phas dga

February 20th, 2024

# The 9th Annual PHAS Symposium

We gratefully acknowledge support from:

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# Land Acknowledgement

The University of Calgary, located in the heart of Southern Alberta, both acknowledges and pays tribute to the traditional territories of the peoples of Treaty 7, which include the Blackfoot Confederacy (comprised of the Siksika, the Piikani, and the Kainai First Nations), the Tsuut'ina First Nation, and the Stoney Nakoda (including Chiniki, Bearspaw, and Goodstoney First Nations). The City of Calgary is also home to the Métis Nation of Alberta (Districts 5 and 6).

The University of Calgary is situated on land Northwest of where the Bow River meets the Elbow River, a site traditionally known as Moh'kins'tsis to the Blackfoot, Wîchîspa to the Stoney Nakoda, and Guts'ists'i to the Tsuut'ina. On this land and in this place we strive to learn together, walk together, and grow together "in a good way."

# 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.

# PHAS DGA Members

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**CJ Osakwe**
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VP Finance

**Jose Trujillo**
VP Finance

**Mahsa Karimi**
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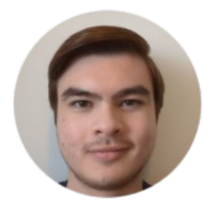

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**Amirhossein Sotoodehfar**
GRC rep

**Ali Mahani**
Member at Large

# Schedule

| TIME | EVENT | Location |
|---|---|---|
| 9:00 - 9:15 am | Check in | ENG 60 |
| 9:15 - 9:30 am | Opening Remarks | ENG 60 |
| 9:30 - 10:30 am | Keynote Speaker – Anna Ordog | ENG 60 |
| 10:30 - 10:45 am | Coffee Break | ENG 207 |
| 10:45 - 11:45 am | Student Talks 1 | ENG 60 |
| 11:45 - 12:45 pm | Lunch | ENG 207 |
| 12:45 - 1:45 pm | Industry Panel | ENG 60 |
| 1:45 - 3:00 pm | Student Talks 2 | ENG 60 |
| 3:00 - 3:30 pm | Coffee Break and Poster Session | ENG 207 |
| 3:30 - 4:45 pm | Student Talks 3 | ENG 60 |
| 5:00 pm | Social Event at LDL (prizes announced) | Last Defense Lounge |

## A special thanks to the furry research assistants of PHAS

# Keynote Speaker → 9:30 – 10:30 am

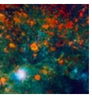
## Dr. Anna Ordog

### Postdoctoral researcher at the Dominion Radio Astrophysical Observatory

Anna is a postdoctoral researcher at UBC Okanagan and the Dominion Radio Astrophysical Observatory, working with Dr. Alex Hill and Dr. Tom Landecker. She completed her PhD in astrophysics at the University of Calgary in 2020, where she studied Galactic magnetism using data from the Canadian Galactic Plane Survey and the Global Magneto-Ionic Medium Survey under the supervision of Dr. Jo-Anne Brown. Since moving to the Okanagan to begin her postdoc at the DRAO, Anna has continued her research on the interstellar medium through radio polarisation studies as a member of the Canadian Hydrogen Intensity Mapping Experiment Galactic science team, and has had the privilege of working with many amazing students from UBCO and U of C. In her free time, Anna enjoys hiking, climbing and various outdoor activities.

