IPS Meeting 2025
24 - 26 September

Institute of Physics Singapore

Conference Program

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1 Foreword

Dear fellow Physicists,

this is a special year, nominated by UNESCO as the International Year of Quantum Science and Technology – and with the presentations you submitted we seem to be strongly aligned with this theme.

We are grateful to return to the area of the Medicine+Science Library at NUS, and for the staff there to be of great help with this event.

As usual, this event aims to give all researchers in physical sciences in Singapore an opportunity to get updated with the quickly evolving research landscape in Singapore, to explore new collaborations, to hunt for new research team members, or just to finally catch up with your colleagues in a relaxed setting with a focus on physics rather than administrative tasks. Most importantly, we need to step out of our usual silos, and make ourselves aware what researchers in other institutions are up to.

We try to highlight outstanding research activities in Singapore and beyond with plenary talks - both from newcomers to our Physical Sciences community in Singapore, as well as researchers who have built up a remarkable programme over a longer time. On the first day, we have plenary talks on core Singapore research activities in physical sciences, starting with YAO Hui from IMRE/A*STAR presenting novel material aspects for sensing and energy conversion applications, followed by WU Lin from SUTD, sharing theoretical aspects for novel optoelectronic applications. On the second day, we dive more into fundamental physics, with Massimo PICA CIAMARRA from NTU addressing a seemingly innocent question on what makes glasses solid, and Maxime RICHARD from CNRS and the Majulab here in Singapore looking at quantum fluid properties of light. On the third day, our plenary speakers focus on two aspects on the hot topic related to clima change – starting with Dale Barker from the Meteorological Services Singapore, moving to CHUNG Keng Yeow sharing the activities of the recently established Institute of Nuclear Safety Research in Singapore. We believe these are strong topics for all interested Physicists.

We also see an increased increase of scientific interaction here in Singapore, and had almost date clashes with two workshops related to physical sciences. We are very happy to align with these events, and welcome a joint session with the Workshop on Macroscopic Superpositions of Levitated Systems, and a joint session with guests from POSTECH, Korea, looking to extend collaboration on quantum topics with Singapore researchers.

Our technical programme covers almost 170 contributions, with 110 oral presentations. To limit the overall time in talks, we had to limit the number of invited presentations to only 12 this year - we hope this is ok with everyone, and encourage to talk more to your colleagues in in the relaxed times over coffee and posters. As of this writing, we have over 60 posters, and encourage to join those who give a poster pitch in the Thursday slot, or nudge yourself to give one if you have not done so yet! As usual, the poster session in the middle of the meeting on Thursday afternoon is really a central part of this event, and as per tradition, of course transitions into a networking event with Pizza and Drinks to provide a proper setting.

As last years, we present awards to contributors to physical sciences in Singapore after the Plenary sessions on Wednesday.

We are, as always, grateful for our institutional supporters, the Department of Physics and the Department of Materials Sciences at NUS, the School of Physics and Applied Physics at NTU, the Graduate Studies Program at SUTD, the Center for Quantum Technologies at NUS. We also are grateful for the support by the Quantum Engineering Programme, the Institute of Advanced Studies at NTU, as well as A*STAR.

Last but not least, let's thank the record number of exhibitors this year, who again help with their generous support to make this conference possible. Without their help, we would not be able to put up this conference – so do spend some time and visit their booths to see what products or services they can offer for your research. Make sure they find this conference useful as well, as they are a pillar for this event to happen!

With this, we wish you an inspiring conference, a refreshing look up from your daily work, new ideas, new contacts, new collaborations for a successful new year of research in physical sciences ahead!

Your organizing team of the IPS meeting 2025

Contents

2 Schedule

(This is still the preliminary schedule – change of times are possible but increasingly unlikely)

Wednesday, 24 September

8.30 AM	Registration (Medicince+Science Library Atrium)			
8.50 AM	Opening Address (LT 26)			
9.00 AM	Plenary talk P1: YAO Kui (Venue: LT 26)			
9.45 AM	Plenary talk P2: (Venue: LT 26)			
10.30 AM	IPS Awards presentation (Venue: LT 26)			
10.45 AM	Coffee/Tea Break + Exhibition (Medicince+Science Library Atrium)			
11.15 AM	Technical Sessions			
	T1 (Room 1) Quantum Algorithms I	T2 (Room 2) Quantum Communication	T3 (Room 3) Photonics 1	T4 (Room 4) 2D Materials I
12.45 PM	Lunch + Exhibition (Medicince+Science Library Atrium)			
2.00 PM	Technical Sessions			
	T5 (Room 1) Quantum Computing ——— J1 (LT 29) Quantum Superpositions for levitated Systems	T6 (Room 2) AMO Physics	T7 (Room 3) Photonics II	T8 (Room 4) Solid State Physics I
3.30 PM	Coffee/Tea Break + Exhibition (Medicince+Science Library Atrium)			
4.00 PM	Technical Sessions			
	T9 (Room 1) Quantum Algorithms II	T10 (Room 2) Quantum Optics	T11 (Room 3) 2D Materials II	T12 (Room 4) Solid State Physics II
5.30 PM	End of Wednesday sessions			

Thursday, 25 September

9.00 AM	Plenary talk P3: Massimo PICA CIAMARRA (Venue: LT 26)			
9.45 AM	Plenary talk P4: Maxime RICHARD (Venue: LT 26)			
10.30 AM	Award Event (Venue: LT 26)			
10.45 AM	Coffee/Tea Break + Exhibition (Medicince+Science Library Atrium)			
11.15 AM	Technical Sessions			
	T13 (Room 1) Quantum Theory I	T14 (Room 2) Astro- and Biophysics	T15 (Room 3) Many-body Physics	T16 (Room 4) Solid State Physics III
12.45 PM	Lunch + Exhibition (Medicince+Science Library Atrium)			
2.00 PM	Rapid Fire poster Pitch session (Venue: LT 29)			
3.15 PM	Coffee/Tea Break + Exhibition (Medicince+Science Library Atrium)			
4.00 PM	Poster session + Exhibition (Medicince+Science Library Atrium)			
5.30 PM	Poster awards + Pizza + Drinks (Medicince+Science Library Atrium)			
6.30 PM++	End of Thursday sessions			

Friday, 26 September

9:00 AM	Plenary talk P5: Dale BARKER (Venue: LT 29)			
9:30 AM	Plenary talk P6: CHUNG KEng Yeow (Venue: LT 29)			
10.30 AM	Coffee/Tea Break + Exhibition (Medicince+Science Library Atrium)			
11.00 AM	Technical Sessions			
	T17 (Room 1) Nuclear Safety Physics	T18 (Room 2) Mathematical and Computational Physics	T19 (Room 3) Quantum Physics II	J2 (LT 29) POSTECH-SG Workshop
12.30 PM	Lunch + Exhibition (Medicince+Science Library Atrium)			
3.00 PM	Quantum SG networking (LT 29)			
4.30++ PM	End of Conference			

3 Plenary sessions

P1: Ferroelectrics and structural imperfections for multifunctional energy conversions and edge intelligence

Dr. YAO Kui
Distinguished Principal Scientist,
Institute of Materials Research and Engineering (IMRE), A*STAR

Wednesday, 24 September 09:00am, Venue: LT 26

Abstract

The development of edge computing and intelligence requires deployment of tremendous and distributed energy-autonomous smart sensors with local processing capabilities, while the existing sensors and electronics typically require external power supply and signal processing. With asymmetric lattice structure and highly responsive electrical polarization, ferroelectric materials possess multiple energy conversion and storage functions, such as piezoelectric, pyroelectric, bulk photovoltaic properties, high dielectric permittivity and switchable polarization. These multiple functions inherent in ferroelectrics may enable edge computing and intelligence in principle, but the signal or energy output from normal ferroelectrics is typically too small for practical energy-autonomous operation. Appropriately introducing various structural imperfections in ferroelectric materials is an effective strategic approach for significantly improving their response magnitude. These structural imperfections include coexistence of multiple phases, lattice defects, and various structural heterogeneities with energy competition. Relevant material systems are cited for discussing the underlying mechanisms and effectiveness. The feasibility for utilizing ferroelectric multiple functionalities with significantly enhanced response for realizing distributed sensors and in-situ intelligence is discussed.

Work with Yasmin Mohamed Yousry, Shashidhara Acharya, and Chao Jiang.

P2: Particle-in-Cell (PIC) Simulations for Next-Gen. Plasmonics & Optoelectronics

Assoc. Prof. WU Lin,
Singapore University of Technology and Design (SUTD)

Wednesday, 24 September, 9:45am, Venue: LT 26

Abstract

Computational simulations are redefining electromagnetism, especially in modeling quantum plasmas—materials where electron dynamics are fast, nonlinear, and strongly coupled to electromagnetic fields. Traditional methods like Finite-Difference Time-Domain (FDTD) and Finite Element Method (FEM) often fall short in these regimes, while the Particle-in-Cell (PIC) method excels by capturing self-consistent interactions between particles and fields [1-4]. Using PIC, we explore nonlinear electron transport in graphene antennas and plasmonic resonators, revealing unexpected even-order nonlinearities that enable frequency-tunable infrared upconversion [3]. Notably, we uncover a mechanism for second-harmonic generation driven by electron funneling in THz optical resonators, where ultrafast electron-surface scattering reduces the required field intensity by 3–4 orders of magnitude. Room-temperature metals and semimetals, acting as cold quantum plasmas, emerge as a promising platform for low-field, high-efficiency nanophotonic applications. PIC's ability to model ultrafast, non-equilibrium carrier dynamics makes it a powerful tool for designing next-generation devices across plasmonics, optoelectronics, and photonics.

[1] Particle simulation of plasmons,
Nanophotonics, **9**(10), 3303–3313 (2020).

[2] Electron dynamics in plasmons,
Nanoscale, **13**, 2801–2810 (2021).

[3] Nonlinear optical resonances from ballistic electron funneling,
ACS Nano, **19**(14), 14150–14160 (2025).

[3] Particle-in-cell simulations of quantum plasmas,
Computer Physics Communications (under review), arXiv:2501.07465.

P3: What makes a glass solid?

Assoc. Prof. Massimo PICA CIAMARRA School of Physical and Mathematical Sciences (SPMS), Nanyang Technological University

Thursday, 25 September, 09:00am, Venue: LT 26

Abstract

Solid state textbooks describe at length the mechanical and transport properties of crystalline solids, while limit their discussion of non-crystalline solids, or glasses, to a minimum. This is not because glasses are unimportant—on the contrary, they are ubiquitous in technology and daily life, from optical fibers and display screens to metallic glasses and polymer-based materials. Rather, it reflects the fact that, despite glasses being used by humankind for millennia, we still lack a first-principles theory of their properties. In this talk, I will discuss recent results addressing the most fundamental question of all: why are glasses solid?

P4: Quantum fluid of interacting photons

Visiting Research Assoc Prof. Maxime Richard
Majulab and CNRS

Thursday, 25 September, 9:45am, Venue: LT 26

Abstract

Tapping into years of expertise in semiconductor nanotechnology and optoelectronic properties engineering, we design and fabricate solid-state microcavities – i.e. light trap for visible light of a few cubic wavelengths volume - in which photons are subject to large interactions with each other. Upon driving such a system resonantly with coherent light, one obtains a few-photon steady-state that consists in many-body quantum fluctuations surrounding a classical mean field, which is the result of a non-trivial interplay between the interactions, and the quantum fluctuations of the environment that this open system is coupled to. In a series of experiments and theoretical development, we show that these fluctuations exhibit a rich panel of quantum states and properties. Depending on the experimental conditions, the system can exhibit the onset of quantum blockade, and hence sub-Poissonian photon emission statistics, or the fluctuations can turn into the photonic counterpart of Bogoliubov states, exhibiting strong photons pairing and time-ordering quantum correlations.

P5: The Challenge of Understanding, Modelling and Predicting the Unique Weather and Climate of the Singapore Region

Prof. Dale BARKER
Meterological Serivce Singapore,
Director of the Centre for Climate Research Singapore

Friday, 26 September, 9:00am, Venue: LT 29

Abstract

Situated approximately one degree north of the equator, Singapore has a unique deep-tropical urban climate that provides a challenging testbed for research, weather prediction and improved understanding of the impact of climate change in coming years and decades. The tropical climate system is highly complex, requiring expertise in a wide range of physical processes e.g. turbulence/convective processes, the Greenhouse effect, cloud microphysics, frictional impacts of different land surfaces, etc. Traditional weather/climate models apply the Navier Stokes equations tailored to include both resolved and parameterized physical processes, optimized for both research and operations on some of the world's larger supercomputers. AI is making a huge impact on traditional weather/climate science, complementing understanding of the physical climate system as we prepare for today's weather and future climate change. This talk will provide an overview of the physical climate system, as well as CCRS' approach to weather/climate modelling, weather prediction and projections of future climate.

P6: Nuclear Safety Research in Singapore

Assoc. Prof. CHUNG Keng Yeow,
Department of Physics, NUS,
Director of the Singapore Nuclear Research and Safety Institute

Friday, 26 September, 09:45am, Venue: LT 29

Abstract

The speaker will give a brief introduction to the nuclear power in the world and the recent development in nuclear reactor technologies. He will also touch on the study of the potential deployment of nuclear power in Singapore and explain how the research at the Singapore Nuclear Research and Safety Institute (SNRSI) supported this effort. The different research areas of SNRSI, namely Reactor Safety, Radionuclide Dispersion, Radiochemistry, Radiobiology and Nuclear Policy will also be presented with emphasis on those areas related to Physics.

4 Posters

As previously, we have a full session (Thursday after lunch) with no parallel technical sessions where all IPS participants get your audience for a supershort (3 minutes) presentation on a poster if the authors want to participate. In order to encourage authors to participate, we will choose the Best Poster Award this year form those submissions where there was short presentation in this session.

For this, we just project your poster on the screen in the lecture hall (please provide us with a PDF file for that purpose). You can email this to us via posters@ipsmeeting.org, or leave it with the reception desk.

IPS Best Poster Award

During the conference the program committee will select the three best poster presentations for the IPS Best Poster Award. The award will be handed over to the winners at the Pizza session after the end of the poster session on Thursday evening, probably around 5.30pm-6.30pm.

General poster presentation

Format

The poster walls fit a A1 sized poster (portrait orientation).

