscience. Our research addresses important fundamental problems and the applicability of nanoscale matter and solid state physics knowledge in tech innovations. This is done by means of computational tools and simulations to build a solid comprehension of the intriguing properties of such materials so one can suggest novel ways of maximizing their abilities. In particular, the CNMG targets the theoretical description of low dimensional systems of considerable technological interest such as organic molecules, carbon nanotubes, 2D materials (e.g., graphene, silicene, and phosphorene), and amorphous nanowire networks. Our computational toolkit includes first-principles electronic structure methods, quantum transport calculations, and Multiphysics/mesoscopic simulations, to study a variety of physical phenomena such as ultra-fast transient quantum transport, electronic switching devices, chemical sensing, transparent conductors, and neuromorphic systems.

Session 1 → 10:45 am – noon

1

Different paths of information routing preserve scale-free neuronal and behavioral dynamics

Anja Rabus

Does the brain optimize itself for storage and transmission of information and if so, how? The statistical physics based critical brain hypothesis posits that the brain self-tunes to a critical point or regime to maximize the repertoire of neuronal responses. Yet, the robustness of this regime, especially with respect to changes in the functional connectivity, remains an unsolved fundamental challenge. Here, we show that even if large changes in information routing at the cellular level are induced by a psychedelic compound, both scale-free neuronal dynamics (associated with behavioral transitions) and self-similar features of behavioral dynamics persist. Specifically, we find that the psychedelic compound ibogaine that is associated with an altered state of consciousness fundamentally alters the functional connectivity in the retrosplenial cortex of mice. Yet, the scale-free statistics of movement and of neuronal avalanches associated with populations of neurons which are either activated or suppressed when the mouse is moving remain largely unaltered. This indicates that the broad repertoire of brain function both at the neuronal level and at the behavioral level is robust under information routing, opening up a new perspective on the interconnectedness of the adaptive nature of functional networks and optimality of information transmission in the brain.

2

Testing the capabilities of the JWST instrument NIRISS for atmosphere detection and transmission spectroscopy of Earth-sized exoplanets

Salma Salhi

Despite only having been launched a year ago, the James Webb Space Telescope (JWST) has already begun revolutionizing many fields within astrophysics. Its new exoplanet data is especially ground-breaking, as the JWST is equipped with several instruments designed to perform high-precision transmission spectroscopy, allowing for the identification of chemical species in the atmospheres of exoplanets at an unprecedented level of detail. Canada has provided one such instrument, the Near-Infrared Imager and Slitless Spectrograph (NIRISS), which allows for single object slit-less spectroscopy (SOSS) from 0.6 to 2.8 microns. The star flux data collected from this instrument can be used to construct spectroscopic light curves and transmission spectra, which can show whether the exoplanet possesses an atmosphere and can further indicate the presence of certain molecules in exoplanet atmospheres. One exoplanet system of great interest is the TRAPPIST-1 system, which is located 39 light years from Earth and contains seven rocky exoplanets. We conducted analyses of incoming data on three of the planets in this system, as well as several other planets. Part of my role was to investigate some noise features we found in the data to ascertain whether the excess noise was due to stellar contamination or instrumental effects. The goal of these first analyses was two-fold: to obtain transmission spectra of these planets to determine whether they have atmospheres, and to test and verify the capabilities of NIRISS. Our preliminary results confirm that NIRISS has the precision necessary to study Earth-sized, temperate exoplanets orbiting M dwarfs, and suggest that we need to develop tools to account for the heavy influence of stellar contamination before making conclusions about the atmospheres of these exoplanets.

