# McGill Quantum Centre

McGill University

# MQC CONFERENCE

## QUANTUM MATTER
## QUANTUM OPTICS AND PHOTONICS
## QUANTUM INFORMATION

**OCT 13 - 14 2026**

**Trottier Auditorium**
**McGill University, Montréal**

## *Conference Program* *(Program may be subject to small changes.)*

# Tuesday, October 13

| TIME | SESSION / SPEAKER | TALK TITLE |
|---|---|---|
| 9:00–9:20 | Arrival and Light Breakfast | — |
| 9:20–9:30 | Opening Remarks | — |
| 9:30–10:30 | **Prof. Andrea Young** | *Superconductivity and magnetism in crystalline graphite allotropes* |
| 10:30–11:00 | Coffee Break | — |
| 11:00–12:00 | **Prof. David Sénéchal** | *Superconductivity from strong electron correlations: universality and specificity* |
| 12:00–12:30 | **Rodrigo Paulino (student speaker)** | *Unconventional Nonlinear Dynamics of the Charge Density Wave Amplitude Mode in $EuTe_4$* |
| 12:30–13:30 | Lunch | — |
| 13:30–14:30 | **Prof. Kiyoul Yang** | *Optical gain and nonclassical light on a chip: Towards quantum control and interconnects* |
| 14:30–15:00 | Coffee Break | — |
| 15:00–16:00 | **Prof. Benjamin Sussman** | *Ultrafast Quantum Photonics: Beating Decoherence with Fast Light Pulses* |
| 16:00–16:30 | **Polina Blinova (student speaker)** | *Critical quantum metrology in the output of an optical parametric oscillator* |
| 16:30–18:45 | Poster Session | — |
| 19:00–22:00 | Banquet Dinner | — |

## *Conference Program*

# Wednesday, October 14

| TIME | SESSION / SPEAKER | TALK TITLE |
|---|---|---|
| 9:00–9:30 | Light Breakfast | — |
| 9:30–10:30 | **Prof. Jacob Biamonte** | *Composing quantum mechanics* |
| 10:30–11:00 | Coffee Break | — |
| 11:00–12:00 | **Prof. Stefania Sciara** | *Harnessing time-bin entanglement for quantum communications* |
| 12:00–12:30 | **Valentin Boettcher (student speaker)** | *Emulating non-Markovian system-bath dynamics with parametrically driven cavities* |
| 12:30–12:40 | Closing Remarks | — |
| 12:40–13:30 | Lunch | — |

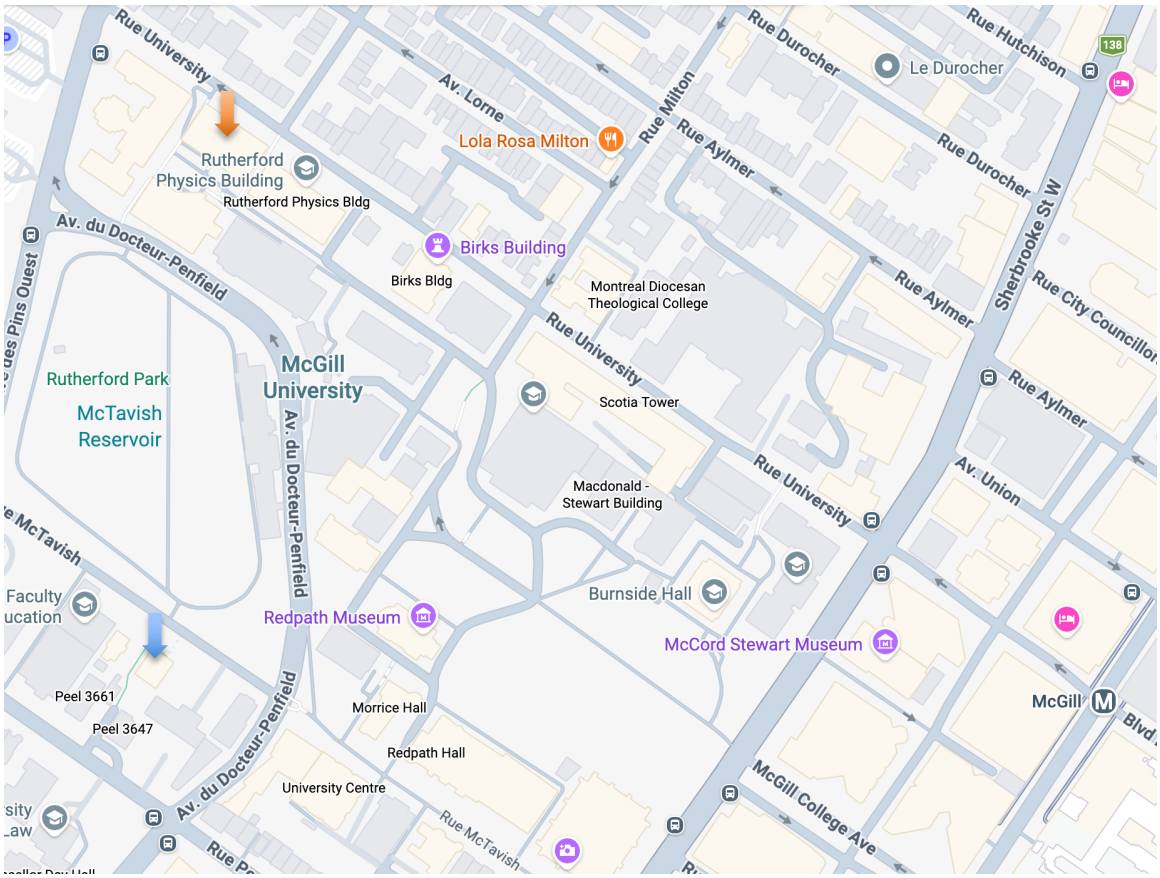
# *Venue & Directions*

## Conference Hall

Trottier Auditorium, Lorne M. Trottier Building, 3630 Rue University, Montréal. ***(Orange arrow)***

## Banquet Dinner

Thomson House, 3650 Rue McTavish, Montréal. ***(Blue arrow)***






MQC CONFERENCE 2026

# *Talk Abstracts*

## Superconductivity and magnetism in crystalline graphite allotropes

**Andrea Young**

UC Santa Barbara

**Abstract**

I will describe the physics of graphite crystals with rhombohedral stacking, where the competition between electron hopping within- and between- the graphene planes leads to a flat electronic dispersion and the crystallinity leads to a near total absence of disorder. The high electronic density of states and Berry curvature—-both of which can be tuned by a perpendicular electric field—lead to a dizzying variety of magnetic and superconducting states, often within the same device, while the high experimental reproducibility enabled by the crystalline nature of these structurally simple systems allows us to investigate a variety of correlated electron phenomena. I will focus on our efforts to use scanning nanoscale magnetometry to probe the nature and origins of magnetism and unconventional superconductivity, as well as the fate of the correlated electron liquid at high temperatures.

## Superconductivity from strong electron correlations: universality and specificity

**David Sénéchal**

Université de Sherbrooke

**Abstract**

Cuprates are the prototype of strongly correlated materials: partially filled d-shell orbitals at the Fermi level are beyond what density-functional theory can handle. Superconductivity in these materials arises from strong electronic correlations instead of electron-phonon interactions. A universal explanation of superconductivity in cuprates can be found in simple models, such as the one-band Hubbard model or the three-band Emery model. They capture universal features: d-wave pairing driven by short-range antiferromagnetic fluctuations, with Tc tied to superexchange. But properties specific to each material cannot be explained by these simple models: the full electronic structure is needed, and this may be accomplished by combining density-functional theory with dynamical mean-field theory. This is an ambitious and complex endeavor that we will illustrate in the case of some multilayer cuprates.