Poster Abstracts

PO.1 Short and long-range magnetic ordering and emergent topological transition in $(Mn_{1-x}Ni_x)_2P_2S_6$

Nasaru Khan*, Deepu Kumar, Shantanu Semwal, Yuliia Shemerliuk, Bernd Buchner, Koushik Pal, Saicharan Aswartham, Pradeep Kumar (Indian Institute of Technology Mandi)

Two-dimensional magnetic materials with tunable physical parameters are emerging as potential candidates for topological phenomena as well as applications in spintronics. The famous Mermin-Wagner theorem states that spontaneous spin symmetry cannot be broken at finite temperature in low dimensional magnetic systems which forbid the possibility of a transition to long range ordered state in a two-dimensional magnet at finite temperature. Though, there are some exceptions to Mermin-Wagner theorem in particular low dimensional magnetic systems with topologically ordered phase transitions. Here, we present an in-depth temperature dependent analysis for the bulk single crystals of two-dimensional $(Mn_{1-x}Ni_x)_2P_2S_6$ with x =1, 0.7, 0.3, 0 using the Raman spectroscopy supported by first-principles calculations of the phonon frequencies. We observed multiple phase transitions with tunability as a function of doping associated with the short and long-range spin-spin correlations. First transition at $\approx$150 K to $\approx$170 K for x =0 to x =0.7, and second one from $\approx$60 K to $\approx$153 K. Quite interestingly, a third transition is observed at low temperature (much below their respective TN) $\approx$24 K to 60K and is attributed to the potential topological phase transition. These transitions are marked by the distinct changes observed in the temperature evolution of the phonon self-energy parameters, modes intensity and dynamic Raman susceptibility.

PO.4 Asymmetric decay of quantum many-body scars in XYZ quantum spin chains

Dhiman Bhowmick*, Vir B. Bulchandani, Wen Wei Ho (National University of Singapore)

Quantum many-body scars are atypical energy eigenstates of chaotic quantum many-body systems that prevent certain special non-equilibrium initial conditions from thermalizing. We point out that quantum many-body scars exist for any nearest-neighbor spin-S XYZ quantum spin chain, and arise in the

form of an infinite family of highly excited yet nonentangled product-state eigenstates, which define periodic textures in spin space. This set of scars, discovered originally by Granovskii and Zhedanov in 1985, encompasses both the experimentally relevant 'spin helices' for XXZ chains and more complicated helix-like states constructed from Jacobi elliptic functions for generic XYZ chains. An appealing feature of Granovskii-Zhedanov scars is that they are well-defined in the semiclassical limit $S \to \infty$, which allows for a systematic and analytical treatment of their dynamical instability to perturbations of the Hamiltonian. Using time-dependent spin-wave theory, we predict that upon perturbing along certain directions in Hamiltonian space, Granovskii-Zhedanov scars exhibit a dramatic asymmetry in their decay: depending on the sign of the perturbation, the decrease of their contrast is either slow and linear, or fast and exponential in time. This asymmetry can be traced to the absence (presence) of imaginarity in the spectrum of the Bogoliubov Hamiltonian governing quantum fluctuations about the scar, which corresponds to the absence (presence) of a non-zero Lyapunov exponent for the limiting classical trajectory. Numerical simulations using matrix product states (MPS) and infinite time-evolving block decimation (iTEBD) confirm that our prediction remains valid even far from the semiclassical limit. Our findings challenge existing theories of how quantum-many body scars relax.

PO.5 Quantifying Polarization Mode Dispersion-induced Errors in Quantum Communications

Rui Ming Chua*, Vadim Rodimin*, Konstantin Kravtsov, Gianluca De Santis, Aleksei Ponasenko, Yury Kurochkin, Alexander Ling, James Anthony Grieve* (Technology Innovation Institute)

Polarization Mode Dispersion (PMD) leads to errors in communication. This effect is one of the limiting factors in high-speed classical communications but particularly pronounced in quantum communications which often utilize comparatively broad signals and rely on measurements in mutually unbiased sets of measurement bases as its foundation to cryptographic security. We studied PMD in the context of broadband quantum communications by examining the wavelength-dependent rotation of polarization states on the Poincaré sphere. We first derived a simple formula to deduce its contribution to error on the first order and validated our model with BBM92 Quantum Key Distribution. Subsequently, we commented on mitigation techniques and expanded our commentary to higher order PMD. Ultimately, our work aims to serve as a guideline to the optimization of quantum communications system.

PO.8 BEYOND F=MA: EMPIRICAL CHALLENGES TO NEWTON'S SECOND LAW IN REAL-WORLD PHYSICS EDUCATION

Amritpal Singh Nafria*, Sugandhi Sharma, Gurwinder Singh Lamba (Lovely Professional University)

This study examines the practical application of Newton's second law (F=ma) by systematically analyzing the effects of resistance forces in real-world systems. Through controlled experiments using calibrated weighing scales, we measure frictional variations (1.44-1.80N across surfaces) and air resistance (0.24-0.37N) to develop an enhanced force equation (F=ma+r) that incorporates cumulative resistances. Our celestial mechanics models demonstrate how a 10N force on a 5kg mass produces environment-dependent accelerations (1.876 m/s^2 on Pluto vs. 0.0408 m/s^2 on Earth), highlighting the importance of contextual factors in force calculations. These findings provide physics educators with empirically validated teaching tools, including practical measurement techniques using standard laboratory equipment and ready-to-implement celestial mechanics examples that bridge theoretical principles with experimental observations.

PO.14 Optical Receiver System Development and Implementation at Singapore Optical Ground Station (SOGS) for Satellite based quantum network

Muskan Varshney*, Moritz Mihm*, Shaik Abdillah*, Nishant Pathak*, Soe Moe Thar*, Ayesha Reezwana*, Joanne Chu*, Alexander Ling* (Center for Quantum Technologies, National University of Singapore)

Quantum mechanics offers unique properties such as entanglement and no-cloning theorem that makes ultra-secure communication possible. While laboratory experiments have proven successful, scaling to global networks faces challenges from optical loss in long-distance fiber links. Satellite-based quantum networks solve this by transmitting quantum signals through space, enabling secure quantum links across continents and oceans for global secure communications and fundamental physics research. This work demonstrates how a laboratory optical experimental set-up is deployed in the Singapore Optical Ground Station (SOGS); a dedicated facility for satellite-based quantum network and first of its kind situated on equator. This project elaborates the implementation of quantum signal receiver optics at the SOGS for satellite-to-ground QKD, demonstrating the optical setup applicability for space-based quantum network. In this work, a table-top optical experimental set-up is minimized to a receiver unit which we call the "backend optics system". It is placed at the optical output of the telescope at the SOGS. The design of the backend optical system comprises three functional sections: i) the polarization-correction system, ii) the fine-tracking system, and iii) the quantum receiver. The objective here is to elaborate over the critical factors like design, weight considerations, development of pointing models of telescope, building pointing, tracking and acquisition (PAT) software for satellites, signal alignment systems with precision sufficient for single-photon detection and the role of downlink ($<$700 nm), uplink ($<$700 nm) and quantum signal $>$700 nm). This architecture allows for extension to C-band downlink beacon compatibility. The future work involves benefiting SOGS and backend optical system to perform last mile connections, faithful entanglement teleportation and entanglement swapping which are critical to building future ultra-secure quantum networks.

PO.16 Biomolecules-Centric Therapeutics on a Hybrid Quantum Platform

Tianqi Chen*, V Vijendran, Lorcan O. Conlon, Jianguo Li, Syed M Assad (BII & SRTT Q. Inc, ARES)

We present a novel framework for encoding pairwise free energy landscapes into a Hamiltonian formalism, enabling efficient modeling of multi-body biomolecular assemblies. The method is particularly suited for coarse, low-grid resolution representations, where traditional high-resolution approaches may become computationally prohibitive. This Hamiltonian-based encoding establishes a foundation for scalable quantum and classical simulations of complex biomolecular interactions. Future directions include extending this approach toward non-variational Hamiltonian simulation techniques, opening pathways for more accurate and resource-efficient studies of large-scale biomolecular systems.

PO.17 Integrating Superconducting Circuits with Er^{3+}: $CaWO_4$ via Trenched Sapphire Bonding

Sakshi Mishra*, Kritika Mundeja, Zhikun Han, Steven Touzard (MSE NUS and CQT)

Integrating superconducting circuits with rare-earth-doped crystals presents a promising avenue for spin-assisted quantum memories, efficient microwave-to-optical transducers, and reliable optical–microwave entanglement. Er^{3+} in $CaWO_4$ is particularly attractive for these systems due to their long spin coherence times and optical transitions around 1.5 μm, which makes it compatible with telecom infrastructure. We present a scalable technique that combines Er^{3+}: $CaWO_4$ with superconducting microwave resonators and a transmon qubit, fabricated on trenched sapphire substrates. Sapphire is a widely used substrate for superconducting circuits owing to its exceptionally low dielectric loss and high qubit coherence times. Our platform leverages these material's advantages while incorporating Er^{3+} ions through a direct bonding technique. We observed long spin coherence times in undoped $CaWO_4$ and demonstrate that resonators integrated into trenched sapphire have internal losses comparable to those on planar substrates. A 3D Purcell filter is utilised to attain rapid, high-fidelity readout while preserving coherence. The trench-bonded architecture eliminates the need for intermediate materials such as vacuum grease, which can introduce radiation losses and degrade coupling, enabling improvements in areas such as quantum memory efficiency. This architecture addresses the challenges of resonator–crystal integration and enables tuning of spin–resonator coupling via trench geometry. Our work demonstrates a robust hybrid device platform for spin-based memories and transduction, facilitating coherent microwave–optical interfaces in scalable quantum networks.

PO.19 Resource-efficient Hadamard test circuits for nonlinear dynamics on a trapped-ion quantum computer

Eleftherios Mastorakis, Muhammad Umer*, Milena Guevara-Bertsch, Juris Ulmanis, Felix Rohde, Dimitris G. Angelakis (Centre for Quantum Technologies, National University of Singapore)

Resource-efficient, low-depth implementations of quantum circuits remain a promising strategy for achieving reliable and scalable computation on quantum hardware. This paradigm not only reduces gate resources but also enhances computational reliability by limiting the accumulation of noisy operations. Here, we propose a low-depth implementation of a class of Hadamard test circuits, complemented by the development of a parameterized quantum ansatz specifically tailored for variational algorithms that exploit the underlying Hadamard test framework. Our findings demonstrate a significant reduction in single- and two-qubit gate counts, suggesting a reliable circuit architecture for noisy intermediate-scale quantum (NISQ) devices. Building on this foundation, we tested our low-depth scheme to investigate the expressive capacity of the proposed parameterized ansatz in simulating nonlinear Burgers' dynamics. The resulting variational quantum states faithfully capture the shockwave feature of the turbulent regime and maintain high overlaps with classical benchmarks, underscoring the practical effectiveness of our framework. Furthermore, we evaluate the effect of hardware noise by modeling the error properties of real quantum processors and by executing the variational algorithm on a trapped-ion-based IBEX Q1 device. The outcomes of our demonstrations highlight the resilience of our low-depth scheme, faithfully capturing the shockwave signature of the turbulent regime while retaining high overlaps with classical benchmarks. Our work contributes to the advancement of resource-efficient strategies for quantum computation, offering a potential blueprint for a reliable and scalable framework for tackling a range of computationally intensive problems across numerous applications.

PO.20 Sensitivity-enhanced Dual-axis Zero-field Atomic Magnetometer Based on Pulsed Magnetic Field Modulation

Shushan Gao*, Xiaoyu Li, Zhongyu Wang, Jianwei Sheng, Jixi Lu (Beihang University)

Quantum sensing instruments based on the long coherence time of alkali-metal atomic vapors are of great significance for promoting the development of various frontier fields. Among them, atomic magnetometers rely on detecting the interactions of atoms with light and magnetic fields and achieve ultra-high sensitivity in the field of extremely weak magnetic field measurement. Atomic magnetometers have been widely used in biomagnetism, fundamental physics research, magnetic anomaly detection, and engineering testing. Notably, miniaturized zero-field atomic magnetometers typically use continuous high-frequency magnetic fields to modulate atomic spin precession for multi-axis measurements. However, this modulation induces additional spin-exchange relaxation, which significantly broadens the resonance linewidth and limits sensitivity. In this study, we introduced pulsed magnetic field modulation instead of continuous modulation to reduce the effective duration of the magnetic field. This operation significantly diminishes the perturbations of steady-state spin distribution in Zeeman sublevels caused by Larmor precession during each modulation cycle, thus effectively mitigating decoherence effects. The relationship between spin-exchange relaxation and pulsed field parameters is studied based on the generalized hyperfine Bloch equations, and a spin dynamics model under the pulsed modulation is developed. Agreement between experimental and theoretical results validates the suppression effect of spin-exchange relaxation and the accuracy of this model. Experimental results indicate that the pulsed modulation scheme results in a 30% reduction in spin-exchange relaxation and achieves dual-axis sensitivities of 1.5 $\mathrm{fT/Hz^{1/2}}$ and 2.5 $\mathrm{fT/Hz^{1/2}}$, respectively, representing improvements of 25% and 20% over conventional continuous modulation methods. Our approach provides a higher sensitivity for multi-axis magnetic measurements, thereby opening up the potential to achieve higher precision in biomagnetic imaging, particularly in the fields of magnetocardiography (MCG) and magnetoencephalography (MEG).

PO.28 Single-period Quasi-phasematching

Jia Boon Chin*, Euk Jin Alexander Ling (Centre for Quantum Technologies, National University of Singapore)

Quasi-phasematching (QPM) is commonly employed in Spontaneous Parametric Downconversion (SPDC) and other nonlinear optical processes to maintain the relative phase between the interacting light waves. QPM is traditionally achieved using periodically poled crystals, in which the crystal domains are periodically inverted to correct for any phase mismatch.

Typical poling periods are tens of microns or less to correct for significant phasemismatch, while the crystal lengths are typically a few millimetres to achieve significant photon-pair generation rates or frequency conversion efficiency. This results in $\approx 10^2 \ldots 10^3$ poling periods within the crystals in conventional QPM.

We demonstrate that QPM can be achieved with only a single poling period. By operating near non-critical phasematching (NCPM) conditions, this could be achieved using two single-domain crystals. The change from NCPM to simultaneous QPM of orders m=1 and m=-1 was observed.