Session 1 → 10:45 am – noon

3 Hydrogel imaging using scanning electron microscopy

Zoe Hoyda

Imaging soft materials, while possible using techniques like scanning electron microscopy (SEM), is a process that involves careful consideration due to its complexity. Samples are often damaged in the preparation process, and fundamental characteristics of the materials eventually erode. Most importantly, typical imaging involves some sort of sample-altering sputter-coating to ensure electron detection on the electron microscope. Even with this step, soft materials can be difficult to resolve in SEM. Briefly, SEM is a technique that involves rastering an electron beam across a surface. The different detectors employed detect respective emitted electrons. With SEM, we imaged hydrogels in combination with nanoparticles. Hydrogel-nanoparticle composites are a class of soft materials that can be made to regain their original shape after dehydration and rehydration. They are stable materials which can be conditioned to respond to simple stimuli over many cycles.

Repeated reversibility of these materials is the focus of our current research. As such, we required imaging solutions using SEM that highlighted the structure of the gel network for later analysis. This method also had to be non-adulterating and high resolution. We found that it was possible to create reliable imaging of these composites using basic lab equipment. During this study, we looked at best imaging modes on a non-environmental, non-cryogenic SEM. We tested modes like variable-pressure secondary electron (VPSE), back-scatter (BSD), inLens, and secondary electron II (SE2). All modes produce slightly varied results in the images shown due to the optical interactions of the electrons with light.

To employ any of the modes, we needed to understand the optical processes of SEM to ensure the image veracity and quality. We had to balance modes which produced higher contrast, BSD and SE2, with modes that appeared not to distort the overall network, like VPSE. All of which was done at high magnification and close working distance without any sample-surface modifications. In gathering numerous images of these soft materials, we were able to establish a reliable, high quality and reversible process. This could only be done by testing various imaging modes against our samples, demonstrating the physical and optical processes of SEM in soft materials like ours. The knowledge gained by extensive testing provides further insight into the statistical properties of the gel-gold hybrids and their applications as reversible materials.

4 Successes and Failures in Overcoming a Toilsome Lack of Experimental Data Integrity

Jonah Richards

A first experience with data collection in the field is accompanied by many challenges not often encountered in the well controlled environment of a physics laboratory. Environmental error heavily compounds ever present instrumentation, telemetry, and computational errors. A variety of techniques are used to correct noise and integrity issues is sensor readings from a sounding rocket launch. Unique problems are addressed by computational solutions of varying effectiveness, covering the topics of noise-filtering, regressions, trajectory reconstruction and reference frame transformations. Accompanied by some of the mechanics and aims of sounding rocketry.

5 Beyond the Starry Night: Probing the Small-Scale Structure of the Galactic Magnetic Field

Kierra Weatherhead

The Galactic magnetic field that permeates our entire Galaxy affects not only the structure of the interstellar medium, but also that of the entire Galaxy. From driving the flow of matter, to influencing star formation and stellar distribution, this essential force play an large role in the dynamics of the Milky Way. Even more critically, it prevents our Galaxy from collapsing under the force of its own gravity and influences how it evolves over time. Despite its importance, much is still unknown about it due to the fact that it does not emit any light. As such, it has proven elusive and difficult to study and we are only able to observe it indirectly.

Although it doesn't emit light itself, the Galactic magnetic field does still affect polarized light through the Faraday effect. This effect is proportional to both the strength and direction of the magnetic field in a region, and we have been able to gain some information about the structure of the GMF by observing Faraday rotation. As this effect is larger at longer wavelengths, it is typically studied at radio wavelengths. However, in order to achieve the same angular resolution at longer wavelengths, larger telescopes are required. As such, the scales that we can study the GMF using this method is still largely limited by technological constraints.

Until recently, the resolution of Galactic plane surveys at radio wavelengths has been much larger than at higher wavelengths, making it impossible to study the small-scale structure of the GMF. The THOR survey changes this. With an angular resolution of 20", three times better than the previous radio survey of the same region, we are able to make observations on much smaller scales. My work focuses specifically on well-resolved, extended radio galaxies found within this survey. Using polarimetry, I can measure both the amount of Faraday rotation and the depolarization experienced by these galaxies along a section of the Galactic plane. By observing multiple regions in close proximity to one another, I will be able to study small-scale fluctuations in the strength of the GMF. This will lead to a better understanding of the structure of the GMF, how it evolves, and how it may have formed in the first place.