## Unconventional Nonlinear Dynamics of the Charge Density Wave Amplitude Mode in $EuTe_4$

**Rodrigo Paulino**

McGill University

**Abstract**

A charge density wave (CDW) is an ordered macroscopic state driven by strong electron-lattice coupling, creating a periodic charge density modulation. Its complex order parameter hosts dynamic amplitude and phase excitations. In non-centrosymmetric materials, the so-called Higgs amplitude mode becomes infrared-active, and strong terahertz (THz) electric fields can resonantly drive this mode into a highly nonlinear regime, probing the CDW potential's anharmonicity. Previous efforts to modulate the order parameter focused on superconductors, where the amplitude mode is degenerate with the superconducting gap, inherently entangling the resulting dynamics. The quasi-2D material $EuTe_4$ offers an ideal platform to isolate these dynamics, as its non-centrosymmetric structure hosts an exceptionally robust CDW state with a transition temperature exceeding 600 K. Using in-house-grown $EuTe_4$ single crystals, we use room-temperature reflection-mode THz spectroscopy to identify the IR-active phonons and collective CDW modes. To explicitly probe their anharmonicities, we deploy two-dimensional THz (2D THz) spectroscopy. By applying a pair of intense, time-delayed, phase-locked THz pulses, this technique drives the material out of equilibrium and effectively isolates the dynamics of weak nonlinear signatures from the dominant linear background. At ~100 kV/cm peak fields, preliminary 2D spectra reveal a pump-probe nonlinear response scaling independently of the driving field amplitude. This diverges directly from the perturbative dynamics of a standard anharmonic order parameter potential, which would typically yield a linear or quadratic pump dependence for second- or third-order nonlinearities, respectively.

## Optical gain and nonclassical light on a chip: Towards quantum control and interconnects

**Kiyoul Yang**

Harvard University

**Abstract**

In this presentation, we will explore optical gain and nonclassical light in integrated photonics, spanning rare-earth lasers and amplifiers as well as nonlinear parametric processes. These approaches enable the generation and transduction of nonclassical light, while rare-earth photonics offer promising building blocks towards quantum control at scale. We will also highlight recent advances in computational methods that extend our ability to design and simulate large-scale photonic integrated circuits. Together,

these developments point toward scalable chip-based systems for quantum control and interconnects.

## Ultrafast Quantum Photonics: Beating Decoherence with Fast Light Pulses

**Benjamin Sussman**

NRC & University of Ottawa

**Abstract**

Ultrafast optical pulses - femtoseconds to picoseconds in duration - are of interest for quantum processing due to their potential to encode information in brief time-bins, beating rapid decoherence. The development of essential components for optical quantum technologies will be discussed, including a single photon switch based on the optical Kerr effect in single-mode fibres and a single photon memory based on fibre cavities. The switch controls single photon routing without adding noise, while the memory addresses a key scaling challenge by temporarily storing quantum states without loss of coherence, enabling quantum process synchronization. Application of these components in photonic quantum processing and quantum sensing will be discussed, including random walks and more general processing, as well as quantum enhanced ranging and approaches to imaging and spectroscopy using correlated photons.

## Critical quantum metrology in the output of an optical parametric oscillator

**Polina Blinova**

McGill University

**Abstract**

Many quantum sensors infer parameters from continuously emitted fields, yet unmonitored loss can obscure how much critical enhancement remains accessible at the output. We calculate the frequency-resolved output quantum Fisher information (QFI) of a stationary vacuum-seeded optical parametric oscillator for cavity-detuning estimation. We show that, for any fixed nonzero unmonitored loss, the peak sideband-pair QFI grows quadratically with intracavity photon number near threshold, but its bandwidth shrinks inversely with that number, leaving the integrated QFI rate linear. We identify a far-detuned near-threshold regime where the monitored output alone asymptotically reaches the loss-imposed joint cavity–output information rate bound. We show that critical operation asymptotically attains the same optimal information rate as passive coherent sensing at fixed intracavity population, but with different requirements on drive power, pump stability, and measurement time. We further identify operating points that maximize the output QFI rate per intracavity photon and a frequency-resolved homodyne strategy that can approach the output QFI. Our

results connect critical enhancement to accessible output information, providing concrete guidance for the design and readout of dissipative parametric sensors.

## Composing Quantum Mechanics

**Jacob Biamonte**

ÉTS

**Abstract**

Physics explains complicated things by composing simpler ones. Quantum mechanics makes composition itself surprisingly difficult. Obstructions to composition have shaped my two-decade effort to understand and reason with quantum systems. Along the way, the structures developed to overcome them acquired names: ground-state spin logic, ZX Hamiltonians, categorical tensor networks, and graphical normal forms for quantum states. Each framework solved a concrete problem. Yet beneath them runs a single question at the heart of the classical–quantum divide: how can parts be joined without losing the structure that gives the whole its meaning? The recent Quantum Composition Paradox brings this broader question into focus. Quantum amplitudes compose, but the probabilities assigned by the Born rule can discard the phases—and therefore part of the genealogy—that produced them. Composing amplitudes before applying the Born rule can give a different result from applying the rule at each stage and then composing the resulting probabilities. I classify when probabilities inherit the composition of amplitudes and when restarting from an intermediate boundary changes the history of a process. This opens a space to reflect on a new quantum theory of music. Operations become notes, genealogically consistent patterns of composition define rhythm, and an intermediate cue can change not only what comes next, but the history we hear.

## Harnessing time-bin entanglement for quantum communications

**Stefania Sciara**

ÉTS

**Abstract**

Photonic entanglement is a at the core of quantum physics and its applied technologies. The capability of generating, distributing, and detecting entanglement is at the basis of several quantum communications protocols like quantum state teleportation and quantum memory devices, where entanglement can be transferred between quantum platforms of different natures like flying qubits (photons) and stationary qubits (nuclear or electron spins). In quantum key distribution (QKD) protocols, the generation and distribution of entangled photons enables device-independent schemes, meaning that two or multiple users can share secret keys without the need to trust either the photon source or their measurement device. Encoding quantum information into a photon's arrival time, a method known as time-bin

encoding, offers a highly practical approach for quantum communication networks, as photons' time bins can be easily generated, processed, and transmitted using standard, commercially available fiber-optic architecture with low decoherence. To fully unlock the benefits of time-bin encoding, it is crucial to develop interferometers that can deliver high phase stability, efficiency, and precise time accuracy, and high efficiency. This talk presents different frameworks used as interferometric schemes for scalable time-bin entanglement generation and processing. The first optical framework consists of a synthetic temporal photonic lattice implemented on a fully fiber-based loop system. The other framework consists of a cascade of on-chip interferometers enabling the generation and processing of ultrafast time-bin entangled photons. Notably, this system was used to demonstrate the first entanglement-based QKD scheme extended to qudits. This work shows that multi-level entangled photons (qudits) lead to enhanced secret key rates, loss resilience, and security with respect to the two-level counterparts (qubits). It further enables the telecom-ready usage of quantum information processing and demonstrates the significant potential of time-bin entangled photonic systems to achieve high data rates and security levels for a variety of quantum communication protocols in optical fiber links over long distances.