PO.37 Applications of Trapped Ions Quantum Processor

Nigel Lee*, Jiacheng You*, Eugene Koh*, Rongjie Zhang*, Mu Young Kim*, Jaren Gan*, Dzmitry Matsukevich* (Centre for Quantum Technologies)

Trapped ions are one of the leading platforms to realise quantum computation both for discrete spin states and for continuous variables such as position and momentum of a harmonic oscillator. We demonstrate our implementation of a small, trapped ion quantum processor and its application to both discrete and continuous variable quantum information processing. We present a test of quantum bi-contextuality with two qubits proposed by our theory collaborators [1]. We present both the experimentally testable inequalities and experimental evidence that these inequalities are violated.

We also demonstrate the implementation of a non-linear gate, such as the cubic phase gate (CPG) acting on the state of the harmonic oscillator. An approximate CPG may be realised via a sequence of qubit spin rotations and spin dependent displacement operations [2]. We discuss our recent attempt to implement such a gate and to measure the Wigner function of the final state via direct characteristic-function tomography [3].

[1] G. Ruffolo et al. Bi-Contextuality: A Novel Non-Classical Phenomenon in Bipartite Quantum Systems. (2025). arXiv: 2507.08461 [quant-ph].

[2] K. Park and R. Filip. Efficient bosonic nonlinear phase gates. npj Quantum Inf 10, 25 (2024).

[3] C. Flühmann and J. P. Home. Direct Characteristic-Function Tomography of Quantum States of the Trapped-Ion Motional Oscillator. Phys. Rev. Lett. 125 043602 (2020).

PO.43 Force-Dependent Right-handed Helical Conformation of Single-Stranded DNA and its Mechanical Stability

Karis Kungsamutr*, Yan Jie* (National University of Singapore)

The conformation which a single-stranded DNA (ssDNA) takes is essential to understanding the functions it can perform under a given environment. While nucleic acids are known to deform when placed under mechanical force, the range of conformations which a given sequence of ssDNA can take under varying forces is not yet well understood. We apply molecular dynamics simulations to map out the structures which 5 different 16 bp ssDNA strands (including a poly-A, poly-C, poly-G, poly-T and a sequence of random bases) take over varying extensions and the forces required to maintain those structures, starting with a maximally overextended ssDNA structure and gradually decreasing the length by which the molecule is extended. We report the discovery that short ssDNA strands, traditionally regarded as an unstructured flexible polymer, adopts a stable right-handed helical conformation under forces ranging from 8 to 20 pN, regardless of sequence. At higher forces, this helical conformation undergoes an "overstretching" transition, marked by a force plateau around 20 pN. Below 6 pN, the helical structure collapses in a strongly sequence-dependent manner, except for poly-A, which remains resistant to collapse. Poly-G collapses stepwise, each step corresponding to a distinct structural transition, while poly-T, poly-C, and the random sequence collapses with large fluctuations among diverse structures. These findings provide insights into the conformations of short nucleic acid sequences and have significant implications for biological processes such as D-loop and R-loop formation.

PO.45 Automated Switchover of Quantum Traffic with All-Transparent Optical Routers

Hou Shun Poh*, Xiao Duan, Matthew Wee, Yu Cai, Jing Yan Haw, Hao Qin, Michael Kasper, Alexander Ling, Christian Kurtsiefer (Centre for Quantum Technologies, National University of Singapore)

The QKD quantum channel operates near single-photon level and requires an all-transparent fibre route between nodes, making it more susceptible to fibre faults than conventional communication systems. To ensure high availability, we implemented a scheme using our previously developed all-transparent optical router, that enables the automated switchover of quantum traffic to a backup route when degradation is detected in the main fibre route.

We demonstrated this scheme using commercial QKD systems based on polarisation and time-bin degrees of freedom. In the test setup, one of the nodes was connected to the rest of the QKD system via two deployed fibre routes (main and backup) through a pair of synchronised optical routers. A variable optical attenuator was inserted inline with the main route to simulate an increasing insertion loss. A monitoring system continuously polled the system for various operational metrics. Threshold was defined on specific metric to trigger the switchover. Upon reaching the threshold, the system automatically switched to the backup route and restarted the QKD process.

PO.47 mmWave Detectors Based On Dirac Semimetal Heterostructures

Xuan Yi Ang, Mengting Jiang, Piyush Agarwal, Xavier Loh, Ruihuan Duan, Zheng Liu, Karen Ke Lin, James Lourembam* (Institute of Materials Research and Engineering, Agency for Science, Technology and Research, Singapore 138634)

Terahertz (THz) radiation offer unique advantages such as non-destructive imaging/characterization and fast wireless communication. However, passive detection of THz radiation at room temperature remains highly challenging due to the inherently low photon energy ($\approx$meV), which limits the sensitivity of photodetectors based on conventional semiconductors. To address this, we explore type-II Dirac semimetals (DSM) particularly platinum dichalcogenides (PtX2), whose gapless band structure and existence of massless fermions supports the generation of highly mobile carriers under low-energy excitation. In this study, we fabricate and investigate two-dimensional (2D) homostructures and heterostructures based on graphene and PtX2. We report room temperature detection of continuous wave (CW) 0.1 THz using DSM with responsivity performance >10 V/W. By tuning their stacking configurations, we examine their photodetection performance in the CW THz regime, providing insights into design strategies for next-generation THz optoelectronic devices.

PO.48 Emerging 2D Ferroelectric Niobium Oxyhalides as Efficient Terahertz Emitters

Xavier Loh, Mengting Jiang, Piyush Agarwal, Chungqi Zheng, Xuan Yi Ang, Yuying Zhou, Karen Ke Lin, James Lourembam* (Institute of Materials Research and Engineering, Agency for Science, Technology and Research, Singapore 138634)

Two-dimensional (2D) ferroelectric materials are primed to drive rapid advancements in quantum and optoelectonic technologies. Niobium oxyhalides are a class of 2D ferroelectric materials that are predicted to have spontaneous polarisation in tens of $\mu\mathrm{C\,cm^{-2}}$. Here, we demonstrate broadband and efficient THz emission from tens of nanometer niobium oxyhalides, where the emission is dominated by optical rectification, a second-order nonlinear optical process. They exhibit strong anisotropy, and the pump polarisation significantly affects THz emission due to the orientation-sensitive optical rectification governed by the anisotropic second-order nonlinear susceptibility ($\chi^{(2)}$). This polarisation dependence offers insight into crystal symmetry and supports the development of tunable THz sources and polarisation-sensitive devices for spectroscopy and quantum sensing.

PO.52 Higher A-infinity-categorification of Floer Homologies

Arif Er*, Meng-Chwan Tan (NUS)

In this presentation, I show how, via a 3d gauged Landau-Ginzburg model interpretation of certain topologically-twisted 5d N=2 and 8d N=1 gauge theories, one can derive novel Fueter type A-infinity-2-categories that 2-categorify the 3d-Haydys-Witten, Haydys-Witten, and holomorphic Donaldson-Thomas Floer homology of two, four, and five-manifolds, respectively. In the 8d case, one can also derive higher A-infinity-categories, such as a novel Cauchy-Riemann-Fueter type A-ininfity-3-category that 3-categories the Haydys-Witten Floer homology of four-manifolds via a 4d gauged Landau-Ginzburg model interpretation of the theory. Together with our previous results from [arxiv:2410.18575] and [arxiv:2311.18302], this work extends the scheme of categorifying gauge-theoretic Floer homologies we previously developed to higher categories, and furnishes purely physical proofs and generalizations of the mathematical conjectures by Bousseau, Doan-Rezchikov, and Cao.

PO.55 EELSMapper: Automated Unsupervised Phase Mapping in High-Resolution STEM-EELS for Material Discovery

Zhen Yuan Yeo*, Wenhui Lai, Jong Hak Lee, Deepan Balakrishnan, Barbaros Özyilmaz, N. Duane Loh (Department of Statistics and Data Science, National University of Singapore)

High-resolution Scanning Transmission Electron Microscopy-Electron Energy Loss Spectroscopy (STEM-EELS) enables detailed chemical characterization of novel battery materials, but high noise and absent reference spectra pose challenges. We present an unsupervised machine learning workflow to identify phases in silicon-carbon composite anodes. Using background subtraction, principal component analysis (PCA), and Uniform Manifold Approximation and Projection (UMAP) with k-means clustering, we group spectral signatures from Si L-edge, C K-edge, and O K-edge. Mutual information analysis reveals co-occurring phases, identifying SiC, SiO_2, and elemental Si. Validated against reference spectra, this approach maps local chemical heterogeneity, bypassing reliance on incomplete databases. This method accelerates phase characterization in noisy, high-resolution data, with applications in battery optimization and materials discovery. We developed the eelsmapper Python package to automate this data processing pipeline.

PO.56 Modeling the Thermodynamic Stability of Halide Perovskites Nanocrystals with B-site Alloying

Leng Ze Tang, Xufa Huang, Zhidong Leong*, Yun Liu* (Institute of High Performance Computing (IHPC), A*STAR)

Lead toxicity remains one of the main challenges to the commercialization of halide perovskite nanocrystals (NCs). Beyond reducing lead content, the partial substitution of Pb^{2+} with suitable divalent cations offers a promising strategy to tune optoelectronic properties and enhance stability. Recent advances in synthesis techniques, including high-entropy alloying, have enabled stable NCs with over 50% Pb replaced at room temperatures. However, experimental identification of the exact phases remains challenging. Instead, computational techniques can explore a wider compositional space at a fraction of the cost. In this work, we investigate the thermodynamic stability of orthorhombic $Cs(M_xPb_{(1-x)})Br_3$ ($0.01 \leq x \leq 0.99$), where M = Sr, Ca, Cd, or Mg. Density Functional Theory (DFT) was used to compute configurational energies across various alloying ratios. To accelerate predictions over a large compositional space, machine learning (ML) models were trained on the DFT data using cluster expansion

(CE) parameters. Subsequently, these ML models were employed in simulated annealing of NC supercells to construct phase diagrams and identify the transition temperatures. Our results show that kernel ridge regression outperforms regularized linear CE methods in predictive accuracy, demonstrating the importance of nonlinear models in capturing lattice distortion effects from alloying. Among the systems studied, $Cs(Sr_xPb_{(1-x)})Br_3$ exhibits phase transitions well below room temperatures, while other systems typically show transitions near or above room temperatures. By starting with binary substitutions, this work paves the way for designing and understanding more complex, lead-reduced perovskites.

PO.60 Small hole polarons in yellow phase δ-$CsPbI_3$

Yun Liu* (Institute of High Performance Computing (IHPC), Agency for Science Technology and Research (A*STAR))

A heterophase containing both the optically active α-$CsPbI_3$ and nonactive δ-$CsPbI_3$ has been demonstrated as an efficient white light emitter. This has challenged the conventional perspective that nonactive phases of perovskites are undesirable in any metal halide perovskite-based optoelectronic devices. To understand the role that yellow phase δ-$CsPbI_3$ plays in the light- emission process, we performed a systematic computational study on its electronic and optical properties, which are unexplored in the literature. Using the Fröhlich model we showed that both the electron and hole exhibit moderate coupling to longitudinal optical phonons. Explicit density functional theory calculations show that small hole polarons exist with a formation energy of -96 meV, corresponding to the contraction of the Pb-I bonds within a [PbI6] octahedron. Nudged elastic bands calculations show that the hole polaron can hop into neighboring [PbI6] octahedral sites with a small activation barrier of 2.1 meV. Molecular dynamics simulations also show that the hole polaron exhibit periodic localization and delocalization behavior similar to carrier hopping with a characteristic lifetime of 0.3 ps. Our results have elucidated the role that δ-$CsPbI_3$ plays in the self-trapped emission in perovskite-based white light emitting diodes by supporting the presence of the localized small hole polaron.

PO.62 Multi-Party Quantum Key Distribution with All-Transparent Optical Routers

Justin Peh*, Hou Shun Poh*, Alexander Ling, Christian Kurtsiefer (Centre for Quantum Technologies, National University of Singapore)

Quantum Key Distribution (QKD) is a point-to-point protocol that requires an all-transparent fibre route between the parties. In this work, using our previously developed all-transparent optical router, we demonstrated continuous QKD on a 3-node mesh network with polarisation-entangled photon pairs. The parties generate shared keys pairwise via time-division multiplexing.

PO.64 A Unified Approach to Quantum Contraction and Correlation Coefficients

Ian George*, Marco Tomamichel* (National University of Singapore)

In classical information theory, the maximal correlation coefficient is used to establish strong limits on distributed processing. Through its relation to the χ^2-contraction coefficient, it also establishes fundamental bounds on sequential processing. Two distinct quantum extensions of the maximal correlation coefficient have been introduced to recover these two scenarios, but they do not recover the entire classical framework. We introduce a family of non-commutative L2(p) spaces induced by operator monotone functions from which families of quantum maximal correlation coefficients and the quantum χ^2-divergences can be identified. Through this framework, we lift the classical results to the quantum setting. For distributed processing, using our quantum maximal correlation coefficients, we establish strong limits on converting quantum states under local operations. For sequential processing, we clarify the relation between the data processing inequality of quantum maximal correlation coefficients, χ^2-contraction coefficients, and f -divergences. Moreover, we establish the quantum maximal correlation coefficients and χ^2-contraction coefficients are often computable via linear algebraic methods, which in particular implies a method for obtaining rigorous, computable upper bounds for time-homogeneous quantum Markov chains with a unique, full rank fixed point.

PO.66 Asymmetric spintronic terahertz emission

Piyush Agarwal, Avinash Chaurasiya, Yuying Zhou, Lisen Huang, James Lourembam, Rajdeep Singh Rawat*, Karen Ke Lin* (Institute of Materials Research and Engineering, Agency for Science, Technology and Research, Singapore 138634)

Spintronic terahertz (THz) devices have emerged as a promising candidate for next-generation THz technologies, offering low-cost, scalable solutions for data processors. Their sensitivity to external magnetic fields makes them attractive for ultrafast spintronic memory applications, particularly for writing operations in magnetic random-access memory (MRAM). However, the readout operation involves a fundamental challenge that requires comparing the electrical signal against a reference value. To address this, a magnetically insensitive reference signal is essential for reliable data processing. In this work, we present, for the first time, a hybrid approach that combines magnetic field-sensitive and field-insensitive THz charge current within a single platform. This is achieved by leveraging properties from a bare ferromagnetic layer deposited over a quartz substrate, which generates two independent current sources separated by approximately 2 ps. Hence, the resulting far-field THz waveform consists of both magnetic-field-sensitive and -insensitive components, while the magnetic-field-sensitive THz pulse exhibits strong asymmetry as a function of the device's azimuthal angle, incident laser polarization, and excitation intensity. Our results offer a novel pathway for the coherent control of THz phase and amplitude, enabling new strategies for integrated THz photonics and advancing the development of ultrafast spintronic memory devices.