## The Polarised Radio Sky at the DRAO and the Quest to Understand the Magnetized Milky Way.

**Abstract:** The Milky Way Galaxy hosts an extensive and complicated magnetic field structure ranging in scale from stellar environments up to the Galactic spiral arms. Establishing a thorough understanding of the present-day three-dimensional Galactic magnetic field morphology is instrumental to developing a complete understanding of the physics of the Milky Way and other galaxies. The magnetized interstellar medium imprints signatures of its structure onto polarisation maps of the sky at radio wavelengths, and a wealth of information can be gained by studying how observed polarised synchrotron emission varies with frequency through the effect of Faraday rotation. In this talk, I will present recent progress toward Galactic polarisation maps from Canadian radio telescopes, and share my experiences as a postdoc at the Dominion Radio Astrophysical Observatory. Specifically, I will show results from the Canadian Hydrogen Intensity Mapping Experiment (CHIME) and the DRAO 15-m telescope 'DRAGONS' survey, highlighting the many contributions from students at UBC Okanagan as well as U of C. These data sets will form the low-frequency, Northern hemisphere component of the Global Magneto-Ionic Medium Survey. This is an ongoing international effort to map the entire polarised radio sky over a broad frequency range, yielding unprecedented spatial coverage and Faraday rotation resolution for studying large-scale structures in the magnetized interstellar medium. The maps are already yielding fascinating insights into the Galactic magnetic field structure, and I will summarize some of the early science results.



# Session 1 → 10:45 – 11:45 am

1

## Galactic Fields Revealed: Magnetic Insights from Supernova Remnants

### Larson Scullion

The Galactic magnetic field (GMF) plays a critical role in the formation of stars and the support of the vertical structure of the Milky Way against gravity. However, the precise structure and origin of this magnetic field is still largely unknown in part due to the difficulties involved in measuring it. Since magnetic fields do not produce radiation, information about the GMF must be deduced from their effects on radiation. The most common technique for mapping the GMF is to observe compact sources of polarised light, and to analyze how the angle of polarisation has rotated from the interaction between the light and the GMF. This information allows us to learn details about the GMF throughout the Galaxy, but is inherently restricted to the locations of these sources. Historically, this technique has been performed utilizing polarised emissions from either highly-magnetized pulsar stars in the Milky Way Galaxy or extragalactic radio sources. My work investigates the use of an alternative source of polarised light: supernova remnants (SNRs). These expanding shock waves left behind by supernova explosions also generate polarised radio light that can be used to probe the GMF. By analyzing these SNRs and comparing them to simulated models, I aim to both greatly increase the number of line-of-sight data points for our growing map of the magnetic environment in the Galaxy and create “anchor points” with known distance where the three-dimensional GMF is known. My research focuses on determining the magnetic environment around SNRs within the Milky Way Galaxy by building models of the radio emission from SNRs and comparing them to radio observations. I am using data from both the Effelsberg 100 meter telescope in Germany and the Synthesis Telescope at the Dominion Radio Astrophysical Observatory in British Columbia as part of the Canadian Galactic Plane Survey. In this talk, I will highlight my work in building these computational models, and how they can be used to build on previous survey efforts to produce a more detailed and accurate map of the Milky Way’s magnetic field than previously possible.

2

## Exploring the Principles of Distributed Coding in the Brain

### Farzad Karimi

Recent technological advances have allowed us to simultaneously record brain activity across multiple brain areas with unprecedented level of detail. These recordings have revealed that many brain computations are more distributed than previously thought, suggesting that several brain areas might simultaneously encode and process the same information. This distributed coding may underlie efficient network communication strategies, such as robustness to noise or focal damage, but the degree to which it happens remains uncertain. In this study, we used large-scale recordings of cortical activity of mice performing visually guided decision-making tasks from the Allen Brain Institute to explore the principles of distributed coding in the brain. These datasets consist of multi-unit neuropixel recordings that simultaneously cover most visual cortical areas.

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By exploring the simultaneous recordings across cortical visual areas, we have been able to resolve that the population encoding of visual features differs between them. These differences were observed in the level of the average activity of each population as well as in the average timing of their responses. Differences across areas were also observed when comparing the population variability across different stimuli with the intrinsic trial-to-trial variability for a given stimulus. These results suggest that the connectivity underlying higher-order visual encoding might be in between purely distributed and purely feedforward network architectures. Additionally, we also observed differences in the visual responses across areas based on whether the animal was actively engaged in a decision-making task. Based on this, we decided to further explore the contributions of task-related variables (such as reward) to the activity of individual cells across areas, since these differences could be linked to the encoding of different features, or to the same features encoded in different architectures. We employed several statistical models, including Poisson General Linear Models (pGLM) with ridge regression, to characterize the spiking activity of each cell. Using stimulus onset, spike history, reward time, lick time, running speed and visual stimulus change onset as task variables, we could model their contributions to the activity of each single cell. Although some of the non-sensory task variables barely contributed to the single-cell activity, preliminary data based on the low-dimensional embedding of the population activity across multiple areas, suggests that their information could still be present at the network level.