## Emulating non-Markovian system-bath dynamics with parametrically driven cavities

**Valentin Boettcher**

McGill University

**Abstract**

We introduce and characterize a scheme for emulating non-Markovian quantum system-bath dynamics using the discrete electromagnetic field modes of a parametrically driven cavity. In this scheme, the character of a bosonic bath (the form of the bath spectral density) is tied directly to the shape of the real-time waveform describing periodic parametric cavity modulation. As an explicit example, we demonstrate the feasibility of this scheme for a fiber-loop experiment with currently achievable parameters, supported by numerical simulations and analytical estimates. In particular, we show that a localization transition of the spin-boson model can be accurately emulated in this fiber-loop cavity system. This localization effect is characterized by a sharp transition from partial decay to complete decay for a two-level system coupled to a bosonic bath as the bath spectral density $J(\omega) \propto \omega^s$ is continously tuned from the sub-ohmic ($s < 1$) to the super-ohmic ($s > 1$) regime. The scheme presented here can enable the realization of a modular platform for engineering custom non-Markovian baths, with potential applications in quantum thermodynamics, thermalization of many-body systems, and resource-efficient quantum simulations of open quantum systems.

# *Poster Abstracts*

## P01 Nanoscale defects as probes of time reversal symmetry breaking

**Presenter: Suman Jyoti De**

Affiliation: McGill University

**Supervisor: Tami Pereg-Barnea**

**Abstract**

Nanoscale defects such as Nitrogen Vacancy (NV) centers can serve as sensitive and non-invasive probes of electromagnetic fields and fluctuations from materials, which in turn can be used to characterize these systems. Here we specifically discuss how NV centers can probe time-reversal symmetry breaking (TRSB) phenomena in low-dimensional electronic systems. We argue that the difference in relaxation rates $\Gamma_{\pm\hat{z}}$ of NV centers starting from m = ±1 spin states to the ground state with m = 0 directly probes TRSB. The effect arises from the difference in the fluctuation spectrum of left and right-polarized electromagnetic fields emanating from such materials. In the quantum Hall setting, the NV center experiences (nearly zero) large additional contribution to its relaxation due to the presence of the material when its magnetic dipole (anti-) aligns with the external field. More generally, the difference in the relaxation rates is sensitive to the imaginary part of the wave-vector dependent Hall conductivity. We argue that this can be used to determine the Hall viscosity, which can potentially distinguish candidate fractional quantum Hall states and be used to infer the pairing angular momentum in TRSB superconductors. We compute the average relaxation rate $[\Gamma_{+\hat{z}} + \Gamma_{-\hat{z}}]$ near thin film superconductors and find that it exhibits a Hebel-Slichter like enhancement below $T_c$. The difference $\Gamma_{+\hat{z}} - \Gamma_{-\hat{z}}$ also inherits this peak but is only non-zero for $T < T_c$ and only if the superconductivity is chiral. We provide concrete estimates for observing this effect in stacked twisted Bismuth strontium calcium copper oxide (BSCCO).

## P02 Parameter Estimation with Adaptive Control for Noisy Spin Qubits

**Presenter: Noah Pinkney**

Affiliation: McGill University

**Supervisor: Bill Coish**

**Abstract**

Efficient Hamiltonian parameter estimation protocols are needed to calibrate spin qubits in semiconductor quantum dot devices. For example, two parameters (the strength of the exchange interaction and a Zeeman energy difference) must be estimated before performing a two-qubit gate for Loss-DiVincenzo (spin-½) qubits to achieve good performance. For hole-

spin qubits, determining g-tensor elements is another relevant multiparameter estimation problem. Natural strategies for parameter estimation involve a sequence of (either adaptive or non-adaptive) preparations, free evolutions, and measurements. These strategies can be effective for determining a single parameter (e.g., the qubit Larmor frequency), but for two-parameter problems (e.g., determining both the magnitude and direction of an effective magnetic field), they are inefficient in terms of the number of measurements required to reach a target uncertainty. Improved strategies that take advantage of additional interstitial control pulses between preparations and measurements can reach much higher efficiency, approaching one bit of information per measurement. We consider such “information amplification” protocols where the number of interstitial control pulses is selected adaptively conditional on the past measurement history and where the control parameters are subject to noise.

## P03 Fisher-information training of optical sensing front ends from natural fluctuations

**Presenter: Abhinav Sinha**

Affiliation: McGill University

**Supervisor: Kai Wang**

**Abstract**

Fisher-information-based optimization of programmable optical front ends in situ generally requires a response model or parameter-labeled measurements. We show that natural parameter fluctuations can instead provide the training signal. We construct proxies for the Fisher information (FI) of one parameter and the prior-weighted FI spectrum of multiple parameters from measured covariances after subtracting conditional detection noise, assuming locally affine responses. We use simulated photon counts from two incoherent point sources to train a mode sorter that approaches the quantum limit for separation and the Nagaoka--Hayashi single-copy bound for joint centroid--separation estimation. We demonstrate count-only updates that require no instrument response model and achieve performance comparable to model-based gradients. Our results provide a route to adaptive optical measurements without controlled parameter scans.

## P04 Light-induced asymmetric Pseudogap below TC in cuprates via TR-ARPES

**Presenter: Dario Armanno**

Affiliation: INRS

**Supervisor: Fabio Boschini**

**Abstract**

The possibility of optically driving ultrafast phase transitions paves the way for the dynamical study and control of the electronic properties of quantum materials [Boschini, Rev. Mod. Phys. 96, 015003 (2024)]. To this end, time- and angle-resolved photoemission spectroscopy (TR-ARPES) offers direct access to the transient evolution of different phases of strongly correlated materials, such as copper oxides. Since their discovery, one of the foremost challenges has been to fully understand the origin of both the d-wave long-range superconductivity (SC), together with the still enigmatic pseudogap (PG) phase. The latter is characterized by a partial suppression of spectral weight at the Fermi level, that is evident above the superconducting critical temperature (TC) over a broad range of doping levels. One of the key open questions include how SC emerges alongside and competes with the PG. Here, we use TR-ARPES with mid-infrared laser light excitation capabilities [Longa, Opt. Express 32, 29549-29557 (2024)] on optimally doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) to disrupt superconductivity in an ultrafast fashion and expose a transient, non-thermal state transitioning from a SC-like to an asymmetric PG-like density of states.
This work challenges the paradigm that superconductivity emerges by establishing phase coherence on the pseudogap phase. Supported by phenomenological theory, our results represent a direct probe of the SC-PG competition, yielding essential information on the nature of the ground state of cuprates superconductors.

## P05 Generalised all-optical correction and Kerr-based preparation of the cat code

**Presenter: Ari Boon**

Affiliation: Polytechnique Montreal

**Supervisors: Nicolás Quesada, Olivier Landon-Cardinal**

**Abstract**

We have shown that a simple optical circuit can be used to correct loss in the higher orders of the cat code, with higher-order cats showing significant improvements over their standard two-component (first-order) counterparts. For a channel with 1 dB of loss, the third-order cat requires 70 times fewer correction stages than a first-order cat, albeit at a 3.6 times increase in the required mean photon-number. This savings in resources requires the ability to generate these many-component states, for which little literature exists. Thus as a follow-up, we have devised multiple generalisable protocols that produce high-quality many-component cat states and their Bell counterparts, relying on Kerr gates applied to coherent state resources.