PO.71 NQSN Testbed: A fully interoperable quantum-safe network with versatile reference applications

Hao Qin*, Jing Yan Haw*, Matthew Wee, Romain Frappier, Cassey Liang, Xiao Duan, Yu Cai, Sanat Sarda, Kaiwei Qiu, Ramana Murthy, Tosanut Rimprongern, Biplab Sikdar, Nelly Ng, Christian Kurtsiefer, Michael Kasper, Alexander Ling* (Centre for Quantum Technologies, National University of Singapore)

We present the strategic framework and technical foundations of the National Quantum-Safe Network (NQSN) Testbed — a resilient and fully interoperable quantum-safe network. Built on a star-topology architecture over production-grade fiber infrastructure, the testbed supports multi-protocol quantum key distribution (QKD), post-quantum cryptography (PQC) and accommodates diverse applications from multiple vendors. Interoperability is enabled by a centralized key and network management system, ensuring seamless integration across heterogeneous technologies. We showcase a range of reference applications, including secure data center interconnects, edge computing, hybrid QKD–post-quantum cryptography (PQC) encryption, and multi-layer integration within the OSI stack. These implementations underscore the feasibility and adaptability of deploying quantum-safe technologies in complex, multi-input, multi-output network environments. The presentation will also preview upcoming efforts in the new phase of the testbed, including node expansion, ongoing experiments, and explorations into satellite-enabled capabilities.

PO.73 Conditions of tabletop reversibility: when is Petz recovery cost-free?

Minjeong Song*, Hyukjoon Kwon, Valerio Scarani (Centre for Quantum Technologies)

A Petz recovery map offers a near optimal recovery although open quantum dynamics are inherently irreversible. However, its experimental implementation has been found challenging due to its innate complex definition. In this work, we present conditions when the Petz recovery map can be realized in not only experiment friendly but also cost effective way.

PO.76 State learning from pairs of states

Martin-Isbjoern Trappe*, Berge Englert (Centre for Quantum Technologies)

Consider the following quantum tomography problem: given a sequence of qubits from two unknown pure states, estimate those states. While this is impossible with single-copy inputs, we show how the unknown states can be reconstructed with high fidelity from measuring a sequence of qubit pairs. Measuring a few thousand pairs with existing technology (based on single-qubit tetrahedron POVM) yields sufficient accuracy. We extracted the maximum likelihood estimators for the true states from simulated data using an in-house implementation of a covariance matrix adaptation evolution strategy (CMA-ES) for global optimization of challenging objective functions. This work had been published in PRA 111, 062428 (2025), in collaboration with P. Agarwal, N. Ali, C. Polvara, and M. Hillery (Hunter College, NY). Based on this tomograhy scheme, we propose a novel QKD protocol (akin to B92, but with private states).

PO.77 Impact of Annealing on The Performance of Next-Gen Ru Interconnects

Devshan Fernando*, Ivan Erofeev, Antony Hartanto, Harold Philipsen, Antoine Pacco, Frank Holsteyns, Utkur Mirsaidov (National University of Singapore)

The recent surge in demand for computational performance, combined with stringent constraints on energy consumption necessitates continued scaling of transistors and memory cells densities in integrated circuits. However, conventional metal interconnects face significant challenges in downscaling due to materials limitations at the nanoscale, resulting in considerable performance degradation. To address this, next-generation interconnects require alternative materials. Ruthenium (Ru) has emerged as a leading candidate1, offering low resistivity, excellent scalability, and barrierless integration at a reduced cost. Nonetheless, its practical application is hindered by the requirement for annealing at temperatures far above the currently accepted limit2. In this study, we investigate the effect of high-temperature annealing on grain size and electrical resistivity in patterned Ru nanowires (NWs). Using transmission electron microscopy (TEM) with in situ heating, we directly observe the real-time structural evolution of the NWs. Additionally, we introduce a Phase Field Model (PFM) as a predictive computational framework for evaluating and optimizing annealing conditions in metal nanostructures.

PO.79 Laser Initiated Site-selective Formation of Fluorescing Silver-Iron Oxide Nanocomposites for Electron Detection

Yue Yin, Aseera Jannath, Zheng Zhang, Chorng Haur Sow*, Sharon Lim* (National University of Singapore)

There has been continual interest in the fabrication of silver-iron oxide composite nanostructures due to its effectiveness in antimicrobial, catalytic and sensing applications. However, traditional processes involve multiple steps and harsh conditions, making them time consuming and energy intensive. A focused laser beam is used as an alternative tool to fabricate fluorescing silver iron-oxide composite nanostructures. The rapid thermal annealing and quenching process leads to uniformly distributed particles that form site-selectively in the lasered regions. Performed without demanding conditions or any additives, this process is more precise, energy and cost-efficient compared to traditional methods. Presence of Ag within the composite enhances the intrinsic fluorescence of Fe_3O_4 by more than 10 times through surface plasmon resonance effects. This exclusive trait turns the composite into an effective micro-beta particle detector with in-situ optical feedback. This work offers a glimpse to the benefits of developing alternative synthesis processes as a means to uncover alternative applications.

PO.82 Quantum-Limited Optical Vector Analysis

Karthik Dasigi*, Pavel Dmitriev, Kah Jen Wo, Fumiya Hanamura, Steven Touzard (CQT, NUS)

Optical Vector Analysers (OVA) are critical for emerging technologies such as integrated photonics and optical positioning. Achieving a sensitivity near the Standard Quantum Limit (SQL) while acquiring a wide spectrum allows an accurate measure- ment of targets that are fragile, non-linear, or that scatter most of the probe light away. While existing OVAs operate with both high frequency accuracy and high dynamic range, their sensitivity remains orders of magnitude below the SQL. In this paper, we use a free-running Mach-Zehnder Interferometer as a quantum-limited OVA, with a frequency range of 20 THz. We introduce methods to mitigate the phase noise and obtain a unit signal-to-noise ratio for powers at the fW level. We apply this technique towards quantifying the fabrication quality of microring resonators in thin-film lithium Niobate. Our characterisation yields a signal-to-noise ratio above 1 with much less than 1 circulating photon and reveals a quality factor above 5 millions, unambiguously attributed to low internal losses.

PO.84 Towards Entangling a Superconducting Qubit to Erbium Defects

Kritika Mundeja*, Sakshi Mishra, Zhikun Han, Steven Touzard* (CQT, Department of Materials Science and Engineering, Department of Physics, NUS, Majulab Sinagpore)

Superconducting circuits are promising candidates for building quantum processors due to their scalability, design flexibility, fast gate operations and high fidelity. However, their operation at microwave frequencies presents challenges for integration with existing telecommunication infrastructure which relies on optical fibres for long-distance signal transmission at room temperature. To bridge this frequency gap, we explore the use of rare-earth ions, specifically Erbium ions, as intermediaries for achieving fast and reliable optical-microwave entanglement. Erbium ions in solids offer unique advantages for quantum information storage and processing, with their fine structure and Zeeman splitting enabling coupling to both optical and microwave photons. This capability makes them a powerful candidate for mediating interactions between superconducting circuits and optical networks.

Our initial focus is on entangling an ensemble of Erbium ions with a superconducting Transmon qubit through a microwave cavity. By leveraging the strong collective coupling previously demonstrated in other platforms, we align the Zeeman splitting of Erbium ions with the microwave regime of our superconducting cavity. Additionally, we implement chirped pulse sequences to efficiently retrieve excitations stored in the ensemble. These techniques allow us to control quantum states in this hybrid system. This poster presents our entanglement protocol and experimental results, showcasing long spin coherence times, good spin-resonator cooperativity and high Transmon qubit coherence in a magnetic field. Our work represents a significant step toward the seamless integration of superconducting circuits with optical quantum networks, paving the way for scalable quantum communication and hybrid quantum computing architectures.

PO.85 Light-matter interaction via Lithium Niobate Ring Resonators

Kah Jen Wo*, Karthik Dasigi*, Fumiya Hanamura*, Steven Touzard*, Di Zhu, Pavel A. Dmitriev*, Lingda Kong (CQT, NUS)

A critical component in the realisation of a global quantum network is the coupling between photons at the optical and microwave frequencies. A well-known promising candidate to build the key quantum light-matter device are rare earth ions (REIs). However, to achieve efficient optical interface with the REIs, a tuneable high quality factor resonator is required to leverage Purcell enhancement. Here, we focus on the application of thin film lithium niobate (LN) photonic integrated chips, incorporating microring resonators, to interface with an erbium-doped calcium tungstate ($CaWO_4$) host crystal.

PO.86 On-Surface Synthesis and Electronic Characterization of 2D Conjugated Metal-Organic Frameworks on Transition Metal and vdW Substrates

Chengkun Lyu* (Institute of Materials Research and Engineering, A*STAR)

Two-dimensional conjugated metal–organic frameworks (2D c-MOFs) are a class of low-dimensional materials that host extended π-electron delocalization and exhibit rich quantum phenomena, including magnetic ordering, Dirac-like band structures, and potential topological phases. These characteristics make them attractive for next-generation electronic, spintronic, and quantum devices. Despite considerable theoretical interest, the bottom-up synthesis of high-quality monolayer c-MOFs with controlled coordination geometry and electronic structure remains a formidable challenge. In this work, we present a systematic investigation into the formation and electronic properties of M_3HAT_2 frameworks (M = Ni, Co, Fe, Cu; HAT = 1,4,5,8,9,12-hexaazatriphenylene) fabricated via on-surface coordination reactions [1]. Using scanning tunneling microscopy and spectroscopy (STM/STS) in conjunction with density functional theory (DFT), we study the structural motifs, electronic orbital coupling, and site-specific states of these frameworks on multiple substrates, including coinage metals (e.g., Au(111), Ag(111)) and layered van der Waals (vdW) materials (e.g., MoS_2) [2,3]. We find that the M_3HAT_2 frameworks exhibit metal-specific behaviors in lattice symmetry, adsorption configuration, and electronic resonance features [4]. Notably, the structure formed on MoS_2 closely resembles the ideal free-standing geometry, with minimal substrate-induced distortion or electronic hybridization [3]. This observation highlights the critical role of vdW substrates in preserving the intrinsic properties of c-MOFs and facilitating the realization of electronically decoupled, quantum-confined 2D lattices. Our results provide fundamental insights into the interplay between coordination chemistry, electronic structure, and interfacial coupling. This study not only advances the mechanistic understanding of on-surface MOF synthesis but also establishes design guidelines for integrating 2D c-MOFs with device-compatible platforms for functional applications in quantum materials research. References: [1] Lyu, C.; Gao, Y.; Gao, Z.; Mo, S.; Hua, M.; Li, E.; Fu, S.-Q.; Chen, J.-Y.; Liu, P.-N.; Huang, L.; Lin, N. Angew. Chem., Int. Ed. 2022, 61, e202204528. [2] Lyu, C.; Gao, Y.; Zhou, K.; Hua, M.; Shi, Z.; Liu, P. N.; Huang, L.; Lin, N. ACS Nano 2024, 18, 19793-19801. [3] Lyu, C.; Wong, C. P. Y.; Gao, Y.; Wang, X.; Huang, L.; Goh, K. E. J.; Lin, N. Surf. Sci. 2024, 122594. [4] Lyu, C.; Chen, Y.; Hua, M.; Mo, S.; Gao, Y.; Wang, X.; Huang, L.; Lin, N. Nanoscale 2025, in press.

PO.96 Local Thermal Operations and Classical Communication

Rafał Bistroń, Jakub Czartowski* (Nanyang Technological University)

In quantum thermodynamics, understanding the interplay between locality, thermal constraints, and communication remains an open challenge. In this manuscript, we introduce Local Thermal Operations and Classical Communication (LTOCC), a novel operational framework that unifies the distant laboratories paradigm with thermodynamic restrictions, defining the fundamental limits on transformations between spatially separated systems. We establish a hierarchy of LTOCC protocols, demonstrating inclusion relations between different levels and revealing their deep connection to semilocal thermal operations. To formalize this framework, we develop thermal tensors and bithermal tensors, extending tristochastic tensors to thermodynamic settings and providing new mathematical tools for constrained quantum processes. Furthermore, we explore the role of LTOCC in approximating logical gates such as CNOT and SWAP and investigate its potential to generate correlations between distant systems.

PO.97 Coherent Photoelectric Spin Readout of Boron Vacancy Defects in Hexagonal Boron Nitride

Shihao Ru*, Fedor Jelezko, Weibo Gao (NTU SPMS-PAP)

Negatively charged boron vacancy (VB-) in hexagonal boron nitride (hBN) is the most extensively studied room-temperature quantum spin system in two-dimensional (2D) materials. Nevertheless, the current effective readout of VB- spin states is carried out by systematically optical methods. This limits their exploitation in compact and miniaturized quantum devices, which would other-wise hold substantial promise to address quantum sensing and quantum information tasks. In this study, we demonstrated a photoelectric spin readout technique for VB- spins in hBN. The observed photocurrent signals stem from the spin-dependent ionization dynamics of boron vacancies, mediated by spin-dependent non-radiative transitions to a metastable state. We further extend this electrical detection technique to enable the readout of dynamical decoupling sequences, including the Carr-Purcell-Meiboom-Gill (CPMG) protocols, and of nuclear spins via electron-nuclear double resonance. These results provide a pathway toward on-chip integration and real-field exploitation of quantum functionalities based on 2D material platforms.