6 The molecular-rich outflow of giant stars

Kelly Ma

When stars like our Sun reach the end of their lives, they become giants and eject a lot of their initial mass through a slow, dense outflow. These winds are driven by microscopic solid particles (dust grains) that condense in the cool stellar atmospheres. Dust is the product of a large number of chemical reactions that take place in the extended atmosphere and outflow, which also lead to the formation of several molecules. By studying the abundances and distribution of these molecules, a better understanding of the chemistry and physical properties of the ejected gas can be achieved.

Using 2 sample sets collected from the Atacama Compact Array (ACA) in Band 6 and Band 7, we identified molecular lines from the circumstellar envelopes (CSE) of 68 evolved stars. From about 30 observed lines, we identify those of HCN isotopes (H13CN and HC15N) and CS isotopes (12CS and 13CS) as particularly interesting in a subsample of stars. These allow us to probe the 12C/13C and 14N/15N isotopic ratios, which are important probes of the initial stellar mass, an elusive property of AGB stars. We compare our results with models for the evolution of AGB stars.

Session 2 → 1:00 – 2:00 pm

Neuroscience of hearing, a computational approach

Josue Ibarra Molinas

Hearing is a key function to interact with our environments. It allows us to localize sound sources in space, varying from the rustling of some bushes behind to a song being played in our surroundings. In humans it is of particular relevance also because of its role not only in speech perception, but production as well.

The Primary Auditory Cortex (A1) is the central area in the brain that processes auditory information in humans and many other vertebrates. Constructing a model of how neurons located in A1 implement this information processing could help to understand hearing better. More concretely, it could also contribute to develop general technologies such as machine learning algorithms, or Brain-Computer Interface (BCI) devices with purposes including entertainment, mental training, or diagnostics and treatments of related health conditions like Tinnitus or cochlear injuries.

My research uses computational and dynamical systems tools to propose a simple, informative, yet realistic model of how mouse A1 neurons encode auditory information, and how this model could arise from the underlying biology.

Magnetic Fields During Gravitational Experiments with Antihydrogen

Adam Powell

The Antihydrogen Laser Physics Apparatus (ALPHA) collaboration uses low energy antiprotons to produce, trap, and study the bound state of an antiproton and positron, antihydrogen. Hydrogen has been studied extensively through history and has many physical properties known to a high precision experimentally and theoretically. Therefore, comparisons between hydrogen and its antimatter equivalent offer highly sensitive tests of many fundamental symmetries. In a new venture, ALPHAg, the collaboration is attempting to observe the effect of Earth's gravity on antihydrogen through a controlled magnetic release.

ALPHAg will store low field seeking antihydrogen in a vertical magnetic minima trap, two short solenoids providing vertical confinement will then be slowly ramped down. Due to the difference in height between the two solenoids the trapping potential is different at each end by $mg\boldsymbol{\Delta}h$. Given this potential difference antihydrogen will "fall" in a direction biased by g and annihilate. Since this potential difference is equivalent to a ~ 4×10^{4} T magnetic field variation, and with a background field changing from 1.7 T to 1 T during release, it is clear that observing any effect is only achievable through careful design, control, and measurement of magnetic fields.

I will introduce the ALPHA experiment and a technique that determines the magnetic fields inside our experiment by measuring the cyclotron frequency of an electron plasma. I will then lay out the necessary steps to display control and understanding of the magnetic environment by showing results of extensive mapping of the on-axis field of several magnets, and characterisations of field drifts in the experiment.