## P06 Quantum Limits and Information Retention in Few-Channel Thermal Measurements

**Presenter: Justin Bourdignon**

Affiliation: McGill

**Supervisor: Kai Wang**

**Abstract**

Thermal radiation encodes information about an object's temperature and emissivity across its emitted spectrum. Fully spectrally resolved detection can extract this information efficiently, but thermal imaging often requires a trade-off between spatial and spectral resolution under a limited detector-channel budget. This motivates the question of how much Fisher information is lost under spectral coarse graining, and how rapidly finite-channel measurements approach the available quantum precision benchmark as the number of channels increases.

Starting from a quantum-state description of thermal radiation, we analytically derive the symmetric logarithmic derivatives and quantum Fisher information matrix for joint estimation of temperature and emissivity. Treating emissivity as a nuisance parameter, we formulate the effective Fisher information available for temperature estimation and obtain an analytical measure of information retention under spectral coarse graining. In particular, we relate the Fisher information lost by grouping spectral modes into finite bins to the variance of the relevant SLD eigenvalues within each bin, providing a direct criterion for how spectral resolution should be allocated. We then optimize the spectral-bin boundaries to maximize the retained effective Fisher information.

We find that a relatively small number of appropriately chosen spectral channels can retain a large fraction of the information available from spectrally resolved detection. As the emissivity model becomes more flexible and introduces additional nuisance parameters, more spectral structure is required to distinguish temperature variations from changes in material response. These results provide an information-theoretic framework for designing compact thermal measurements that balance estimation precision against detector complexity.

## P07 Chemically Programmable Negative Hole-Migration Barriers on $TiO_2$

**Presenter: Nuray Basaran**

Affiliation: École de technologie supérieure

**Supervisor: Omur E. Dagdeviren**

**Abstract**

Charge migration in metal-oxide semiconductors is often described by thermally activated transport; however, reactive surfaces can reorganize carrier motion through facet and stoichiometry-dependent defects and adsorbate interactions. Here, we use time-resolved atomic force microscopy to resolve hole-migration dynamics on rutile $TiO_2$(111) under temperature variation, high-energy ultraviolet (UVC) irradiation, and alcohol exposure. Pristine $TiO_2$(111) exhibits an apparent negative effective migration barrier, revealing a mobility-controlled, defect-coupled regime rather than conventional thermally activated hopping. UVC irradiation modifies the barrier, indicating that photoinduced surface oxygen vacancies reorganize, but not simply activate, the migration landscape. Alcohol adsorption preserves the negative-barrier response while making it chemically selective: both ethanol and methanol produce a nearly UVC-insensitive barrier, whereas methanol drives the barrier to more negative values. Our measurements show that ethanol and methanol are not equivalent hole scavengers on $TiO_2$(111). More broadly, these results demonstrate that $TiO_2$ charge migration can be programmed at the surface through facet selection, irradiation, and adsorbate chemistry.

## P08 Room-temperature Phonon Localization in GaAs/AlAs Superlattices revealed by THz spectroscopy

**Presenter: Defi Junior Jubgang Fandio**

Affiliation: McGill University

**Supervisor: Samuel Huberman**

### Abstract

Phonon localization, the spatial confinement of vibrational modes in disordered materials, has recently been predicted and observed in GaAs/AlAs superlattices (SLs) at cryogenic temperatures. The inclusion of ErAs nanodots on the surface of the GaAs/AlAs interfaces provides strong scattering and destructive interference events, leading to the localization of some specific modes. Most experimental techniques harnessing phonon localization are limited to low temperatures and rely on the overall SL thermal conductivity without a clear identification of the localized modes. In this work, we use THz time-domain spectroscopy (THz-TDS) to study room-temperature phonon localization in ErAs-doped GaAs/AlAs SLs. We report an experimental decay in phonon modal transmission with superlattice thickness in the 0.7 - 1.7 THz range. This behavior is consistent with the localization of phonons as they propagate along the SLs' growth direction. First-principles calculations also agree with these results, as they show that room-temperature localized modes scatter with a characteristic length $\xi$ smaller than the mean free path of propagating modes. Our results also show that the corresponding $q \cdot \xi$ values are consistent with disorder-induced phonon localization. Our results also demonstrate THz-TDS as an alternative method to access mode-resolved thermal phonon transport in quantum materials.

## P09 Camera-Based 2D ODMR Mapping of NV Centers for Quantum Sensing

**Presenter: Atefe Safinezhad**

Affiliation: ETS

**Supervisor: Bora Ung**

**Abstract**

Nitrogen-vacancy (NV) centers in diamond are a promising platform for quantum sensing because their spin states can be read out at room temperature using optically detected magnetic resonance (ODMR). In conventional ODMR measurements, the fluorescence signal is often collected from the entire sensing area, which does not show how the ODMR response varies across the sample. In this work, we use a scientific CMOS camera to perform spatially resolved ODMR measurements from an NV-containing sample.

Camera-based NV sensing uses a wide-field optical setup to image a whole two-dimensional area at once. By projecting the red photoluminescence from an ensemble of NV centers onto a camera sensor, the fluorescence response can be measured simultaneously at many spatial locations instead of scanning point by point. During the measurement, the microwave frequency is swept across the NV resonance while fluorescence images are recorded. The images are then divided into smaller regions, and an ODMR spectrum is extracted from each region. This allows the generation of a two-dimensional map of the ODMR contrast across the sample.

This approach is particularly beneficial for imaging because it enables parallel detection over a large field of view and reveals spatial variations in the NV response. It therefore provides a practical route toward wide-field quantum imaging and future spatial mapping of local magnetic-field, electric-field, or temperature distributions.

## P10 Multipartite entanglement in monitored fermion many-body systems

**Presenter: Aidan Marcelissen**

Affiliation: McGill University

**Supervisor: Tami Pereg-Barnea**

**Abstract**

Quantum many-body systems subject to random monitoring produce measurement-induced phase transitions (MIPTs). This quantum critical point constitutes a new state of matter, with applications across quantum communication and error correction. MIPTs at criticality demonstrate long-range entanglement, mapping to classical percolation theory in select cases. In fermionic MIPTs, unitaries are restricted by parity preservation. The very notion of entanglement is further modified in the fermionic picture, as quantum operations such as the partial trace and partial transpose must further preserve parity. Consequently, in unitary, charge-conserving (U(1)) Dirac fermionic conformal field theories (CFTs), fermionic entanglement $\mathcal{N}^{f}_{k}$ is larger in magnitude, and in the bipartite case, has no sudden-death at increased distance. This project seeks to determine how fermionic parity changes the critical scaling and spatial structure of entanglement in monitored interacting circuits. Via data scaling collapse of the ancilla entropy we determine $p_c \approx 0.335$ and identify our fermionic model to reside in the parity-preserving Haar universality class. We further recover constant bipartite entanglement probability at long range, upper-bounded but not identical to the rate of percolation. We explain these classically connected but bipartite separable ``gap states'' by finding the fermionic genuine multipartite negativity of these states when one or more qubits are retained in their subsystem.