PO.99 On-Chip Topological Beamformer for Terahertz 6G to XG Wireless

Wenhao Wang*, Yi Ji Tan, Thomas Caiwei Tan, Abhishek Kumar, Prakash Pitchappa, Pascal Szriftgiser, Guillaume Ducournau, Ranjan Singh* (University of Notre Dame)

Terahertz (THz) wireless communication holds immense potential to revolutionize future 6G to XG networks with high capacity, low latency, and extensive connectivity. Efficient THz beamformers are essential for energy-efficient connections, compensating path loss, optimizing resource usage, and enhancing spectral efficiency. However, current beamformers face challenges including significant loss, limited bandwidth, constrained spatial coverage, and poor integration with on-chip THz circuits. We present an on-chip broadband THz topological beamformer using valley vortices for waveguiding, splitting, and perfect isolation in waveguide phased arrays, featuring 184 densely packed valley-locked waveguides, 54 power splitters, and 136 sharp bends. Leveraging neural network-assisted inverse design, the beamformer achieves full 360° azimuthal beamforming with gains of up to 20 dBi, radiating THz signals into free space with customizable user-defined beams. Photoexciting the all-silicon beamformer enables reconfigurable control of THz beams. The low-loss and broadband beamformer enables a 72 Gbps chip-to-chip wireless link over 300 mm and eight simultaneous 40 Gbps wireless links. Using four of these links, we demonstrate point-to-4-point real-time HD video streaming. Our work provides a complementary metal-oxide-semiconductor (CMOS) compatible THz topological photonic integrated circuit for efficient large-scale beamforming, enabling massive single-input multiple-output (SIMO) and multiple-input and multiple-output (MIMO) systems for terabit-per-second 6G to XG wireless communications.

PO.101 On-Chip Topological Edge State Cavities

Wenhao Wang*, Zhonglei Shen, Yi Ji Tan, Kaiji Chen, Ranjan Singh* (University of Notre Dame)

Confining light in an on-chip photonic cavity with strong light-matter interactions is pivotal for numerous applications in optical and quantum sciences. Recently, topological valley photonics has introduced new schemes for light confinement with topological protection, enabling robust on-chip light manipulation. Here, we present a topological edge state cavity that confines light within a topological bandgap while robustly guiding it to circulate around the cavity via topological edge states. We demonstrate a giant enhancement in the intrinsic quality factor by three orders of magnitude, while simultaneously increasing the free-spectral range by 139% through tailoring the radiation leakage and group index of topological valley edge state. Our work provides a novel and robust on-chip cavity platform for a wide range of applications, including high-capacity communications, nonlinear optics, atomic clocks, and quantum photonics.

PO.102 Scaling of quantum entanglement in spin-1 chains with unfrustrated long-range interactions

Mohitha Adira*, Pinaki Sengupta (SPMS, NTU)

We study a spin-1 chain with long-range Heisenberg exchange interactions decaying as $J_r \propto (-1)^{r-1}/r^{\alpha}$, which preserves bipartiteness while enhancing connectivity. These interactions induce a quantum phase transition from the topologically non-trivial Haldane phase to a symmetry-broken AFM ordered phase as α is varied. Understanding this transition not only provides deeper insights into the robustness of the Haldane phase, but also sheds light on the nature of quantum criticality in systems with long range interactions. In particular, we explore the possibility of a deconfined quantum critical point in one dimension in $S > 1/2$ spin systems.

PO.106 Qutrit unitary gates in ^{87}Sr using optimal control

Chirantan Mitra*, Lucas Gabardos, Chang Chi Kwong, David Guéry-Odelin, David Wilkowski, Francois Impens (Nanyang Technological University)

The precise control of quantum systems has been pivotal in developing technologies based on qubits. A key area of interest lies in manipulating quantum states in higher-dimensional Hilbert spaces, such as qutrits, which promise significant advantages in quantum simulation [1] and quantum information processing [2; 3]. However, state preparation in these systems is often hindered by the number of SU(2) rotations needed to realize a unitary operation [4]. Here, we report the experimental progress on using optimal control to design single-step qutrit unitary operations in an ultracold gas of ^{87}Sr atoms. The unitary operations optically encode the qutrit onto the three $^1S_0$ nuclear spin states in a tripod system while minimizing the population in the long-lived excited state of $^3P_1$. The experimental gate fidelity is expected to be mainly limited by the residual spontaneous emission and the atomic velocity, the latter of which can be circumvented in other experiments by pinning the atoms in an optical tweezer. The ability to control multiple internal states using engineered optical unitary operations could become a powerful tool in quantum information processing and atom interferometry sequences.

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PO.107 MANTIS: Multiple Anomaly-Detection Networks for Tensor Inspired Solutions

Si Min Chan*, Apimuk Sornsaeng*, Dario Poletti* (Singapore University of Technology and Design)

Anomaly detection is vital across a wide range of applications, from cybersecurity to quality assurance, where the goal is to identify fraudulent activities or unexpected patterns in data. A central challenge in this task is that models are typically trained only on normal data, while anomalies—by nature—are diverse and sparse, occupying a virtually unbounded space. With advanced technologies, neural networks have been used to for detection and classification, but explainability remains a challenge. Tensor networks, originally developed in quantum many-body physics, have been identified recently as an alternative framework, providing additional benefits of efficiency and scalability. By leveraging their ability to compactly represent high-order correlations in data, tensor networks can serve as interpretable and data-efficient models.

In this work, we train a new model of tensor networks defined as the superposition of multiple bond dimension-one matrix product operators. The novel model that we implement is advantageous as it is highly parallelizable, explainable, and lightweight. We demonstrate how tensor network representations can be trained to model the typical behavior of a dataset and subsequently identify anomalies with features that deviate significantly from the learned structure. Our approach shows promising performance on benchmark datasets, achieving competitive accuracy while offering significant advantages in terms of model size and interpretability. These results suggest that superpositions of bond-dimension one tensor networks offer a new physics-inspired toolkit for scalable and explainable anomaly detection in complex data environments.

PO.108 SNRSI Public Education and Outreach

Zhengxin Liang*, Keng Yeow Chung (Singapore Nuclear Research and Safety Institute)

The Singapore Nuclear Research and Safety Institute’s (SNRSI) Outreach Team aims to dispel common misconceptions about nuclear energy through a range of activities that engage different segments of the public. Leveraging SNRSI’s technical expertise and its international and local collaborations, these educational activities may include lectures, workshops, and hands-on demonstrations. Such activities aim to engage members of the public and foster a deeper understanding of current nuclear technologies and radiation safety. Drop by to learn more about our outreach activities!

PO.109 SNRSI Research Work

Singapore Nuclear Research And Safety Institute* (Singapore Nuclear Research and Safety Institute)

The Singapore Nuclear Research and Safety Institute (SNRSI) was officially launched on 11 July 2025. SNRSI concentrates expertise and knowledge in nuclear technology and safety under one institute, and aims to sustain a critical mass of professionals across a range of nuclear-related activities relevant to Singapore and the region. This is achieved through a combination of scholarships, research excellence, education, and outreach initiatives. The research team comprises experts from a wide range of disciplines, including nuclear engineering, physics, chemistry, biology, materials science, law, and policy studies.

PO.110 Internal Dynamics of Anyon Cluster in Fractional Quantum Hall Fluids

Qianhui Xu*, Guangyue Ji, Bo Yang*, Yuzhu Wang, Ha Quang Trung (SPMS-NTU)

We investigate the effective interactions between anyons emerging from either model or realistic bare electron-electron (e-e) interactions in Laughlin and Moore-Read fractional quantum Hall (FQH) fluids. Instead of being purely repulsive or attractive, such anyons display rich internal dynamics with interesting experimental consequences. Two Laughlin anyons prefer to form bound states with short-range e-e interactions, leading to $2e/3$ bunched quasiholes at low temperatures instead of the $e/3$ quasiholes. In non-Abelian Moore-Read FQH phases, two $e/4$ quasiholes can fuse into topologically distinct "1" or "ψ" anyons that are no longer degenerate with realistic two-body e-e interaction. This suggests the possibility of energetically separating and manipulating the two types of anyons by tuning the bare electron-electron interactions. We propose that the recently developed high-resolution STM measurements can be used to probe effective anyon interactions when anyons are clustered together after the tunneling of electrons. The local density of states from the energetics of the various bound states of anyon clusters is simulated for both Abelian and non-Abelian systems with (screened) Coulomb interactions.

PO.114 Topological robustness of quantum skyrmions in complex media

Chenjie Zhang*, Zhenyu Guo, Anton Vetlugin, Yijie Shen* (NTU)

The degradation of quantum coherence induced by complex media such as atmospheric turbulence and obstacles constitutes a critical barrier to the practical implementation of quantum information technologies. The environmental perturbations not only induce modal distortions in quantum states but also cause significant deterioration of quantum entanglement characteristics. Through the construction of a quantum skyrmion system incorporating complex media, this study reveals a breakthrough phenomenon: While quantum skyrmions undergo diminished entanglement in complex media, their topological characteristics maintain exceptional stability against external perturbations, demonstrating intrinsic topological protection mechanisms. We established a dynamical model linking environmental perturbations to quantum state evolution using spiral imaging techniques, and rigorously demonstrated the intrinsic mechanism of topological robustness through coordinate transformation theory. Experimental and theoretical studies jointly confirm that quantum skyrmions can preserve the integrity of topological information without requiring error correction. This discovery resolves the long-standing challenge of stable quantum information transmission in complex media, providing an interference-resistant framework for practical applications including satellite-to-ground quantum communication and distributed quantum network.

PO.120 Rotational Spectroscopy and Magic 3D Optical Lattices for Ultracold ^{6}Li^{40}K Molecules

Xiaoyu Nie*, Victor Avalos*, Hao Lin Yu*, Yiming Liu*, Anbang Yang*, Kai Dieckmann* (CQT, NUS)

We report our progress in achieving long coherence times for ^{6}Li^{40}K molecules confined in magic 3D optical lattices. Our study begins with rotational spectroscopy of the J=1 hyperfine structure at 215.5 G.

Through precise measurement and analysis of transition frequencies to excited rotational states, we extract the hyperfine interaction constants. A specific stretched state transition is further investigated. In a 1070 nm optical dipole trap, the coherence time is limited to approximately 10 microseconds. To extend the coherence time, we perform frequency-dependent polarizability calculations for both the ground state and the first rotationally excited state of ^{6}Li^{40}K. Spin-orbit coupling between A1S and b3Pi reveals a critical transition from ground state molecules to the $\left|b^3\Pi, \nu = 0, J = 1\right\rangle$ state at 314.2305 THz. Experimentally, we calibrate the polarizability spectra and identify a broad, far-detuned magic wavelength where the differential light shift across the trap is negligible. Magic points happen at detunings of -8.9 GHz (for 90° laser polarization) and +6.8 GHz (for 0° laser polarization) relative to the nearest transition. At the +6.8 GHz magic point, the differential polarizability changes by only 70 mHz/(W/cm^2) as laser intensity varies from 0 to 7 kW/cm^2. Based on these results, we have constructed a 3D magic optical lattice, with fine-tuning of coherence optimization is currently underway.

PO.122 Towards High-Fildeity Single- and Two-Qubit Operations on a Neutral Atom Array Processor

Kai Xiang Lee*, Jintao Yang*, Mujahid Aliyu, Vasu Dev, Ahbishek Jamunkar, Zhengjiang Li, Kelvin Lim, Vincent Mancois, Subrahmanyam Mantha, Boon Long Ng, Thanh Nguyen, Tong-Yan Xia, Jinyu Zhou, Zilong Chen*, David Wilkowski* (Centre for Quantum Technologies)

We report on the progress toward development of 200-qubit quantum processors based on reconfigurable Cs neutral atom arrays. Single-qubit operations will be realised through Raman transition on the D1 line, and the two-qubit operation will be performed via the $^7P_{3/2}$ intermediate state to the nS Rydberg orbitals. We describe our designs for the low-noise laser system used to realise these operations, and our estimated error budgeting breakdown.

PO.123 A Gate-tunable Ambipolar Quantum Phase Transition on in a Topological Excitonic Insulator

Yande Que*, Bent Weber (School of Physical and Mathematical Sciences, Nanyang Technological University)

Topological excitonic insulator (TEI) is an exotic state of mater that uniquely combines highly correlated insulating ground state due to the strong Coulomb interactions among electrons and holes in 2D semimetals, with non-trivial band topology. Here, via molecule-beam epitaxy, low-temperature scanning tunnelling microscopy, as well as k·p tight-binding calculations, we present a direct evidence for the TEI state in WTe2 monolayers through a gate-tunable quantum phase transition (QPT). The interplay of topology and 2D correlated excitonic condensation might further allow to realize recent predictions of 2D triplet superconductivity with an excitonic pairing mechanism.

PO.125 Unveiling the Influence of Fourth-Order Dispersion on Modulational Instability

Amdad Chowdury*, Dawn Tan* (SUTD)

Modulational instability amplifies small perturbations on a carrier wave, generating periodic high-intensity pulses and new spectral components. We investigate how fourth-order dispersion shapes this process and influences the Akhmediev breather, an exact solution of the nonlinear Schrödinger equation. Our results show that weak fourth-order dispersion triggers strong resonant radiation, leading to the disappearance of the Akhmediev breather and a broad spectral expansion; intermediate dispersion reduces both radiation and spectral width; while strong fourth-order dispersion results in the resurgence of the Akhmediev breather. These findings highlight how fourth-order dispersion governs energy exchange among phase-matched components, enabling the formation of complex yet coherent temporal patterns.

PO.128 Improved gate fidelity by phase noise suppression

Jia-Yang Gao*, Clarence Liu Huihong, Jasper Phua Sing Cheng, Jianwei Lee, Morteza Ahmadi, Pei Jiang Low, Subhadeep Chakraborty, Manas Mukherjee* (CQT NUS)

Laser phase noise is one of the limiting factors that dictate the gate fidelities in trapped-ion quantum systems. Previously, we observed that when the Rabi frequency is close to the servo bump phase-noise frequency, the driving laser limits the fidelity. To address this issue, we developed a phase-noise stabilization setup for a 1762 nm laser that drives a qubit transition in barium ions, employing an electro-optic modulator (EOM) with an electrical feedforward servo. Our results demonstrate that this setup can suppress servo-bump phase noise by up to 15 dB near the bump peak frequency. The laser phase noise is analyzed using delayed self-heterodyne interferometry (DSHI). We also tested the stabilized beam with a Doppler cooled single ion in our trap. Based on Rabi oscillation near servo bump frequency, we observed an improvement in the coherence time from 3.69 μs to 21.73 μs.

PO.136 Efficient Estimation of Local Observables through Concentrated Monte Carlo Sampling

Wenxuan Zhang*, Dario Poletti* (Singapore University of Technology and Design)

Monte Carlo methods are widely used for estimating observables in quantum many-body quantum systems. However, conventional sampling schemes often require a large number of samples to achieve sufficient accuracy. In this work, we propose the concentrated Monte Carlo sampling (CMCS) approach, which focuses sampling efforts on the relevant local subspaces of the configuration space. By extracting unique samples and assigning exact probabilities, our results demonstrate that CMCS yields higher accuracy for local observables in short-range correlated states while requiring substantially fewer samples. This approach provides a promising direction for efficient simulations of thermal states and could be extended to accelerate variational and neural-network based Monte Carlo frameworks.