Session 2 → 1:00 – 2:00 pm

3 Visualizing Nuclear Orbitals

Resha Mau

The aim of my senior thesis project is to create a visual model of nuclear orbitals. Currently, there is no existing resource available that serves as a visual tool for nuclear shell theory. The creation of such a resource can serve as a great educational tool to facilitate greater understanding of nuclei, and to a certain extent, ignite further interest in nuclear physics. These orbitals will be modelled for all nuclides in the table of nuclides. The starting point for orbital visualizations follows the method used to solve the hydrogen atom. This process entails solving the Schrodinger equation for a spherically symmetric potential, using the separation of variables. The shell model of the nucleus proposes that nucleons (protons or neutrons) occupy their own shells in single particle orbits. Their distribution is governed by the Pauli exclusion principle, which states that particles with half-integer spins cannot occupy the same state in a quantum system. Each nuclear shell can be described by the same set of quantum numbers that are used to describe electron states. A major reason that led to the development of the shell model for nuclei was the attempt to explain the phenomena of "magic numbers". These refer to nuclei that have a total of 2, 8, 20, 28, 50, 82 or 126 nucleons. Nuclei that correspond to a "magic number" have been noted to be particularly stable. Experiments have also found that magic-number nucleons represent closed nuclear shell configurations, in the same way that the noble gases represent closed valence shells of electrons.

4 Probing the Galactic Magnetic Field with the Remnants of Dead Stars

Larson Scullion

The Galactic magnetic field (GMF) plays a critical role in the formation of star forming regions throughout our Milky Way Galaxy, as well as in supporting the large-scale vertical structure of the Galaxy's disk. However, the precise structure and origin of this magnetic field is still largely unknown in large part due to the difficulties involved in measuring it. Since magnetic fields do not directly produce radiation, information about the GMF must be deduced from indirect measurements. The most used technique for mapping the GMF is to observe background sources of polarized light, and to analyze how the angle of polarization has rotated from the interaction between the light and the GMF. This information allows for indirect measurements of the GMF throughout the Galaxy but comes with the limitation that the magnetic field can only be probed directly along the line-of-sight to the background sources used. Historically, this technique has been performed utilizing polarized emissions from either highly magnetized pulsar stars in the Milky Way Galaxy or extragalactic radio sources. It has been demonstrated, however, that the expanding shell of gas left behind by supernova explosions also generates polarized radio light that can be used to probe the GMF. By analyzing these supernova remnants (SNRs), we can greatly increase the number of data points for our growing map of the Galaxy's magnetic environment. My research makes use of radio observation data from the Canadian Galactic Plane Survey taken at the Dominion Radio Astrophysical Observatory to apply the technique of polarization angle rotation measurements to numerous SNR radio sources. This work will build on previous survey efforts to produce a more detailed and accurate map of the Milky Way's magnetic environment than previously possible.

Session 2 → 1:00 – 2:00 pm

5

Towards Rare-Earth Molecular Crystals as a New Platform in Quantum Networks

Farhad Rasekh

Long-distance quantum communication and quantum computers have many applications, ranging from drug design and cybersecurity to financial modeling and mitigating climate change. Quantum memory is essential in implementing long-distance quantum communication and is a key component in linear optics quantum computing. Rare-Earth atoms have a unique atomic energy level structure, which leads to excellent coherence properties. As a result, Rare-Earth Ion (REI) doped materials are promising candidates for implementing light-matter interfaces in photonic quantum technologies, such as quantum memories. To exploit these rare-earth atoms' properties in quantum technologies, they must be hosted in a solid-state material. However, it is difficult to combine many of these host materials with photonic devices. To overcome this, molecular chemistry offers a novel host material, namely molecular crystals, that has unmatched flexibility in terms of combination with photonic structures. In addition, this platform enables having control over the spacing between ions at the angstrom level as well as having a sample that consists of two different RE atoms. Contrary to other host materials, such as bulk crystals, where RE atoms are doped randomly in a crystal lattice, all RE atoms in molecular crystals will be fixed at a specific positions in the crystal lattice. This enables the implementation of quantum ensemble gates on these platforms. This research focuses on crystals formed from a molecular complex hosting one of two different rare-earth atoms, erbium and thulium. Among all REIs, erbium is attractive due to its optical transition (around 1530 nm), which enables the storage and retrieval of photons in the so-called telecommunication band, over which transmission in optical fibers is maximum among all other wavelengths. In addition, thulium has a simple and straightforward four-level optical system under an external magnetic field so that a Λ system can be selected, which is vital for the functionality of many quantum technologies. As these crystals have not yet been studied for quantum information purposes, the study begins with performing a series of optical spectroscopy measurements. Then, using quantum memory protocols, we evaluate the suitability of the samples for quantum level light-matter interfaces. We will also investigate the controlled electric dipole-dipole interactions between REIs in crystals containing one of the rare-earth elements and one containing a mix of two different REIs. These investigations aim to explore the possibility of implementing one- and two-qubit gates for quantum computing purposes.