## P11 Multiple Light-Induced Topological Transitions and Spin Splitting with Interatomic Spin–Orbit Coupling

**Presenter: Runhan Li**

Affiliation: University of Sherbrooke

**Supervisor: Maia Garcia Vergniory**

**Abstract**

Floquet engineering provides a versatile platform for realizing and manipulating diverse exotic topological phases inaccessible in equilibrium. This method has not only facilitated the manipulation of topological phases in quantum materials but also broadened our understanding of quantum systems under periodic fields. Here, we demonstrate that the irradiation of circularly polarized light can induce spin-degeneracy breaking in a class of buckled monolayer materials, thereby triggering band closing-and-reopening processes that further generate new topological phases. Based on first-principles calculations, we demonstrate light-induced topological phase transitions among the quantum spin Hall (QSH) state, the quantum anomalous Hall (QAH) state with high Chern numbers, and higher-order topological phases in 2D group-V monolayers. In particular, a higher-order topological insulator undergoes successive transitions with the Chern number changing from C = 0 to C = 1 and then to C = 2, whereas a QSH state evolves directly into a Chern insulator with C = 2. To better understand the microscopic mechanism, we build an extended Slater–Koster tight-binding model for honeycomb lattices that incorporates both onsite and interatomic spin–orbit coupling (SOC). A minimal symmetry-constrained Floquet k·p model further reveals distinct contributions of onsite and interatomic SOC to the light-induced spin splitting.

This study realizes multiple phase transitions between two-dimensional topological states via Floquet engineering, paving the way toward artificial topological materials.

## P12 Direct observation of chiral phonons in monolayer $MoS_2$ with ultrafast phonon diffuse scattering

**Presenter: malik lahlou**

Affiliation: McGill

**Supervisor: Bradley Siwick**

**Abstract**

Ultrafast electron diffraction and diffuse scattering (UED(S)) enables direct measurement of non-equilibrium structural dynamics in materials with femtosecond resolution. In pump–probe experiments, an optical pulse disturbs a material out of its equilibrium state, initiating a collective excitation, then a time-delayed electron pulse measures transient changes in diffraction intensity, providing a reciprocal-space map of the evolving lattice. Here, UEDS is used to uncover signatures of vibrational dichroism in monolayer Molybdenum disulfide, a two-dimensional transition metal dichalcogenide (2D-TMD). By exciting the material at the band gap with left and right-handed circularly polarized light, carrier are selectively excited into a single K valley. We show the first observation of the momentum-valley polarized phonon distribution correlated with the carrier valley depolarization.

## P13 Disorder Beyond Phenomenology: Calculating Response Functions in Disordered Quantum Systems

**Presenter: Jonathan Discenza**

Affiliation: Concordia University

**Supervisor: Saurabh Maiti**

**Abstract**

Disorder plays an important role in determining the experimentally observed properties of quantum materials. However, its effects on measurable observables are often introduced phenomenologically, for example through effective scattering rates or broadenings, rather than derived directly from a microscopic description of disorder. In this work, I develop numerical approaches for calculating observables in disordered electronic systems from microscopic models, with particular emphasis on superconductors.

Starting from disorder-averaged Green's functions, I evaluate correlation functions relevant

to spectroscopic measurements while accounting explicitly for impurity scattering and its effect on quasiparticle dynamics. Particular attention is given to vertex corrections, which describe repeated impurity scattering and can qualitatively modify the resulting response. These methods provide a framework for studying quantities such as optical conductivity, and Raman spectroscopy, in both normal and superconducting states.

By comparing clean and disordered limits, this approach makes it possible to determine how disorder modifies, broadens, or generates features in experimentally measurable spectra. More broadly, the work aims to establish a microscopic framework for connecting models of disorder and many-body physics directly to experimental observables.

## P14 Engineering an Altermagnet in a Heterostructure of $FeSe^{+}$ Cuprate

**Presenter: Augustin Davignon**

Affiliation: Université de Sherbrooke

**Supervisor: Maia G. Vergniory**

**Abstract**

Altermagnetism is a new form of collinear antiferromagnetism that combines the spin-split electronic bands expected in ferromagnets with a zero net magnetic moment, characteristic of antiferromagnets.
These combined properties are of great interest for spintronic applications; consequently, methods for inducing altermagnetism in real materials are attracting considerable attention. For instance, the pursuit of altermagnetism has recently extended to the Lieb lattice of cuprates. However, realizing such states via oxygen magnetism remains a challenge. Here, we propose an alternative pathway by engineering an altermagnet in the heterostructure of two 2D superconductors, consisting of a cuprate layer and FeSe, where Cu and Fe atoms form a $CuFe_2$ Lieb lattice.

## P15 Charge-density wave phase diagram of $CsV_3Sb_5$ under pressure

**Presenter: Iñaki Agraso**

Affiliation: University of the Basque Country (UPV/EHU)

**Supervisors: Ion Errea, Maia G. Vergniory**

**Abstract**

The recently discovered family of Kagome metals $AV_3Sb_5$ (A=k, Rb, Cs) have arisen as an excellent platform to study the interplay between charge-density wave (CDW) transitions, non-trivial topology, spontaneous time-reversal symmetry breaking and superconductivity.

Although the ambient-pressure CDW phase has been understood through quantum anharmonic effects, its evolution under pressure remains unresolved. In $CsV_3Sb_5$ a pressure-induced suppression of the CDW is observed, together with a double-dome-like behaviour of the superconductivity, suggesting an unusual interplay between the CDW and superconductivity. In this work we combine a non-perturbative treatment of anharmonicity from first principles with fine-tuned machine learning interatomic potentials to study the evolution of the CDW phase under pressure. Our results correctly predict the suppression of the CDW under pressure, capturing the complete suppression at 2 GPa in close agreement with experiments. Our work highlights that quantum ionic and anharmonic effects are fundamental to accurately describe the quantum phase diagram of Kagome metals.

## P16 A Single-Particle Picture of Charge Localization

**Presenter: Théo Dionne**

Affiliation: Université de Sherbrooke

**Supervisor: Maia Vergniory**

**Abstract**

A natural characterization of insulators is provided by the localization of electric charge. However, most formulations broadly applicable to materials rely on noninteracting band structures, hindering their use for strongly correlated electrons. Using the analytically solvable SSH+HK model, we develop a symmetry-forward framework based on the single-particle Green's function. We show that effective atomic limits extracted from occupied symmetry-resolved spectral weight reproduce the charge-center displacement implied by the spin-resolved polarization of correlated insulating phases. The quantum volume of single-particle reduced density matrices provides a complementary geometric perspective of one-body state space. Together, these results suggest a route to diagnosing interacting charge localization using numerically accessible single-particle quantities.

## P17 Phase-sensitive Hong–Ou–Mandel interferometry for birefringence sensing

**Presenter: Mohammad Khalilikelaki**

Affiliation: Université du Québec - Institut national de la recherche scientifique [INRS-EMT]

**Supervisor: Bienvenu Ndagano**

**Abstract**

We present a phase-sensitive quantum-sensing protocol based on Hong–Ou–Mandel (HOM) interferometry. Conventional HOM measurements probe photon indistinguishability through coincidence dips and peaks but are insensitive to a common optical carrier phase. Here, we exploit the relative phase of polarization-entangled biphoton states to encode sample-induced birefringence in polarization-resolved coincidence measurements.

In our implementation, HOM interference and coincidence post-selection generate polarization-entangled photon pairs. A birefringent sample placed in one output arm introduces a relative phase between the polarization components, continuously changing the contributions of symmetric and antisymmetric polarization superpositions. Output polarization analyzers convert this state evolution into measurable coincidence modulation. Coincidence events are recorded using two individual single-photon avalanche diode (SPAD) detectors under four polarization projection settings.