PO.137 Development and Characterization of 8-Qubit Quantum Processor

Rangga Perdana Budoyo*, Long Hoang Nguyen, Rasanayagam Kajen, Paul Tan, Rainer Dumke (Centre for Quantum Technologies)

We discuss the recent progress in the development and characterization of our 8-qubit quantum processor. We have improved the fabrication yield as well as the spread in junction resistance, allowing more accurate qubit frequencies. Additionally, changes in packaging design and suppression of parasitic modes result in improved and more consistent qubit coherence times. Finally, we describe the initial attempt of applying 2-qubit cross-resonance gate on the chip and discuss further experiments and improvements.

PO.140 QUANTUM SIMULATION WITH ULTRACOLD FERMIONS

Haotian Song*, Rishav Koirala*, Kai Dieckmann* (Center for quantum technologies)

We report progress towards quantum simulation of localization effects in disordered two-dimensional systems using interacting ultracold fermionic 6Li atoms. Our setup employs a tuneable optical lattice geometry with adjustable trap depths and relative beam phases, allowing access to square and topological honeycomb lattice geometries. RF beat-note stabilization provides control over lattice phase noise, achieving a 40 dB improvement in signal-to-noise ratio. By leveraging the broad Feshbach resonance of 6Li and optical speckle potential strengths up to $\approx$1.8 E_{recoil}, we aim to explore the interplay of strong interactions and disorder within the Fermi–Hubbard model. Quasi-2D confinement in the x-y plane is achieved with an accordion-type lattice in the z-direction, with $\hbar\omega_z/E_{\text{Fermi}} \gtrapprox 5$. Preliminary diffusion experiments on bulk gases demonstrate disorder-induced suppression of transport, with fitted cloud sizes providing quantitative characterization. These advances establish a flexible platform for studying interaction-driven localization in 2D fermionic systems, paving the way for controlled investigations of localization effects in strongly correlated matter.

PO.144 Towards A Pulsed, Non-Degenerate, Polarization Entangled SPDC Source in the Linear Displacement Interferometer Design

Rui Ming Chua*, Yury Kurochkin, Alexander Ling*, James A. Grieve* (Technology Innovation Institute)

Entangled photon-pair sources are an important resource in many types of quantum information technologies. Pulsing expands the possible applications of entangled photon-pair sources due to the clear timing information which it provides. In most cases, sources operate within a single communication band and are subject to the advantages and disadvantages of the single band. In a non-degenerate system, it becomes possible to balance between the advantages and disadvantages of different communication bands to enhance the performance of the system.

In this work, we describe our efforts towards assembling a non-degenerate, polarization entangled, spontaneous parametric down conversion-based (SPDC) photon pair source which operates in the near-infrared (850nm) and telecommunication O-band (1310nm). We determined the spectral characteristics of the source based on Type-0 SPDC phase-matching conditions and validated them with experimental measurements. We anticipate the need for phase compensation in order to obtain high fidelity polarization entanglement due to its broadband spectral characteristics and source configuration and determined multiple suitable solutions to the problem.

PO.146 Efficient z-Transform with Tensor Networks: A Quantum-Inspired Framework

Noufal Jaseem*, Dario Poletti (Singapore University of Technology and Design)

We present a tensor-network formulation of the discrete z-transform. The transform is represented as a matrix-product operator (MPO) acting on an amplitude-encoded signal. The MPO factorizes into an exponential-damping map and a Fourier-phase map. Numerical tests show that the z-transform compresses efficiently to very small bond dimensions, enabling faster runtimes while preserving accuracy.

PO.147 Towards high fidelity, fast gates in 137-Ba+

Clarence Liu*, Jasper Phua*, Subhadeep Chakraborty*, Manas Mukherjee* (Centre for Quantum Technologies)

Single-qubit and two-qubit gates between energy levels separated by a microwave frequency, such as the hyperfine ground states in atoms and ions, benefit from reduced gate times when mediated by Raman laser beams rather than direct microwave radiation. High-powered lasers with tight focusing can generate stronger electric fields than uncollimated microwaves, but high-intensity Raman beams also reduce fidelity through uncompensated differential light shifts and off-resonant photon scattering. Increasing the Raman laser detuning suppresses scattering but lengthens the gate time, requiring higher optical power to compensate. In barium ions, Raman transitions are typically driven with 532 nm lasers, though this wavelength is not necessarily optimal for minimising differential light shifts. We present our ongoing theoretical and experimental efforts to identify the magic wavelength that minimises differential light shifts in Raman transitions applied to the ground-state clock qubits of 137-Ba+, while balancing the competing demands of short gate times and high fidelity.

PO.150 Chalcogen-vacancies in transition metal dichalcogenides: impact on electronic properties and air degradation

Fabio Bussolotti*, Kuan Eng Johnson Goh* (Institute of Materials Research and Engineering)

Semiconducting transition metal dichalcogenides (TMDs) are emerging as key materials for future optoelectronic and valleytronics applications.[1,2] In this context performance and long-term stability of devices are closely related to the TMDs' quality, which is often affected by the presence of defects such as chalcogen vacancies introduced during growth or fabrication. In this presentation, we explore how these vacancies influence both charge injection at metal/TMD interfaces and oxidation in air environment.[3,4] Our findings show that chalcogen vacancies introduce electronic gap states that create a significant electron injection barrier (0.5 eV) at interface with metals, while hole injection remains largely unaffected.[3] Additionally, the air oxidation of TMDs is found to become significant at defect concentrations above 10%, whereas TMDs with lower defect concentrations show longer stability in air environment.[4] Theoretical calculations indicate that single chalcogen-vacancies do not oxidize spontaneously. In contrast, vacancy pairing at higher concentrations facilitates interaction with atmospheric oxygen which accelerates material degradation. These results underscore the importance of controlling defect density in TMDs to optimize devices' performance.

References [1] Goh, K. E. J., et al., Advanced Quantum Technologies 3 (2020) 1900123 [2] Bussolotti, F., et al, Nano Futures 2 (2018) 032001 [3] Bussolotti, F., et al., ACS Nano 15 (2021) 2686 [4] Bussolotti, F., et al., ACS Nano 18 (2024) 8706

PO.152 Randomised measurements for non-Gaussian entanglement certification

Moritz Straeter*, Michael Tsesmelis*, Leong-Chuan Kwek (Centre for Quantum Technologies (CQT))

Entanglement certification of continuous-variable (CV) quantum systems remains a challenging task, particularly as standard criteria based on second-order moments - such as the Duan and Simon inequalities - often fail to detect non-Gaussian entanglement. For discrete-variable quantum systems, randomised measurements are already used to certify entanglement. We explore randomised measurements in a CV setting to certify non-Gaussian entanglement in a truncated Fock space. Furthermore, we explore non-Gaussian entanglement detection using state representations that differ from the standard Fock basis density matrix. Indeed, for classical descriptions of CV quantum states, this density matrix suffers from the curse of dimensionality for high-photon-number entangled states. This work advances the characterisation of non-Gaussian bosonic states, which has the potential to simplify future theoretical and experimental efforts in CV quantum information.

PO.153 Simulating Spin–Photon Coupling in Ge/Si Double Quantum Dot Qubits

Nopparuj Sodsri*, Wister Wei Huang* (National University of Singapore)

Spin-photon coupled quantum-dot-based spin qubits have proven to be a strong candidate for a quantum processor, combining spin qubits' long coherence time with strong photon-mediated interaction that enables long-range coupling, desirable for flexible scaling. However, coupling spin states to a photon requires spin-charge hybridization, wherein charge states serve as an interaction intermediary, and is complicated. In this work, we study the dynamics of a Ge/Si double quantum dot (DQD) spin qubit coupled to a microwave-range cavity in a quantum electrodynamics (QED) resonator. The study can be divided into two main parts. First, we investigate single-spin readout through a shift of resonance frequency induced by the changes of the state[1]. We test the limits imposed by parasitic capacitance, which determine constraints on device design such as the number of qubits that can be integrated and the achievable gate density. The second part we analyze the validity of the approximation that has been used in governing Hamiltonians [2] that have been shown to realize two-qubit quantum operations can be constructed by coupling double quantum dots to superconducting resonators.

[1] F. Vigneau et al., Appl. Phys. Rev. 10, 021305 (2023)
[2] M. Benito et al., PHYSICAL REVIEW B 100, 081412(R) (2019)

PO.154 Strain-induced Ettingshausen effect in spin-orbit coupled noncentrosymmetric metals

Gautham Varma K*, Azaz Ahmad, Gargee Sharma (Indian Institute of Technology Mandi)

Elastic deformations couple with electronic degrees of freedom in materials to generate gauge fields that lead to interesting transport properties. Recently, it has been well studied that strain-induced chiral magnetic fields in Weyl semimetals lead to interesting magnetotransport induced by the chiral anomaly (CA). Recent studies have revealed that CA is not necessarily only a Weyl-node property, but is rather a Fermi surface property, and is also present in a more general class of materials, for example, in spin-orbit-coupled noncentrosymmetric metals (SOC-NCMs). The interplay of strain, CA, and charge and thermomagnetic transport in SOC-NCMs, however, remains unexplored. Here we resolve this gap. Using a tight-binding model for SOC-NCMs, we first demonstrate that strain in SOC-NCMs induces anisotropy in the spin-orbit coupling and generates an axial electric field. Then, using the quasi-classical Boltzmann transport formalism with momentum-dependent intraband and interband scattering processes, we show that strain in the presence of external magnetic field can generate temperature gradients via the Nernst-Ettingshausen effect, whose direction and behavior depends the on interplay of multiple factors: the angle between the applied strain and magnetic field, the presence of the chiral anomaly, the Lorentz force, and the strength of interband scattering. We further reveal that time-reversal symmetry breaking in the presence of an external magnetic field generates the Berry-curvature-driven anomalous Ettingshausen effect, which is qualitatively distinct from the conventional Lorentz-force-driven counterpart. In light of recent and forthcoming theoretical and experimental advances in the field of SOC-NCMs, we find our study to be particularly timely and relevant.

PO.156 Longitudinal magnetoconductance of higher-pseudospin fermions

Azaz Ahmad*, Gargee Sharma (IIT Mandi)

Electron transport in Weyl semimetals has attracted significant attention in the condensed matter community due to the solid-state realization of Weyl fermions. While magnetotransport in pseudospin-1/2 (Weyl) systems is well established, its extension to higher-pseudospin fermions remains a frontier with critical implications for transport phenomena in materials with multifold fermions. We present a rigorous quasiclassical analysis of longitudinal magnetotransport in pseudospin-1 fermions, advancing beyond conventional models that assume constant relaxation times and neglect the orbital magnetic moment and global charge conservation. Our study uncovers a magnetic-field dependence of the longitudinal magnetoconductance: it is positive and quadratic in B for weak internode scattering and transitions to negative values beyond a critical internode scattering strength. Notably, the critical threshold is lower for pseudospin-1 fermions compared to their pseudospin-1/2 counterparts. We show analytically that the zero-field conductivity is affected more strongly by internode scattering for pseudospin-1 fermions than conventional Weyl fermions. Furthermore, we extend our study to fourfold-degenerate fermions (pseudospin 3/2), which exhibit multiple Fermi surfaces, and uncover the nuanced nature of magnetotransport arising from distinct scattering channels. These insights provide a foundational framework for interpreting recent experiments on multifold fermions and offer a road map for studying magnetotransport in candidate materials with space group symmetries 199, 214, and 220.

PO.162 Quantum-Secured Data Centre Interconnect in a field environment

Kaiwei Qiu, Jing Yan Haw*, Hao Qin*, Nelly Ng, Michael Kasper, Alexander Ling (National University of Singapore)

The rise of quantum computing poses serious risks to conventional public key infrastructure, driving the need for quantum-safe solutions. Quantum key distribution (QKD) offers a mature, commercially ready technology that enables the establishment of secure symmetric keys between trusted entities, ensuring resilience against eavesdropping. We present a QKD field trial conducted within a commercial data centre environment, using existing fibre infrastructure. The system achieved an average secret key rate of > 2 kbps with a quantum bit error rate below 2%, validating the real-world feasibility of QKD. As a demonstration, we implemented a Quantum-Secured Virtual Private Network (Q-VPN) for secure file transfers between two data centres, powered by QKD-generated keys. This study highlights the potential of QKD to enhance data centre interconnect security, offering a practical step toward quantum-safe communications in the emerging quantum era.

PO.163 Towards atom-photon entanglement at telecom wavelengths

Zifang Xu*, Ankush Sharma, Chang Hoong Chow, Boon Long Ng, Vindhiya Prakash, Alexander Ling, Christian Kurtsiefer* (Centre for Quantum Technologies; Department of Physics, National University of Singapore)

Realizing effective quantum interfaces between stationary qubits and photons is necessary for building distributed quantum networks. We establish such interfaces by generating atom–photon entanglement in free space using polarization and time encoding. In the polarization encoding, we detect 600 entangled pairs per minute with a fidelity of 81(2)%, and verify that this correlation is preserved after frequency conversion to the telecom band at a rate of 20 pairs per minute. We also present ongoing work on engineering atom–photon time-bin entanglement as a resource for low-loss, long-distance quantum communication.

PO.164 Correlated Photon Emission from a Cold Atomic Ensemble

Yifan Li*, Christian Kurtsiefer (Centre for Quantum Technologies (CQT))

We investigate nonlinear photon emission in an elongated cold atomic ensemble, focusing on three topics related to the correlated photon pairs and triplets. First, we observed collective effects in photon-pair generation. While emission strength is typically expected to scale linearly with atom number, our measurements show a scaling of N^4 with optical depth, exceeding the conventional prediction, which is a signature of superradiant enhancement in photon-pair generation. Second, we analyzed correlated photon pairs as a heralded single-photon source. By revising the heralded autocorrelation in terms of triple coincidences, we clarified how anti-correlation emerges from the underlying thermal statistics. Finally, we studied correlated photon triplets generated in distinct spectral modes via a fifth-order ($\chi^{(5)}$) nonlinear process. We present a theoretical protocol for triplet generation and report preliminary experimental observations. These results highlight the strong potential of cold atomic ensembles as a platform for generating multi-photon quantum states.