Revealing the principles of distributed coding might offer new insights into the hierarchy of cortical areas and how information is processed, opening the door for the development of novel brain-inspired machine learning algorithms.

3

## Functional Network Dynamics of Aging

Emma Garrison

The human brain is a complex and dynamical system that undergoes structural and functional changes throughout the lifetime. As the complexities of the human brain during aging are better understood, greater context can be provided to the experiences and challenges as well as understand more about diseases that can affect these populations. Non-invasive imaging techniques such as functional magnetic resonance imaging allow us to measure large scale connectivity of the human brain. The changes to these networks across the lifetime are still poorly understood. My research is developing and testing a model for understanding changes to brain connectivity during aging by constructing functional brain networks from fMRI data at longitudinal time windows across the lifetime. These time points can be analyzed for which factors, either internal or external to the network, are driving change over time. This can lead to greater understanding of the distinction between healthy and patient populations as well as the dynamics of the connections during aging. This will allow us to map how changes in these connections are linked to specific experiences or biomarkers that occur during the lifespan of an individual. These types of dynamics will bring greater insight to the experiences and challenges that occur during human aging and in future, help individuals experiencing neurodegenerative illness.

# Session 1 → 10:45 – 11:45 am

## Illuminating Unique Profiles of Amyloid Deposits in Type II Diabetes Using the Spectrally Active Fluorophore K114

Paula Brandt

Type 2 diabetes (T2D) is anticipated to affect 1.3 billion people globally by 2050. Strict blood sugar control doesn't consistently prevent organ failure, implying factors beyond high blood sugar contribute to complications in these patients. Deposits of misfolded proteins known as amyloid destroy insulin-producing cells in the pancreases of those with T2D, yet the role of amyloid in T2D complications such as kidney disease remains unexplored. Current methodologies used to study amyloid only confirm protein composition, disregarding nuanced conformational features which may be crucial for personalized care. Our lab has developed techniques exploiting spectrally active fluorophores which emit unique spectra based on amyloid conformation. This study assesses the potential of these fluorophores in exploring the link between amyloid and T2D.

Pancreatic sections from autopsies of non-diabetic and T2D patients were stained with the spectrally active fluorophore K114 and imaged using a spectral confocal microscope.

Bright and spectrally red-shifted deposits exhibiting typical features of amyloid-bound K114 were observed in the pancreases of T2D patients. These deposits exhibited remarkable heterogeneity in their colour and brightness, suggesting the existence of many different conformations of amyloid. Clustering algorithms revealed that the majority of amyloid deposits exhibited spectral features that were unique to each individual patient. This underscores the complexity of amyloid formation in T2D and the patient-specific nature of these pathological deposits.

The fluorophore K114 revealed diverse amyloid deposits in T2D pancreases, largely unique to each patient. Further validation could enhance insights into amyloid involvement in T2D, offering potential diagnostic and therapeutic advancements.

# Industry Panel → 12:45 – 1:45 pm

**Dr. Abdullah Khalid | 1QBit**

Abdullah Khalid obtained his PhD from the University of Calgary in 2018, under the supervision of Dr. Barry Sanders. His research was on the design and modeling of quantum optics experiments for quantum information application. After his PhD, he worked at a Astronomy Edutainment startup in Pakistan. For the next three years, he was an assistant professor in the Integrated Science and Mathematics department at Habib University, Pakistan. Since 2023, he has been a Scientist at 1QBit, where he works on designing new age computers. He is currently writing a book on quantum error correction and fault tolerant quantum computing. In his spare time, he is learning to play Tabla.