A four-step phase-shifting reconstruction algorithm combines normalized coincidence measurements in complementary linear and circular polarization projections to retrieve the sample-induced retardance. Once temporal overlap is calibrated, phase reconstruction is performed at a fixed interferometer delay, without a delay scan during the sensing measurement. This combination of HOM-generated polarization entanglement, single-photon coincidence detection, and computational phase retrieval provides a label-free approach to phase-sensitive characterization of birefringent materials.

## P18 Learning from Thermal Equilibrium: Quantum Equilibrium Propagation with Gibbs States

**Presenter: Guanyi Heng**

Affiliation: McGill/ETS

**Supervisors: Jacob Biamonte, Zeljko Zilic**

**Abstract**

We examine the free-energy formulation of quantum equilibrium propagation (QEP) for finite-dimensional systems at finite temperature. The Gibbs variational principle identifies the Gibbs state as the unique minimizer of the Helmholtz free-energy functional, with excess free energy quantified by quantum relative entropy. Coupling a cost observable to a parameterized Hamiltonian produces a nudged equilibrium state. In the infinitesimal-nudge limit, mixed derivatives of the equilibrium free energy relate the expected-cost gradient to the response of Hamiltonian-derivative observables. This formulation distinguishes thermal equilibration from parameter optimization and establishes the connection between Gibbs-state thermodynamics and QEP learning rules.

## P19 Nonlinear Switching via Topological Amplification in a Driven Kerr Chain

**Presenter: Mathis Lechaume-Robert**

Affiliation: McGill

**Supervisor: Kai Wang**

**Abstract**

We study directional amplification and nonlinear switching in a coherently driven, dissipative chain of coupled Kerr resonators. The nonlinear coupled-mode equations admit phase-winding steady states, and linearising fluctuations around such a state yields a non-Hermitian Bogoliubov–de Gennes (BdG) dynamical matrix. This matrix can acquire a non-trivial spectral winding number, linking the stability and linear response of the nonlinear system to non-Hermitian topology.
A difficulty is that changing from periodic to open boundary conditions generally alters the nonlinear steady state itself, and therefore the BdG matrix topology. We introduce an edge counter-drive that preserves the steady state under open boundary conditions, restoring the OBC-PBC correspondence expected from the bulk topology.
In the topological regime, the open-chain BdG matrix develops a singular value that decays exponentially with system size, producing strongly directional end-to-end amplification. A weak perturbation applied at one edge produces an exponentially large response at the other edge. When the system operates in a bistable regime, this amplified response can exceed the switching threshold and drive a hysteretic transition to the high-intensity state. The result connects non-Hermitian topology to a macroscopic switching response triggered by an exponentially weak perturbation.

## P20 Temperature-Independent Anomalous Hall Effect in Thin Bismuth from near 0 K to 300 K

**Presenter: Edgar Ma**

Affiliation: McGill University

**Supervisor: Guillaume Gervais**

**Abstract**

In a recent study, we demonstrate the occurrence of an anomalous Hall effect (AHE) that is temperature-independent from 15 mK to 300 K in a van der Pauw device fabricated from a 68 nm thick bismuth flake. Using Onsager's reciprocity theorem, we reconstruct the longitudinal and transverse resistances of our device from different voltage/current probe configurations, revealing a temperature-independent AHE that saturates at a magnetic field of ~1 T, and is accompanied by a temperature-dependent longitudinal resistance with very

weak magnetoresistance. The presence of the AHE is surprising due to bismuth being a diamagnetic material, which a priori does not break time-reversal symmetry. However, recent numerical work demonstrates bismuth to have a finite Berry curvature at the surface, which we propose as a possible explanation for the observed temperature-independent AHE.

## P21 Time-Multiplexed Ultrafast Pump-probe Quantum Imaging

**Presenter: Vincent Quenneville-Guay**

Affiliation: INRS

**Supervisor: Bienvenu Ndagano**

**Abstract**

We have developed an ultrafast quantum imaging technique enabled by mapping time bins into structured spatial correlations. The approach uses the principles of ghost imaging in addition to the ability to structure SPDC photon pair correlations to generate space-time multiplexed images. By post-selecting on the different biphoton correlation structures acquired with a single-photon avalanche diode (SPAD) camera, one can reconstruct the temporal evolution of a pump-probe transient absorption process with picosecond resolution, independently of the camera's framerate.

## P22 Developing a Rotational Quantum Sensor

**Presenter: Simon Darveau**

Affiliation: Institut national de la recherche scientifique

**Supervisor: Bienvenu Ndagano**

**Abstract**

We aim to develop an original rotational quantum sensor based on Hong-Ou-Mandel (HOM) interference of photon pairs generated via spontaneous parametric down-conversion (SPDC). By pumping a nonlinear crystal with structured light, we demonstrate that the transverse rotation of the pump beam's spatial mode modulates the HOM coincidence signal, providing information about angular velocity and acceleration. This project lays the groundwork for a quantum inertial sensor capable of measuring position and rotation through HOM signal.

## P23 Impact of Internal Electric Fields on Nitrogen Vacancy Magnetometry Accuracy

**Presenter: Jack Faller**

Affiliation: McGill University

**Supervisor: Lilian Childress**

**Abstract**

Accurate vector magnetometry is a critical component of modern navigation, geoscience, and space exploration. Nitrogen-vacancy (NV) center spin ensembles offer a quantum solution, as their room-temperature capacity and intrinsic vector measurements point toward a compact and portable, yet accurate vector magnetometer. However, random internal electric fields (RIEFs), arising from charged dopants in diamond, shift the spin-transition frequencies, and their impact on accuracy has not been investigated. This poster aims to explain how and why NV centers are used for accurate magnetometry, how we characterized RIEFs' effects on the NV spin-transition spectra, and what we can do to minimize their impact on accuracy.

## P24 Characterizing Mott Insulators in the Interacting One-Body Picture

**Presenter: Santiago Villodre Martinez**

Affiliation: Donostia Internatinal Physic Center - University of the Basque Country

**Supervisor: Maia Garcia Vergniory**

**Abstract**

The one-body picture underlies our understanding of weakly interacting solids but breaks down in strongly correlated systems. We develop a general framework, based on the single-particle Green's function and the one-body reduced density matrix (1RDM), to characterize correlated electronic phases. Applying it to the Hubbard diamond chain, we combine density matrix renormalization group and cellular dynamical mean-field theory to construct symmetry-resolved effective orbitals and track their evolution across its Mott transitions, while the 1RDM purity provides a scalar indicator of the phase boundaries. These tools offer a general route to extend one-body concepts to correlated materials.

## P25 Tensor Network Characterization of Fractional Chern Insulators

**Presenter: Mateo Maximiliano Blanco Rodriguez**

Affiliation: DIPC-UPV/EHU

**Supervisor: Maia Garcia Vergniory**

**Abstract**

We study the Haldane model of spinless fermions on the honeycomb lattice, supplemented by a density-assisted next-nearest-neighbor hopping term, at filling v = 1/3 of the lowest Chern band. Using the infinite density matrix renormalization group (iDMRG) on an infinite cylinder, we represent the many-body ground state as a matrix product state (MPS), which turns the two-dimensional problem into an effectively one-dimensional one. Threading a magnetic flux through the cylinder lets us measure the charge pumped across a bipartition of the cylinder. A fractional Chern insulator is signaled by one-third of an electron pumped per flux quantum, corresponding to a Hall conductivity $\sigma_{xy} = e^2/3h$. We complement this with the entanglement spectrum, the topological entanglement entropy and the correlation length. Our goal is to map out the phase diagram as the Hamiltonian parameters are varied, and to identify the fractional Chern insulator and its competing phases.