PO.173 Topological Magnetic Lattices for On-Chip Nanoparticle Trapping and Sorting

Xi Xie*, Yijie Shen* (Nanyang Technological University)

On-chip optical lattices based on surface plasmon polariton (SPP) fields have shown diverse topologies and potential for nanoparticle sorting. However, metallic SPP excitation suffers from significant ohmic loss and heat buildup. In this work, we propose a magnetic topological lattice based on Bloch surface waves (BSWs) excited on transparent dielectric multilayers, offering ultralong propagation lengths and markedly reduced thermal effects. In contrast to conventional SPPs, rich topologies appear in the magnetic field and spin vector. Furthermore, large-scale dynamic manipulation as well as size-dependent sorting of nanoparticles is feasible by reconfiguring lattice topologies via polarization and phase adjustments, which further expands its functional versatility. Our results provide new insight into optical topologies governed by magnetic fields and hold promise for application in other wave systems, including elastic and water waves.

5 Technical Sessions

Please observe the technical instructions for talks to comply wiht regulations. We will leave a copy for each chair in the rooms.

T1: Quantum Algorithms I

Time: Wednesday 24 Sept, 11:15am; Venue: Room 1; Chair:
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T1.21 Double-bracket algorithm for quantum signal processing without post-selection

Yudai Suzuki, Bi Hong Tiang, Jeongrak Son, Nelly Ng, Zoe Holmes, Marek Gluza* (School of Physical and Mathematical Sciences, Nanyang Technological University, 637371, Singapore)
11:15am – 11:30am

Quantum signal processing (QSP), a framework for implementing matrix-valued polynomials, is a fundamental primitive in various quantum algorithms. Despite its versatility, a potentially underappreciated challenge is that all systematic protocols for implementing QSP rely on post-selection. This can impose prohibitive costs for tasks when amplitude amplification cannot sufficiently improve the success probability. For example, in the context of ground-state preparation, this occurs when using a too poor initial state. In this work, we introduce a new formula for implementing QSP transformations of Hermitian matrices, which requires neither auxiliary qubits nor post-selection. Rather, using approximation to the exact unitary synthesis, we leverage the theory of the double-bracket quantum algorithms to provide a new quantum algorithm for QSP, termed Double-Bracket QSP (DB-QSP). The algorithm requires the energy and energetic variance of the state to be measured at each step and has a recursive structure, which leads to circuit depths that can grow super exponentially with the degree of the polynomial. With these strengths and caveats in mind, DB-QSP should be viewed as complementing the established QSP toolkit. In particular, DB-QSP can deterministically implement low-degree polynomials to ”warm start” QSP methods involving post-selection.

Based on: arXiv:2504.01077

T1.124 FeynmanDD: Quantum Circuit Analysis with Classical Decision Diagrams

Ziyuan Wang, Bin Cheng*, Longxiang Yuan, Zhengfeng Ji (Centre for Quantum Technologies, National University of Singapore)
11:30am – 11:45am

Applications of decision diagrams in quantum circuit analysis have been an active research area. Our work introduces FeynmanDD, a new method utilizing standard and multi-terminal decision diagrams for quantum circuit simulation and equivalence checking. Unlike previous approaches that exploit patterns in quantum states and operators, our method explores useful structures in the path integral formulation, essentially transforming the analysis into a counting problem. The method then employs efficient counting algorithms using decision diagrams as its underlying computational engine. Through comprehensive theoretical analysis and numerical experiments, we demonstrate FeynmanDD’s capabilities and limitations in quantum circuit analysis, highlighting the value of this new BDD-based approach.

T1.157 On distributed MBQC with pattern gadgets and graph state knitting techniques

Xiufan Li*, Zheng Qin, Yang Zhou, Zhisong Xiao* (School of Instrument Science and Opto-Electronics Engineering, Beijing Information Science and Technology University)
11:45am – 12:00pm

Recent advances have focused on exploring implementations of measurement-based variational quantum algorithms on physically driven systems. One of the most critical challenges in experiment lies in the process of preparing a tremendously large graph state on many-body systems that serves as a resource, which is usually more than the intermediate-scaled quantum devices can afford. In this work, we explore the feasibility of partitioning a large graph state into substates and performing measurement patterns correspondingly on small quantum devices. We develop two measurement pattern gadgets and propose a distributed version of measurement-based hardware-efficient Ansatz, with the aid of graph state knitting techniques and classical processing, to realize large and complicated MBQC algorithms. This architecture paves the path towards efficient implementations of distributed quantum computing tasks and potentially brings up to a wide variety of quantum network computing applications.

T1.121 Contextuality of Quantum Error-Correcting Codes

Andrew Tanggara*, Derek Khu*, Chao Jin, Kishor Bharti* (Agency for Science, Technology and Research (A*STAR))
12:00pm – 12:15pm

Fault-tolerant quantum computation requires quantum error correction (QEC), which relies on entanglement to protect information from local noise. Achieving universality, however, demands overcoming the Eastin–Knill theorem. This is often accomplished through strategies like magic state distillation, a process that prepares computational resources—namely, magic states—whose power is now understood to be rooted in quantum contextuality, a fundamental nonclassical feature generalizing Bell nonlocality. Yet, the broader role of contextuality in enabling universality, including its significance as an inherent feature of QEC codes and protocols themselves, has remained largely unexplored.

In this work, we develop a rigorous framework for contextuality in QEC and prove three main results. Fundamentally, we show that subsystem stabilizer codes with two or more gauge qubits are strongly contextual in their partial closure, while others are noncontextual, establishing a clear criterion for identifying contextual codes. Mathematically, we unify Abramsky–Brandenburger's sheaf-theoretic and Kirby–Love's tree-based definitions of contextuality, resolving a conjecture of Kim and Abramsky. Practically, we prove that many widely studied code-switching protocols which admit universal transversal gate sets, such as the doubled color codes introduced by Bravyi and Cross, are necessarily strongly contextual in their partial closure.

Collectively, our results establish quantum contextuality as an intrinsic characteristic of fault-tolerant quantum codes and protocols, complementing entanglement and magic as resources for scalable quantum computation. For quantum coding theorists, this provides a new invariant: contextuality classifies which subsystem stabilizer codes can participate in universal fault-tolerant protocols. These findings position contextuality not only as a foundational concept but also as a practical guide for the design and analysis of future QEC architectures.

T1.38 Entwine — A web-based graphical user interface for real-time design and simulation of topological error-correcting codes

Entropica Labs* (Entropica Labs)
12:15pm – 12:30pm

The rotated surface code (RSC) is a leading topological quantum error-correcting code that encodes logical qubits onto a 2D lattice of physical qubits. Its geometric structure makes visualisation essential for understanding and designing logical operations like lattice surgery. However, there is currently a lack of interactive graphical user interface (GUI) tools for topological codes, creating a barrier to incorporating visual intuition into the workflow of researchers and educators.

We introduce Entwine, a web-based GUI for quantum error correction that enables a visually interactive way to construct and schedule RSC circuits and lattice surgery operations (e.g. merge, split, grow, shrink), through a click-and-drag interface. Entwine also integrates Stim as its high-performance simulator, allowing users to easily study the effects of their logical operations under noise. By bridging the gap between interactive visualisation and circuit simulation, Entwine offers a novel and accessible platform for any researcher and educator working with topological quantum codes.

T2: Quantum Communication

Time: Wednesday 24 Sept, 11:15am; Venue: Room 2; Chair: Alex Ling
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T2.89 (KEYNOTE) Satellite-based quantum networks with hexagonal boron nitride

Tobias Vogl* (Technical University of Munich)
11:15am – 11:45am

Modern (asymmetric) encryptions are based on unproven mathematical assumptions such as the complexity of the factorization problem. Quantum computers will be able to efficiently break these encryptions, making internet connections insecure. One of the replacement candidates is quantum key distribution (QKD), where the information is encoded in single photon states of light. Due to the fundamental laws of quantum physics, any eavesdropping attempt would be immediately revealed. For QKD to work in the field, one needs to generate single photons and transmit them over long distances. In this talk, I will present our efforts in realizing a compact room temperature single photon source based on a color center in the 2D material hexagonal boron nitride. The performance is sufficient to outperform laser-based QKD protocols. The emitter is directly coupled to a photonic integrated circuit that routes the single photons to different experiments. Beyond the technology demonstrator for QKD, we are also testing fundamental quantum mechanics in micrograyity which could confirm or rule out certain quantum gravity theories. The payload has been integrated on a 3U CubeSat and was launched in 2025 as part of the QUICK3 mission. A constellation of small satellites equipped with the technology developed in QUICK3 could serve as a backbone for a satellite-based quantum internet.

T2.53 Tight and Robust Consecutive Measurement Theorems with Applications to Quantum Cryptography

Chenxun Weng*, Minglong Qin*, Yanglin Hu*, Marco Tomamichel* (National University of Singapore)

11:45am – 12:00pm

In many quantum information tasks, we encounter scenarios where information about two incompatible observables must be retrieved. A natural approach is to perform consecutive measurements, raising a key question: How does the information gained from the first measurement compare to that from both? The consecutive measurement theorem (CMT) provides a general relation between these quantities and has found applications in quantum cryptography. However, its previous formulations are often either too loose or too brittle to yield meaningful bounds. In this work, we first establish a tight CMT and apply it to achieve the best upper bounds on the quantum value of certain nonlocal games and their parallel repetitions to date. We then develop a robust CMT and explore a novel application of CMT to obtain the tightest known no-go theorem for quantum oblivious transfer in some region. These contributions strengthen the theoretical tools for analyzing quantum advantage and have concrete implications for nonlocal games and quantum cryptographic protocols.

T2.58 Key technologies in 302 km entanglement distribution with CMOS silicon photonics chips

Jinyi Du*, En Teng Lim*, Xingjian Zhang, George Chen, Hongwei Gao, Dawn Tan, Alexander Ling* (Centre for Quantum Technologies, NUS; Department of Physics, NUS)
12:00pm – 12:15pm

Entanglement distribution is a foundational capability for quantum networks, enabling applications such as quantum key distribution (QKD), entanglement-based sensing, and distributed quantum computing.

Realizing these capabilities at scale requires sources that are not only high-performing and stable, but also compatible with integrated photonics and long-distance optical fiber infrastructure. Here, we demonstrate polarization-entangled photon pair distribution over long distances using a silicon nanophotonic chip in conjunction with ultra-low-loss (ULL) optical fiber. The chip, fabricated on a standard silicon-on-insulator (SOI) platform, employs spontaneous four-wave mixing (SFWM) in a Sagnac interferometer configuration to generate high-quality entangled photon pairs at telecom wavelengths. The source exhibits an entanglement fidelity of 97.90% and a detected pair rate of 460,000 pairs per second, with low insertion loss (0.64 dB per facet), underscoring its suitability for scalable deployment. In a first-stage demonstration, we achieved entanglement distribution over 155 km of deployed metropolitan fiber, validating the robustness of the chip under real-world conditions and establishing a baseline for long-distance quantum networking using existing fiber infrastructure. Building on this, we transitioned to an ultra-low-loss transmission system to further extend the reach of our platform. By interfacing the chip with ULL fiber (attenuation 0.16 dB/km), we successfully distributed polarization-entangled photon pairs over more than 300 km, surpassing the conventional loss limit of standard SMF-28 fiber. This advance was made possible through a combination of low-loss packaging, sub-0.01 dB splicing between fiber segments, and an automated polarization correction system to actively mitigate dynamic polarization drift throughout the transmission channel. This dual-stage experimental validation is the first over deployed urban fiber and then across ultra-long fiber links using silicon chip, establishes the practicality of our silicon-based entanglement source for both current and next-generation quantum networks. The ability to maintain high-fidelity entanglement across hundreds of kilometers using commercially available ULL fiber, combined with the scalability and manufacturability of silicon photonics, positions this platform as a viable building block for real-world quantum communication systems.

T2.10 The Singapore Optical Ground Station – Supporting satellite quantum networks and beyond.

Shaik Abdillah*, Moritz Mihm, Nishant Pathak, Ayesha Reezwana, Muskan Varshney, Soe Moe Thar, Joanne Chu, Euk Jin Alexander Ling* (Centre for Quantum Technologies, National University of Singapore)

12:15pm – 12:30pm

Global scale quantum networks promise fundamentally secure communication, enabling networks that serve as a resource for quantum information processing. However, terrestrial quantum links are constrained by high photon losses in deployed optical fibres significantly limiting transmission over a global scale. Satellite-based quantum communication provides a viable path towards reaching intercontinental distances, bypassing terrestrial losses by transmitting quantum states through free space. In this pursuit, a network of robust, high-precision optical ground stations capable of establishing and maintaining line-of-sight quantum links with orbiting satellites is required.

In this talk, we present experimental results from the Singapore Optical Ground Station (SOGS), commissioned in 2024 as the first quantum-capable facility located on the equator. The station's geographic position enables broad access to satellites across a range of orbital inclinations, including polar, sun-synchronous, and equatorial orbits. We report successful optical tracking of various space assets—including 3U CubeSats in MEO, equatorial, and LEO satellites. For LEO satellites, we achieve tracking accuracy reaching 38 microradians, approaching the local atmospheric seeing limit (2 arcseconds). Tracking stability is maintained using a hybrid feedback control loop designed to accommodate sporadic link losses caused by cloud cover.

In parallel, SOGS serves as a testbed for optical space situational awareness, including passive satellite monitoring and orbit refinement. These capabilities position SOGS as a regional hub for experimental quantum networking and a critical infrastructure node in Singapore's growing quantum ecosystem. Collectively, these results represent a key step toward the near-term deployment of operational quantum satellite links in Southeast Asia.

T2.155 Engineering High-Performance SNSPDs for Photon-Number Resolution

Shuyu Dong*, Darren Ming Zhi Koh, Filippo Martinelli, Pierre Brosseau, Anton Vetlugin, Christian Kurtsiefer, Cesare Soci (Nanyang Technological University)

12:30pm – 12:45pm

Superconducting nanowire single-photon detectors (SNSPDs) are renowned for their exceptional performance, finding broad applications in quantum technologies, astronomy, space communication, imaging, and LiDAR [1]. Here, we present an end-to-end workflow for in-house fabrication and characterization of high-performance SNSPDs, achieving performance metrics comparable to commercial devices, including an 8 ns reset time, 50 ps timing jitter, system detection efficiency of 60%, and internal detection efficiency close to 100%. Building on this foundation, we further demonstrate photon-number-resolving (PNR) capabilities enabled by advanced multi-pixel architectures. Specifically, an interleaved four-pixel SNSPD array achieves up to four-photon resolution, while a multilayer design is introduced to coherently distribute optical absorption among vertically stacked detectors with near-unity efficiency, offering a scalable route to higher PNR fidelity. Collectively, these results establish a robust and versatile platform for integrating high-performance and PNR-capable SNSPDs into scalable quantum communication, computation, and photonic systems.