Session 2 → 1:00 – 2:00 pm

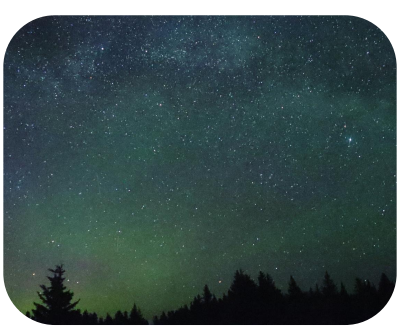
6

Thermo-Electro-Optical Properties of Seamless Metallic Nanowire Networks For Transparent Conductor Applications

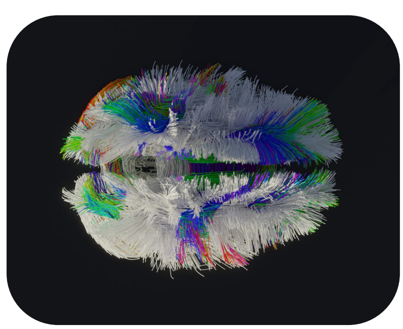
Koorosh Esteki

Rapid reaction time, high attainable temperatures, minimum operating voltage, excellent optical transmittance, and tunable sheet resistance are all desirable properties of transparent conductors, important thin-film components in numerous electronic devices. Here, we have conducted an in-depth computational investigation to study the thermo-electro-optical properties of seamless nanowire networks (NWNs) and understand their geometrical features using in-house computational implementations and a coupled electrothermal model built in COMSOL Multiphysics software. Sheet resistance calculations were performed using Ohm's law combined with Kirchhoff circuit laws for a random resistor network and compared with those obtained employing the COMSOL Multiphysics software. In this work, aluminium, gold, copper, and silver nanowires are the materials of choice for testing the transparent conduction performance of our systems. We have studied a wide range of tuning parameters, including the network area fraction, the width-to-depth aspect ratio, and the length of the nanowire segments. We obtained corresponding figures of merit (optical transmittance/temperature versus sheet resistance) to provide a complete characterization of the performance of real-world transparent conductors idealized with seamless NWNs. Our analysis accounted for the thermo-electro-optical responses of the NWNs and the inspection of various controlling parameters depending on system design considerations to shed light on how the electrical transport, optical qualities, and thermal management of these systems can be optimized.

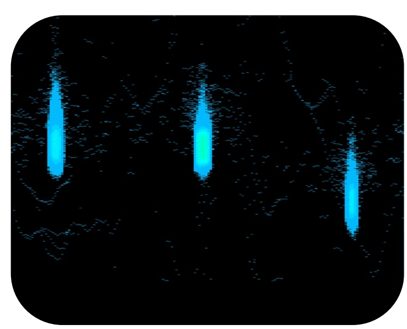
Images of Research Competition entries by PHAS students



The Light We Do Not See
Pamela Freeman



The Complexity of the Brain
Davor Curic



Laser light and the study of antimatter
Pooja Woosaree

To see all images from the competition, please visit
https://grad.ucalgary.ca/my-gradskills/images-research/images-research-entries-2022-23

Keynote Speaker → 2:15 – 3:00 pm

Anna Danko

Lead Data Scientist at ATB Financial

After graduating from a BSc in Physics, Anna took her enthusiasm for computational methods and scripting into the world of medical research, earning a MSc in Medical Sciences with a focus on medical imaging. In graduate school she was introduced to many of the concepts she uses today: machine learning, computer clusters, presenting without panicking, and more. Currently Anna works at ATB Financial as a Lead Data Scientist.