## P26 Building an Ultra-High Vacuum System for Optoelectronic Characterization of Alkali-Doped Graphene

**Presenter: Piotr Jakuc**

Affiliation: McGill

**Supervisor: Thomas Szkopek**

**Abstract**

Extreme alkali doping in graphene is a promising path toward correlated electron behaviour such as superconductivity, with largely unexplored flat-band physics near the van Hove singularity. That said, understanding alkali intercalation, diffusion, and desorption in graphene remains an open area of study. We present the development of an operando Raman and hyperspectral imaging platform to probe alkali-doped graphene. Alkali ($K^+$, $Rb^+$, $Cs^{+)}$ doping will be achieved with getter deposition sources. The system guides an external laser into an ultra-high vacuum chamber, with a secondary imaging path which enables precise laser alignment onto the sample. Mechanical stabilization reduced sample vibrations from approximately 30 μm to 1 μm. The system will measure Raman spectra at 355 nm and 532 nm excitation, and 400-1000 nm hyperspectral reflectance to assess doping uniformity and diffusion dynamics. The system will also be fitted with a cryostat and a heating stage to enable temperature-dependent studies, alongside 4-contact resistance measurements to correlate optical signatures with transport. Future work includes implementing low energy electron diffraction and angle-resolved photoemission spectroscopy to probe Kekulé order and band structure. More broadly, the system will be useful in the study of a wide variety of materials at extreme charge density, including fullerenes, fullertubes, and 2D materials in general.

## P27 Balanced Homodyne Detection design for squeezed light detection

**Presenter: Wenhao Shen**

Affiliation: McGill University

**Supervisor: Kai Wang**

**Abstract**

Balanced homodyne detection is a central technique for measuring optical field quadratures and is essential for the characterization of squeezed states of light. Its performance is determined by both electronic noise and the ability to suppress classical intensity fluctuations from the local oscillator. In this work, we developed and characterized a low-noise balanced homodyne detector for operation at 1550 nm, with particular emphasis on achieving high shot-noise clearance, broad detection bandwidth, and strong common-mode rejection.

The detector achieves a maximum measured quantum shot-noise clearance (QSNC) of 24 dB above the electronic noise floor, with the measurement currently limited by the available local-oscillator power. A QSNC exceeding 20 dB is maintained over a bandwidth of approximately 10 MHz. Through careful photodiode balancing, optical alignment, and low-noise electronic design, a CMRR exceeding 60 dB is demonstrated. The measurable rejection is limited by the available laser intensity modulation depth, making 60 dB a lower bound on the detector CMRR. 

The detector is currently being used to measure squeezed vacuum from a Fabry–Perot optical parametric oscillator (OPO). Phase-sensitive amplification has been observed using a coherent seed, confirming the expected parametric interaction, and anti-squeezing has also been measured in quadrature-noise experiments. Squeezing below the shot-noise level has not yet been resolved, with residual laser phase noise and phase fluctuations currently under investigation as possible limiting factors.

## P28 Towards Electrostatically Enabled Single Photon Emitters in WSe2 via Nanopatterned Graphite

**Presenter: Mohamed Amine Kabraoui**

Affiliation: University of Ottawa

**Supervisor: Louis Gaudreau**

**Abstract**

Single-photon emitters (SPEs) are fundamental for optical quantum technologies. However, achieving high quality and practical SPEs remains challenging, as they must exhibit high purity, indistinguishability, brightness and scalability. Two-dimensional (2D) materials offer a

promising platform, with candidates such as hexagonal boron nitride (hBN) and transition metal dichalcogenides (TMDs) demonstrating suitable properties. In hBN, high-purity single-photon emission at room temperature has been achieved through defect engineering using high-temperature annealing and focused ion beam irradiation. Similarly, in tungsten diselenide ($WSe_2$), strain and defect engineering via nanoscale stressors and electron beam irradiation have enabled high purity single-photon emission.

## P29 Orbital Hall effect in Weyl semimetals

**Presenter: Andoni Zaballa Nuñez**

Affiliation: Universite de Sherbrooke - Universite Paris Saclay

**Supervisors: Maia G. Vergniory, Paul McClarty**

**Abstract**

We investigate the essential differences between the spin and orbital Hall effects in Weyl semimetals, with particular attention to the role of magnetism. Using a recently proposed model of Weyl altermagnets, we first show that the spin Hall effect can arise without spin–orbit coupling, owing to the distinct spin sublattices, whereas a nonzero orbital Hall effect requires it. Building on this, we compute the orbital Hall conductivity from first principles in three representative Weyl semimetals: the altermagnet CrSb, the ferromagnet $Co_3Sn_2S_2$ and the nonmagnetic TaAs.

## P30 nan

**Presenter: Talia Martz-Oberlander**

Affiliation: McGill University

**Supervisor: Guillaume Gervais**

**Abstract**

To date, ultra-high electron mobility GaAs/AlGaAs is the only large area (~ cm^2) semiconducting platform that can host even-denominator fractional quantum Hall (FQH) states of relevance to topological quantum computations. While recent advances in molecular beam epitaxy have nearly doubled the electron mobility, traditional device fabrication techniques used to enable the study of novel physics pose a roadblock to harnessing this material's potential. To circumvent the well-known degradation of electron mobility from chemical or X-ray processing of the host wafer, a flip-chip technique is employed, where all lithographic processing steps are performed on a separate sapphire substrate. Since the semiconductor material of interest is left unprocessed, save for the deposition of ohmic contacts, the flip-chip approach preserves the electron mobility as

reported at wafer growth, amongst other benefits. We report the fabrication and operation of a source-drain-gate three-terminal field-effect electronic devices using GaAs/AlGaAs with a two-dimensional electron gas with an electron mobility of 44(2) million cm^2/(Vs) post fabrication. The advance doubles the previous record for field-effect electronic device mobility and arguably enables access to new regimes of quantum transport and applications that were previously unfathomable due to mobility limitations.

## P31 Exploring Alternative Layered Materials as Gate Dielectrics for 2D Material Based Devices

**Presenter: Isaac Lagaud**

Affiliation: NRC-University Of Ottawa

**Supervisor: Louis Gaudreau**

**Abstract**

The performance and scalability of two-dimensional (2D) based quantum devices are strongly influenced by the choice of gate dielectric. In gate-defined quantum devices high-κ dielectrics improve electrostatic tunability, and reduce gate leakage. Hexagonal boron nitride (hBN), a 2D layered material, has become a widely used dielectric due to the clean interface it forms with 2D materials and its wide band gap. However, its relatively low dielectric constant (κ ≈ 2.5–4) limits the gate capacitance, and incidentally the charge carrier density.

This project aims to explore Lanthanum OxyBromide (LaOBr) as an alternative crystalline layered dielectric. Its properties such as a high dielectric constant, large band gap, and its compatibility with van der Waals heterostructures makes it a promising material to overcome the limitations of hBN while preserving the benefits of a 2D-2D interface.