**Kate Sheehan | Calgary Board of Education**

Kate Sheehan grew up in Halifax and studied chemistry at Acadia University in Nova Scotia. She moved to Calgary to pursue a master's degree in chemistry and nanoscience at the University of Calgary. Upon discovering her love of teaching while working as a TA, she completed a Bachelor of Education and has gone on to teach chemistry, physics, and math at a number of schools across Canada. She also works as a freelance educational video producer, focusing on IB physics. In her spare time Kate enjoys cycling, skiing, hiking, knitting, and painting.

**Dr. Itzel Lucio Martínez | Quantized Technologies Inc.**

Itzel Lucio Martínez is Head of Product at Quantized Technologies Inc. (QTi), a start-up based in Calgary that commercializes quantum cryptography devices. Her role at QTi is to develop next-generation quantum cryptography systems. Itzel holds Master's and Ph.D. degrees in Physics from the University of Calgary, and she is always enthusiastic to apply scientific principles to real-world challenges. As part of her degrees, Itzel performed quantum cryptography experiments across the city of Calgary. Itzel's previous experience include working in the quantum technology industry in Geneva, Switzerland and as data analyst for the World Health Organization.

**Dr. Kalpana Singh | AIMCo.**

Kalpana holds a master's degree in Physics with a specialization in electronics, and she has earned a PhD in Atmospheric Physics. She currently serves as the Director of Internal Audit – Innovation & Advanced Analytics at AIMCo. Leveraging her proficiency in data and advanced analytics, Kalpana has transformed the oversight process, producing novel insights and practical recommendations since her appointment to the Internal Audit team in 2021. Before assuming this role, she played a key role in AIMCo's data management team, spearheading the design and implementation of enterprise data pipelines and contributing to the establishment of robust data governance at AIMCo.

# Session 2 → 1:45 – 3:00 pm

## 1 Benchmarking of universal qudit gates

### David Amaro-Alcalá

We introduce a method for characterising a universal qudit gate set, including controlled T gates. Our scheme and the associated gate set are designed to estimate the average gate fidelity of a T gate. Our approach, when applied to qubits, reduces to the dihedral benchmarking scheme for both single and multi-qudit gates. A novel mathematical identity provides an elegant proof that our scheme is feasible and simple for all dimensions. Our identity links the k-th Bell number, which counts the partitions of a finite set with k elements, to a sum over integer partitions of an integer n greater than k. The implications of our scheme are significant, especially for experimentalists in pursuit of a scheme to characterise a universal gate set. Additionally, the utility of our gate set goes beyond randomised benchmarking, being useful in areas such as the recent shadow estimation technique.

## 2 Searching for Dwarf Galaxies in NGC5128 using Artificial Galaxy Experiments

### Cameron Leahy

Our current cosmological models have been successful at describing many aspects of our universe. However, many mysteries remain and newer observations are challenging the old standards. Some of these challenges center around the distribution of dwarf galaxies in our universe. Dwarf galaxies are small galaxies that contain only a fraction of the mass of galaxies like our Milky Way. Learning more about these galaxies and their distribution in the universe is key to solving many of the current problems in cosmology.

In this project, we plan to go through astronomical images of NGC5128, a giant elliptical galaxy, and develop our own software to detect the dwarf galaxies in the images. NGC5128 is known to be a hotspot for dwarf galaxies, but the distribution and number of dwarf galaxies in the region is still unknown. Detecting such faint objects is not easy, and we will incorporate special techniques into the software, possibly including machine learning. In addition, we will use simulations known as artificial galaxy experiments to learn about how our new software performs on test images we create. This allows us to improve the results of the detection software on the real science images.