"Don't Say XGBoost"

Abstract: Some things in life are widely recognized to be difficult: studying physics, childbirth, finding a good job. Somehow, I've managed to do two of those things. In this presentation I hope to share the insights I gained as I stumbled my way into industry — a strange new world whose language and culture academics and students struggle with.

Session 3 → 3:15 – 4:30 pm

1 Multiple-Reflection Time-of-Flight Mass Spectrometry at TITAN

Gabby Gelinas

TRIUMF's Ion Trap for Atomic and Nuclear Science (TITAN) is a world leader in high precision mass measurements of exotic nuclei. These mass measurements are used to refine theoretical models to push our knowledge beyond experimental capabilities in studies surrounding nuclear structure, nuclear astrophysics, fundamental symmetries, and neutrino physics. As we explore isotopes deeper in the exotic region of the nuclear chart, obtaining high precision mass measurements becomes increasingly difficult. To enable TITAN to study nuclei in this region I sought to further the measurement precision of the TITAN multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) by reimagining the use of existing equipment. I investigated alternative ways to utilize the MR-TOF-MS's mass range selector, a set of four electrodes traditionally used for beam cleaning, to alter the path of the ion of interest as it passes through these electrodes to guide the ion along the analyzer's optimal axis. By applying varying voltage pairs and polarities to the electrodes and calculating the resulting resolving power of the mass measurement of a consistent stable species I was able to determine the ideal parameters for maximizing measurement precision. When taking mass measurements with my beam steering settings applied the measurement's resolving power was up to 25% higher than the previous resolving power standard for this instrument. This higher resolving power results in a further improvement of TITAN's mass measurement precision, a vital step in achieving high impact measurements of the masses of currently untouched exotic nuclei.

2 Self-intersecting surfaces inside black holes

Kam To Billy Chan

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

Session 3 → 3:15 – 4:45 pm

3 Near quantum limited amplifier: Signal amplification in superconducting circuits

Danial Davoudi

Quantum computing is an emerging technology. Their high computational power single them out for resolving current complex and unsolved problems in Math Science, Finance, and Chemistry. Building a quantum computer require robust physical hardware; therefore, over the past ten years, researchers have proposed different platforms as the basis of quantum computers for processing quantum information. In my project, we aim to design and fabricate a new near-quantum-limited amplifier that simplifies the design and nanofabrication of the current methods by using a new material property to decrease the complexity of the current state-of-the-art circuit.

4 Black Holes have Middle Child Syndrome: The Hunt for Intermediate Mass Black Holes

Solveig Thompson

Black holes form when massive stars die and collapse in on themselves, compacting their mass into something so dense that not even light can escape its gravity. They are categorized based on their size; either stellar mass ones under 100 times the mass of the sun (solar masses), or supermassive ones that are over a million solar masses. This begs the question: are there black holes in between? There is a proposed third type of black hole, the intermediate mass black hole (IMBH), that fills the gap between stellar and supermassive, but their existence is controversial, and technological limitations make them very difficult to detect. This mass gap between stellar and supermassive black holes is a sticking point for current supermassive black hole formation models. Different models predict different frequencies of IMBHs in the universe and without data on IMBH frequency in the universe it remains a challenge to narrow down these models.

Compact stellar systems such as ultra-compact dwarf galaxies are dense, massive clusters of stars that are prime candidates for hosting IMBHs. Recently, by pushing ground-based telescopes to their limits a supermassive black hole was detected in an ultra-compact dwarf galaxy, indicating that there may be smaller black holes to be found in similar systems. Technological limitations of ground-based telescopes limit observations to only the biggest and brightest targets, severely reducing the population of which to sample. With the new James Webb Space Telescope that changes. My research uses the James Webb Space Telescope to observe 18 compact stellar systems for evidence of IMBHs via their gravitational influence on nearby stars. I use spectroscopy to detect the motions of stars to derive the center of mass of the system to detect the presence or lack-thereof of black holes in compact stellar systems. This census of IMBH will inform current supermassive black hole formation and evolution theories.