To evaluate LaOBr as a suitable gate dielectric, we fabricated 2D-based field-effect devices and characterized key electrical properties, focusing on the gate leakage current, device carrier mobility, gate dielectric breakdown, and dielectric constant. This work will prompt the study of other layered high k dielectrics as alternatives to hBN, providing additional tuning knobs for heterostructure fabrication.

## P32 Quantized Conductance Suppression in Strained Suspended Bilayer Graphene

**Presenter: Rami Zemouri**

Affiliation: Concordia University

**Supervisors: Alexandre Champagne, Saurabh Maiti**

**Abstract**

Strain is extensively present in devices based on two-dimensional materials and can drastically affect their properties, yet it is seldom modeled in detail for quantum transport. Understanding the effect of strain is therefore essential for modeling devices for application in modern quantum electronic technologies. To this end, we investigate quantum transport in strained suspended bilayer graphene. We show that a 1-3% strain can suppress conductance in discrete steps. We identify trigonal warping in bilayer graphene to be primarily responsible for this effect. Finally, we present a platform to perform in-situ strain-controlled transport measurements and present some preliminary data from bilayer graphene samples. Our work represents a step towards quantitative treatment of strain in quantum transport experiments.

## P33 BBM92 Time-Bin Quantum Key Distribution in the Mid-Infrared

**Presenter: Jean-Christophe Lamanque**

Affiliation: McGill University

**Supervisor: Martin Rochette**

**Abstract**

In the advent of incoming threats posed by quantum computation related to security, quantum key distribution (QKD) stands as a leading candidate for data exchange provably secure by the fundamental laws of quantum mechanics. The mid-infrared (MIR) region offers a unique opportunity for free-space atmospheric transmission QKD. The 3-5 μm window in particular, offers reduced background noise and outperforms near-infrared transmission in adverse meteorological conditions. Among the various photonic encoding schemes, time-bin encoding has emerged as a leading candidate for long-distance quantum communication. By encoding quantum information in the temporal degree of freedom, time-bin qubits are inherently robust against polarization drifts, environmental disturbances and turbulence. Despite these potential advantages, implementing QKD in the MIR remains technically challenging. Efficient single-photon sources, low-noise single-photon detectors, and low-loss optical components are considerably less mature than their visible-near-infrared (VIS-NIR) counterparts. Frequency up-conversion, based on the sum-frequency generation (SFG) nonlinear process, is used to convert MIR photons to the NIR, where single-photon detectors are more efficient than in the MIR. This work aims to evaluate the optimal experimental variables and performance that offer the best compromise between high detection efficiency, low quantum bit error rate (QBER), and high secret-key rate (SKR) using SFG as the detector stage for time-bin QKD.

## P34 Magneto-Transport Study of Hole Quantum Dots in Monolayer WSe2

**Presenter: Antoine Labbe**

Affiliation: University of Ottawa/NRC

**Supervisor: Louis Gaudreau**

**Abstract**

Spin–valley qubits in 2D semiconductors have recently gained attraction as a promising platform for quantum information applications. Transition metal dichalcogenides (TMDs) are of particular interest due to spin-valley locking. In these materials, strong spin-orbit coupling locks opposite spins to the K and K' valleys by spin-splitting the valence band at these points by hundreds of meVs. This potentially leads to spin-valley qubits that are remarkably robust and are expected to exhibit long coherence times. With this goal in mind, the first step is to create and study quantum dots in TMDs and understand their energy spectrum under an applied magnetic field. Here, we present the energy spectrum of a gate-controlled hole quantum dot formed in a monolayer tungsten diselenide ($WSe_2$) heterostructure. The results show a non-trivial evolution of ground and excited states as a function of magnetic field. This allows us to identify the valley and spin configuration of each energy state for different hole occupation numbers in the quantum dot. These results further our understanding of spin-valley qubits and pave the way towards their use in future quantum technologies

## P35 A new platform for quantum electronics based on 2D semiconductors

**Presenter: Justin Boddison-Chouinard**

Affiliation: Conseil National de Researches Canada

**Supervisor: Louis Gaudreau**

**Abstract**

Monolayer transition metal dichalcogenides provide a highly tunable platform for exploring interacting quantum phases in spin-valley locked two-dimensional systems. In monolayer tungsten diselenide ($WSe_2$), strong spin-orbit coupling and broken inversion symmetry couple the spin and valley degrees of freedom, while reduced dielectric screening and a large effective mass enhance the role of Coulomb interactions. These properties make monolayer $WSe_2$ an ideal system for exploring how interactions govern the behaviour of spin-valley locked carriers.

In this poster presentation, I will highlight how spin-valley locking shapes magnetotransport in monolayer tungsten diselenide confined to different dimensions through electrostatic gating.

In two dimensions, we report magnetotransport measurements in perpendicular magnetic

fields up to 8 T, revealing a Landau fan diagram consistent with fully spin-polarized hole transport at low filling factors. At higher carrier densities, the Landau fan exhibits an unconventional alternating resistance pattern.
We further demonstrate electrostatic confinement of monolayer tungsten diselenide into one dimension. In this regime, spin-valley locking combined with strong hole-hole interactions leads to a ferromagnetic ground state, resulting in spin- and valley-polarized transport even in the absence of an external magnetic field. The persistence of this polarized configuration can be tuned using a global back-gate.

Together, these results establish monolayer $WSe_2$ as a versatile platform for engineering and controlling spin- and valley-polarized states, opening opportunities for realizing quantum circuits in 2D semiconductors.

## P36 Magic states in the Asymmetric Quantum Rabi Model

**Presenter: Adair Campos Uscanga**

Affiliation: Universidad Autónoma Metropolitana - Iztapalapa

**Supervisor: Miguel Angel Bastarrachea Magnani**

**Abstract**

Nonstabilizerness (colloquially called magic) is a resource for quantum computing relevant in the interplay of fault-tolerance, universality and quantum advantage. It describes the degree to which Clifford gates cannot generate a given state, capturing the advantage of quantum computing over its classical counterpart. Despite being extensively studied in discrete setups such as qudit networks, its definition in continuous variables and general composite systems remains an open issue. In this work, we study nonstabilizerness in a bipartite system, the asymmetric quantum Rabi model, a paradigmatic model from quantum optics. We explore the presence of nonstabilizerness throughout the Hamiltonian parameter space, the role of light-matter interactions in its generation, and the manifestation of Wigner function negativity in the corresponding bosonic degree of freedom.

## P37 High Q-factor tunable microresonators induced by twisting optical fibers

**Presenter: Samar Deep**

Affiliation: Concordia University

**Supervisor: Pablo Bianucci**


## Abstract

We experimentally demonstrate tunable surface-nanoscale axial photonics (SNAP) microresonators formed by two twisted optical fibers. One end of a pair of slightly separated, almost parallel fibers is fixed while the other is rotated, bringing the fibers into contact at the center and forming a mechanically robust, high-Q whispering-gallery-mode microresonator. The free spectral range tunes from 5 pm to 14 pm with sub-degree changes in twist angle, while the Q-factor remains ~$10^6$, limited by the lab environment. Because the modes and their FSR can be tuned after assembly while the high Q-factor is maintained, prospective applications include cavity quantum electrodynamics experiments, compact tunable optical delay lines, tunable narrowband filters, low-repetition-rate frequency-comb generators, and sensitive photonic sensors.