In summary, our goal of estimating the dwarf galaxy population of NGC5128 will be achieved by developing specialized dwarf galaxy detection software, running it on our images, and then using artificial galaxy experiments to improve our initial estimate. Obtaining a reliable estimate of the dwarf galaxy population of NGC5128 will contribute significantly towards the building of a more accurate picture of the spatial distribution and dwarf galaxy population in the universe, a picture that is needed to address questions that lie at the heart of cosmology.

3

## Exploring Seismicity Complexity through Squashing Rocks in the Lab

### Omid Khajehdehi

Seismicity, whether natural from tectonic plates, induced by industrial activities, or observed on laboratory faults, is complex due to nonlinearity and long-range spatiotemporal correlations in the Earth's crust. Previous studies reveal spatiotemporal clustering and aftershocks, reminiscent of tectonic earthquakes, in fluid-induced seismicity and seismicity on laboratory faults. Further, ongoing debate persists on the presence or absence of magnitude clustering in seismicity, with implications for improved short-term earthquake magnitude forecasting. Therefore, we utilize laboratory stick-slip experiments to address these challenges and enhance our understanding of seismicity. Our investigation reveals magnitude clustering occurring exclusively during slips on laboratory faults, resulting from variations in frequency-magnitude distributions. This offers valuable insights into complex seismicity dynamics and enhances efforts in fluid-induced seismic hazard assessments.

4

## The Source Awakens: An Unexpected Observation of ASKAP J173608.2--321635 in THOR-GC

### Kierra Weatherhead

With the advancement of telescopes and ever improving surveys of the sky, new objects are constantly being discovered in our Galaxy. Sources which appear in the sky for only a short time before fading from view, known as transients, have been historically difficult to observe. Surveys designed to observe the sky continuously have drastically increased the number of known transient sources. However, these sources can also be observed unexpectedly by other surveys if they appear while observing that region of the sky. In particular, the Galactic center is a promising region for finding variable and transient radio sources due to its high stellar density. The nature of some of these transient sources is unclear, including a class of objects known as Galactic Center radio transients (GCRTs). A recently discovered, highly polarized, probable GCRT, ASKAP J173608.2—321635 was observed serendipitously by the Galactic center extension of the HI/OH/Radio Recombination Line Survey of the Milky Way (THOR-GC). This observation fills a gap where no measurements of ASKAP J173608.2—321635 were previously made and almost triples the observed variability range of its rotation measure, a key value utilized in radio astronomy. I present the THOR-GC observations and examine the unique environment in which ASKAP J173608.2—321635 could exist in to cause the variability of its rotation measure and observed depolarization.

# Session 2 → 1:45 – 3:00 pm

5

## Faraday tomography with CHIME: the ‘tadpole’ feature G137+7

Nasser Mohammed

Faraday rotation influences the structures in the polarized sky at the radio wavelength. Within the Fan region—a portion of the radio sky that stands out in polarized intensity from ~100 MHz to 350 GHz—we find an elongated feature, G137+7. Using the first polarization maps of the Canadian Hydrogen Intensity Mapping Experiment (CHIME), we analyze this feature, dubbing it the ‘tadpole’ due to its ‘head’ and ‘tail’ morphology. Our 400-729 MHz bandwidth and 17' to 30' with CHIME allowed us to perform Faraday synthesis to perform an in-depth case study of the tadpole. The tail extends 10 degrees from the head which is ~2 degrees in diameter, the direction of which suggests the B2(e) star HD 20336 is a candidate for creating this feature through the ionization of the ambient interstellar medium. Investigations of HI and H-alpha find no connection to the tadpole. The head is a coherent feature in Faraday depth (~-8 rad/m^2), and Faraday synthesis identifies multiple Faraday components in both the head and tail. Our results show that our ~octave-bandwidth Faraday rotation observations at ~ 600 MHz are sensitive to low-density ionized and partially-ionized gas; undetectable in other tracers.