Session 3 → 3:15 – 4:45 pm

5 Interfacing true quantum level single photons with quantum memory

Nasser Gohari Kamel

At the heart of modern Optical Quantum Computation and Communication (OQCC) are single photons (SP) as the carrier of encoded quantum information, due to their convenience degree of freedom for encoding qubits, weak interaction, and optimal speed of travel. In this regard, one of the main crucial tasks in OQCC is an on-demand quantum level single photon source capable of generating single and entangled photons. However, due to the unavoidable transmission losses present in every communication channel, long distance communication between nodes is limited to a few hundred kilometers.

A solution to overcome the distance limitation, is to realize the Quantum Repeater (QR) protocol. The basic idea behind the QR protocol is to divide transmission line into several sub-links that each link consist of a set of on-demand quantum memory (QM) and entangled photon pair source. In short, in the QR protocol pairs of entangled photons are generated in each sub-link and one member of each pair photon is stored in the QM while the other is sent towards a measurement node halfway between the sources. When photons are successfully transmitted to the measurement nodes in two adjacent sub-links, the stored single photons will be released from the neighboring QMs and an entanglement swapping measurement causes the photons stored in the two distant QMs to become entangled. Evidently, QRs require an efficient quantum interface between photons and atoms that can serve as QM. Therefore, to construct the future quantum network two essential building blocks are genuine SP source and a multimode QM.

In this regard, III-V semiconductor quantum dots are best known for their capability for generating entangled and SPs for the range of IR and telecommunication wavelength. On the other hand, rear-earth ion doped crystals at cryogenic temperatures are among highly ranked candidates for QM. In my presentation, I will elaborate on InAsP quantum dots as quantum level SPs and Ytterbium ion doped into Yttrium Orthosilicate (Yb:YSO) for multimode QM. Finally, I will explain the process of quantum interface between a SP source and a QM towards the future quantum network applications.

6 The World's Tiniest Schrodinger's Cat: Both Dead and Alive on a Nucleus

Pragati Gupta

The famous Schrodinger's cat paradox points to the principle of superposition in quantum mechanics, which predicts that a cat can be both dead and alive, at the same time. An object in a such a superposition is thus called to be in a “cat state”. Cat states are important to test the validity and limitations of quantum mechanics, and are crucial for making quantum sensors and computers. I will present the model of a nucleus that can form a “cat state”, leading to the world's tiniest Schrodinger's Cat, with a size of 10^{-14} m!

Session 3 → 3:15 – 4:45 pm

7 Simulation of Galaxy Formation and Evolution using the Interacting Dust Solution Model

Glynnis Mutch

This research project aims to simulate the formation and evolution of galaxies using the interacting dust solution model, which was derived from a combination of Einstein-Brownian motion and Random Matrix Theory. This phenomenon will be analyzed by conducting a comparative analysis between the dust solution model and another galaxy formation model known as the "Bath Tub Toy" model, both of which will be calculated using characteristic data compiled in the SIMBAD Astronomical Database. The results of this project will provide astronomers with additional information on the behaviour and distribution of matter in space as well as the physical processes involved in galactic evolution.

Join us in the Last Defense Lounge after the symposium

- Please join us **from 5:30 pm** for the post-symposium social at the Last Defense Lounge.
- The Last Defense Lounge is located on the **3rd floor of MacEwan Student Centre.**
- Snacks will be provided.
- Awards for best talks and people's choice will be announced. (If they are unable to attend the social event, winners will be notified by email as well).

PHAS grads in the wild

Team PHAST raised nearly $1000 for the Calgary Distress Center during the 2022 Outrun the Stigma race

PhD student Pam Freeman doesn't follow instructions on a hiking trip in Kananaskis Fall 2022