# Poster session → 3:00 – 3:30 pm

## Two qutrit entanglement detection via neural network | Mahkame Salimi Moghadam

The Entanglement detection in Quantum systems is one of the key tasks in quantum information science. However, this task is an NP-hard problem. In this paper, we propose a machine learning approach to this problem that can be generalized to higher dimensions. Specifically, we build neural network models that can classify entangled state or quantify entanglement for a two-qutrit system. This is the smallest system where efficient entanglement detection techniques like Positive Partial Transpose cannot classify entangled states perfectly. We also compare our model to convex hull approximation and show that our model is computationally more efficient and more accurate.

## The 0.50 Meter Baker-Nunn Telescope: On the Heels of Leading Minor Planet and Transient Research | Eric Hess

Located in the Foothills of Alberta, the 0.50 meter Baker-Nunn Telescope (RAO-BN) overcomes the challenges of ground-based observations to contribute to modern minor planet and transient research. On cloudy nights, it sits in its protective dome waiting patiently for an opportunity to prove its steel. It takes less than 10 seconds for the RAO-BN's f/1 optics to reach the dimmest objects in the sky. Every image contains more than 19 squared degrees of space—that's enough to fit more than 64 Moons in one image. Small yet mighty, powerful yet reliable, the RAO-BN is currently steered by a small Canadian collaboration, consisting of Rothney Astrophysical Observatory (RAO) Intern E. Hess (University of Calgary) and D. D. Balam (DAO/NRC), courtesy of P. Langill (RAO Director, University of Calgary) and J. Pake (RAO, Chief of Technical Operations). Together, our innovative team continues to find ways of making the telescope more autonomous, and with improvements in computational systems, tease out even the faintest objects from the ground. We're committed to pushing the limits of ground-based observing, keeping us on the heels of current research and modern, cutting edge equipment.

# Session 3 → 3:30 – 4:45 pm

## 1 Towards The First Direct Measurement Of The Lamb Shift In Antihydrogen

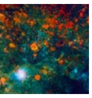
### Abbygale Swadling

The Big Bang is predicted to have produced equal amounts of matter and antimatter, making the apparent lack of antimatter in the universe a mystery. The ALPHA (Antihydrogen Laser PHysics Apparatus) collaboration, based out of CERN, creates antihydrogen to compare and contrast it with hydrogen. This project aims to measure the splitting of the 2S1/2 and 2P1/2 energy levels for the first time in antihydrogen, by driving a transition between the two states with resonant microwave radiation. At zero magnetic field the splitting between 2S1/2 and 2P1/2 is known as the Lamb shift, and it provides highly accurate experimental evidence for the theories of quantum electrodynamics. Measuring the Lamb shift for the first time in antihydrogen allows for the opportunity to either support or contradict these theories with experimental evidence and holds the potential to discover a matter/antimatter difference.

## 2 Black Holes Have Middle Child Syndrome: A Census of Black Holes in Virgo Ultra-Compact Dwarf Galaxies

### Solveig Thompson

Black holes come in a range of masses, from stellar mass that form from the deaths of massive stars and are only a few solar masses, to the supermassive ones over a million times the mass of the sun and are found in all giant galaxies where sought. 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. Competing models of supermassive black hole (SMBH) formation predict different fractions of IMBHs in the universe, but observational challenges in detecting them make it difficult to conclusively narrow down the theories. The key to constraining these formation theories lie in black holes found in low-mass systems such as dwarf galaxies and their related ultra-compact dwarf galaxy (UCD) counterparts which are likely candidates for hosting IMBHs at their core. A central black hole within a UCD suggests that these compact stellar systems were once much larger dwarf galaxies that have had much of their stars stripped away over time. Recently, by pushing ground-based telescopes to their limits a handful of SMBHs were detected in UCDs, indicating that there may be smaller black holes to be found in similar systems. Technological constraints of ground-based telescopes limit observations to only the biggest and brightest targets, severely reducing the population of which to sample. My research uses data obtained by the James Webb Space Telescope (JWST) to search 6 UCDs for central black holes 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 black holes in UCDs will have important implications for competing theories of SMBH formation and evolution, previously inaccessible before the advent of JWST.



# Session 3 → 3:30 – 4:45 pm

## 3 Towards Optically Coherent Nitrogen Vacancy Centers in Diamond Microdisks

### Sean Wilson

Colour centres, defects in the crystal structure of a solid that can absorb and emit light, have applications as qubits in quantum networks. Optically coherent photon emission from colour centres enables the possibility for spin-photon entanglement and subsequent spin-spin entanglement between defects in a lattice, a necessary component for prospective quantum networks. One such example of a potentially useful colour centre is the nitrogen vacancy (NV) centre in diamond. NV centres are defects in the crystal structure of diamond featuring a nitrogen atom and an adjacent vacancy. A long spin coherence time (>1 ms at 300 K) and an optically accessible electron transition make NV centers strong candidates for optically coherent emitters employed in quantum networks. Quantum networks relying on spin-photon entanglement require a high degree of photon indistinguishability. Potential colour centres must therefore produce highly coherent emission. This translates to a narrow linewidth around the emission frequency for a given colour centre. The research presented here involves progress towards the characterization of the emission linewidth of nitrogen vacancy centres in diamond microdisks using photoluminescence excitation (PLE) spectroscopy. This progress includes the construction of a new optical configuration to perform PLE spectroscopy, identification of NV centres in diamond microdisk samples using confocal microscopy, and initial measurements of emission linewidth. Ultimately, we hope to determine whether NV centres have the potential to be employed as qubits in quantum networks, with applications ranging from quantum information to quantum computing.

## 4 Pushing the Boundaries of X-ray Brilliance with Free-Electron Lasers

### Jonah Richards

With applications across material science, chemistry, and medicine, X-ray diffraction has been an instrumental research tool for gaining insight into atomic and molecular structure. For over 100 years, researchers have been working to develop better and brighter X-ray sources, from early X-ray tubes to current-generation synchrotron light sources. The culmination of this technological evolution are accelerator-driven free-electron lasers. The European X-ray Free-Electron Laser (XFEL) is one of the most advanced in the world. A high-energy electron beam is undulated to produce ultra-bright and ultra-short X-ray pulses at brilliances orders of magnitude higher than previous generation light sources. X-ray flashes of various properties can be generated for a wide array of diffraction applications across many disciplines. As a major scientific milestone, the incredible brightness and brevity of pulses generated by XFELs has pushed research into the realm of single-molecule imaging.

# Session 3 → 3:30 – 4:45 pm

## Mood Changes Across the Menstrual Cycle

### Alison Frayne

This project is based on the hypothesis that the changes in hormone levels during a woman's menstrual cycle contribute to the increased rate of affective disorders in women compared to men. The hormone levels may affect the connectivity in the brain. Functional neural networks were constructed from the brain scans of 17 menstruating women taken at three time points in their menstrual cycle. Network and complexity science tools were used to analyze these neural networks to determine changes in the connectivity between regions of the brain - specifically the Default Mode Network and Frontoparietal Network - over the menstrual cycle. These two networks contribute to emotions, mood, and self-referential thinking.

Functional neural networks are composed of nodes and edges. Nodes are anatomical regions, and edges represent two nodes being active at the same time during the scan. Tightly connected nodes make up a network that represents functional networks. Focusing on a subset of the brain nodes that are highly connected (hub nodes), patterns within the brain networks can be deconvoluted. The hub nodes are divided into provincial hub nodes (mainly connected to nodes in their same network) and connector hub nodes (highly connected with nodes of different networks). The analysis demonstrated that the Default Mode and Frontoparietal networks were more connected when menstrual hormones were elevated. Specifically, the connector hub of the Default Mode and Frontoparietal networks have statistically significant connectivity changes over the menstrual cycle, indicating a temporary change in the neural network. Similar connectivity patterns have been associated with affective disorders, specifically major depressive disorder.

# 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).