References [1] You, L, Superconducting nanowire single-photon detectors for quantum information. Nanophotonics, 2020. 9(9): 2673-2692.

T3: Photonics I

Time: Wednesday 24 Sept, 11:15am; Venue: Room 3; Chair: Jaesuk Hwang
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T3.105 Nonlinear finite-difference time-domain method for exciton-polaritons: Application to saltatory conduction in polariton neurons

Kevin Dini*, Helgi Sigurdsson, Nathan W. E. Seet, Paul Walker, Timothy Liew* (Nanyang Technological University - SPMS)
11:15am – 11:30am

Recently emerging complex photonic structures exhibiting giant optical nonlinearity through strong light-matter coupling require new theoretical approaches to accurately capture the interplay of the photonic and interacting-matter degrees of freedom. Extending the finite-difference time-domain method, we develop an algorithm for solving the nonlinear Maxwell-Bloch equations. This allows first-principles modeling of exciton polariton systems for arbitrarily complex photonic structures with photon-exciton coupling and frequency dependent nonlinear response included without approximations or phenomenological parameters. We first validate the algorithm by reproducing the bistable hysteresis cycle of polaritons in the nonlinear regime. We then give a key example of its utility by simulating polariton dynamics in integrated photonic circuitry composed of spatially localized bistable nodes connected by high speed waveguides. We propose a polariton circuit element inspired by saltatory conduction in biological neurons. This design supports faster polariton signal propagation than previous designs, however, requires a full account of the nonlinear field distributions in both propagation and growth directions to be calculated.

T3.143 Metasurface-Engineered Spin-Orbit Coupling in a Perovskite Polariton Laser

Andrea Zacheo, Marco Marangi, Nilo M. Cervera, Yijie Shen, Dario Gerace, Giorgio Adamo, Cesare Soci* (Nanyang Technological University)
11:30am – 11:45am

Spin-orbit coupling (SOC) in exciton-polariton condensates enables spinor control and topological textures. We engineer a monolithic halide perovkiste ($MAPbI_3$) metasurface supporting a high quality factor bound state in the continuum resonance that forms exciton-polaritons with structure-induced spin-orbit coupling. At high fluences the system undergoes polariton condensation, forming two distinct and opposite circularly polarized states with high spin purity. Our approach leverages cavity engineering to simultaneously create both spin states in the condensate, without the need to apply external artificial gauge fields. Metasurfaces with intrinsic exciton-polariton SOC may enable precise control over vortex configurations, enabling new routes to control topological excitations in polaritonic systems.

T3.98 Noise Constraints for Nonlinear Exceptional Point Sensing

Xu Zheng, Yidong Chong* (Nanyang Technological University)
11:45am – 12:00pm

Exceptional points (EPs) are singularities in the parameter space of a non-Hermitian system where eigenenergies and eigenstates coincide. They hold promise for enhancing sensing applications, but this is limited by the divergence of shot noise near EPs. According to recent studies, EP sensors operating in the nonlinear regime may avoid these limitations. By analyzing an exemplary nonlinear system, we show that the interplay of noise and nonlinearity introduces previously-unidentified obstacles to enhanced sensing. The noise effectively displaces the EP in parameter space and reduces its order, thereby eliminating the sought-for divergence in the signal-to-noise ratio. Moreover, the noise near the nonlinear EP experiences a stronger divergence than predicted by standard calculations of the Petermann noise factor, due to the properties of the Bogoliubov-de Gennes Hamiltonian governing the fluctuations. Our semi-analytical estimates for the noise level agree quantitatively with the results of stochastic numerical simulations.

T3.118 Coherent Excitation of Exciton-Polariton Bound State in the Continuum via Optical Parametric Oscillation

Nathan Seet* (Nanyang Technological University)
12:00pm – 12:15pm

Exciton-polariton bound states in the continuum (BICs) are hybrid quasiparticles formed under the strong coupling between optical BICs and excitons. However, as BICs have vanishing linewidth, they are impossible to be directly excited with external optical sources. Using the Finite Difference Time Domain Algorithm coupled with the nonlinear Bloch equations, we show here that the nonlinear nature of exciton-polaritons enable an efficient coherent excitation of the BIC via optical parametric oscillation (OPO). Thanks to the enhanced lifetime of the BIC, the requirement for the pump and the idler being in resonance with a polariton mode is lifted. This allows the OPO process to take place over a large range of pump wavevectors and energy, thereby efficiently populating the polariton BICs.

T3.133 Super-resolution optical metrology of 3D nanoscale objects

Jinkyu So*, Eng Aik Chan, Giorgio Adamo, Nikolay Zheludev (Nanyang Technological University)
12:15pm – 12:30pm

We present the first experimental demonstration of all-optical label free metrology of 3D nanoscale objects with precision of $\lambda/467$ and $\lambda/96$ for the in-plane and out-of-plane object dimensions. The deeply subwavelength precision is facilitated by gathering the a posteriori information on the diffraction patterns from similar objects. The metrology challenges precision of scanning electron microscopy and is suitable for characterization of plasmonic and metamaterial samples.

T3.149 Subwavelength photonic skyrmions propagating without diffraction

Nilo Mata Cervera*, Deepak Kumar Sharma, Ramon Paniagua-Dominguez, Miguel Angel Porras*, Yijie Shen* (Nanyang Technological University)
12:30pm – 12:45pm

It is a fundamental fact of waves that they spread as they evolve freely, regardless of their nature. Previous research to overcome diffraction spreading has led to idealized waves that, in real settings, exhibit quasi-non-diffraction and eventually spread. Here we demonstrate that the optical skyrmion that is naturally present in optical vortices is a structure of light that is exempt from diffraction. It propagates without any change in shape and size within a tube of arbitrary subwavelength radius determined by the vortex orbital and spin angular momenta. Non-diffracting propagation of a subwavelength structure of light that does not raise infinite-power issues differs drastically from all previous forms of light propagation, which may open up new perspectives in its countless applications.

T4: 2D materials I

Time: Wednesday 24 Sept, 11:15am; Venue: Room 4; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T4.50 Discovering a Wigner-like crystal and soft X-ray correlated-plasmons and their couplings in a transition metal dichalcogenide

Thomas Whitcher*, Caozheng Diao, Angga Dito Fauzi, Russell Kwan, Xiao Chi, Muhammad Avicenna Naradipa, Duane Loh, Mark Breese, Andrivo Rusydi* (National University of Singapore)
11:15am – 11:30am

Low-dimensional systems host many exotic physical properties. Using extended resonant soft X-ray scattering supported with theoretical calculations, we observe concomitantly a Wigner-like crystal in a stripe-like QHKL=(001) superlattice with surprisingly long coherence lengths and new soft X-ray correlated-plasmons in WS2. A new electronic transition is found at 125K upon cooling, which is a transition from two-dimensional ordering to three-dimensional ordering, a result of p-d hybridization anisotropy and electronic correlations. Our result shows the importance of the interplay of long-range electron-electron correlation and short-range electronic screening in determining electronics and optical properties of transition metal dichalcogenides.

T4.9 Valley gapless semiconductor: Models and applications

Kok Wai Lee*, Peihao Fu, Jun-Feng Liu, Ching Hua Lee*, Yee Sin Ang* (Science, Mathematics and Technology, Singapore University of Technology and Design)
11:30am – 11:45am

The emerging field of valleytronics harnesses the valley degree of freedom of electrons, akin to how electronic and spintronic devices utilize the charge and spin degrees of freedom of electrons, respectively. The engineering of valleytronic devices typically relies on the coupling between valley and other degrees of freedom such as spin, giving rise to valley spintronics where an external magnetic field manipulates the information stored in valleys. Here, a valley gapless semiconductor is proposed as a potential electrically controlled valleytronic platform because the valley degree of freedom is coupled to the carrier type, i.e., electrons and holes. The valley degree of freedom can be electrically controlled by tuning the carrier type via the device gate voltage. We demonstrate the proposal for realizing a valley gapless semiconductor in the honeycomb lattice with the Haldane and modified Haldane models. The system's valley-carrier coupling is further studied for its transport properties in an allelectrically controlled valley filter device setting. Our work highlights the significance of the valley gapless semiconductor for valleytronic devices.

T4.81 Spin-Mixed and Valence-Mixed 2D Iron-Porphyrin Framework with Dual Sublattices: Insights into Magnetic Excitations and Electronic Structure

Chengkun Lyu*, Calvin Pei Yu Wong, Kuan Eng Johnson Goh* (IMRE, A*STAR)
11:45am – 12:00pm

Spin-mixed systems, composed of different magnetic sublattices, represent a vibrant area of research in statistical and solid-state physics due to their rich and complex critical behaviors. These mixed-spin systems containing spins of various magnitudes may be of technological significance due to their diverse magnetic properties, with potential applications in thermomagnetic recording, holographic waveguides, and random-access memory. Here, we report the synthesis and characterization of a two-dimensional (2D) metal-organic framework (MOF) of Fe2(Fe-DPyP)3, constructed from 5,15-di(4-pyridyl)-10,20-diphenylporphyrin (DPyP) molecules and iron atoms on an Au(111) substrate. Through scanning tun-

neling microscopy (STM) and density functional theory (DFT) calculations, we reveal dual coordination modes: (1) peripheral iron atoms (Fec) coordinate with the pyridyl substituents, forming a honeycomb lattice, and (2) central iron atoms (Fem) bind within the porphyrin core, creating a Kagome lattice. Scanning tunneling spectroscopy (STS) highlights distinct spin-flip excitations in Fem atoms with a magnetic spin state of S = 1, while Fec atoms display a resonance-shape dip with a magnetic spin state of S = 3/2, likely ascribed to the spin-flip excitation quenching by temperature or substrate effects. DFT calculations confirm an in-plane ferromagnetic ground state with spin-polarized Fe d orbitals and molecular p orbitals, resulting in a band structure featuring Dirac cones and flat bands. This study unveils a pioneering 2D honeycomb-Kagome lattice coordination network with spin-polarized metal centers, which holds potential for applications in spintronics and magnetic memory devices. Reference: Wang, X.; Hsu, C.-H.; Lyu, C.; Chuang, F.-C.; Wong, C. P. Y.; et al. A Mixed-Valence and Mixed-Spin Two-Dimensional Ferromagnetic Metal–Organic Coordination Framework, ACS Nano 2025, 19, 18598–18606. Acknowledgement: K.E.J.G. acknowledges the support from the National Research Foundation, Singapore through the National Quantum Office, hosted in A*STAR, under its Centre for Quantum Technologies Funding Initiative (S24Q2d0009).

T4.131 Terahertz Resonance Tuning in Air-Gap Engineered Graphene Metasurfaces

Ruqiao Xia* (A*STAR)
12:00pm – 12:15pm

Conventional metasurfaces typically operate at fixed frequencies determined by their geometric design, limiting their adaptability across different spectral ranges. To overcome this constraint, we present a frequency-agile terahertz (THz) metamaterial based on air-gap-engineered graphene metasurfaces, enabling tuneable operation across a broader range of frequencies. In this study, we introduce a simple and scalable design strategy to achieve continuous frequency tunability for THz metasurfaces. By incorporating small, precisely engineered air gaps into the active elements of the metasurface structure, we can dynamically adjust the resonant frequency without introducing significant fabrication complexity. This approach is broadly applicable to a variety of LC-type resonant arrays.

We further expand the optical modulation range by device excitation from its substrate side. To validate our concept, we designed, fabricated, and experimentally tested graphene-metal metasurface modulators. The devices integrate subwavelength metallic antenna arrays arranged in a brickwork pattern on a p-doped silicon substrate with a 300 nm SiO_2 dielectric layer. Two device variants were fabricated: one incorporating air gaps in the graphene patches, and a control device without air gaps. As a result, we demonstrate terahertz modulators with over four orders of magnitude modulation depth (45.7 dB at 1.68 THz and 40.1 dB at 2.15 THz), and a reconfiguration speed of 30 MHz. These tuneable capacitance modulators are electrically controlled solid-state devices enabling unity modulation with graphene conductivities below 0.7 mS. Besides, THz time-domain spectroscopy measurements demonstrate that the air-gap device exhibits a 0.13 THz resonant frequency shift, while the control device without air gaps shows negligible frequency tuning and reduced modulation performance, highlighting the essential role of air-gap engineering in achieving active resonance control.

The demonstrated approach can be applied to enhance modulation performance of any metamaterial-based modulator with a 2D electron gas. Our results open up new frontiers in the area of terahertz communications, real-time imaging, and wave-optical analogue computing.

T4.2 Quantum emitters in hBN and entangled photon-pair source in rBN

Haidong Liang*, Chengyuan Yang, Andrew Bettiol* (National University of Singapore)
12:15pm – 12:30pm

Color centers are artificial atoms embedded in solids, which are widely used across various quantum technology platforms, including quantum communication, computing, and sensing. In this talk, I am going to discuss color centers in hexagonal boron nitride (hBN): blue emitters and with spin properties for quantum sensing. Recently the negatively charged boron vacancies ( ) in hBN have been shown as spin defects that have great potential in quantum sensing. However, the sensitivity was limited by either photoluminescence (PL) intensity or the optically detected magnetic resonance (ODMR) contrast, and linewidth. In this work, we demonstrate the generation of these spin defects using high energy helium ion beams and perform ODMR measurements with different laser and microwave powers. The spin defects generated by high energy helium ions exhibit a high PL intensity and ODMR contrast while keeping a small linewidth, hence a good sensitivity. Entangled photon-pair sources are pivotal in various quantum applications. Miniaturizing the quantum devices to meet the requirement in limited space applications drives the search for ultracompact entangled photon-pair sources. The rise of two-dimensional (2D) semiconductors has been demonstrated as ultracompact entangled photon-pair sources. However, the photon-pair generation rate and purity are relatively low, and the strong photoluminescence in 2D semiconductors also makes the operational wavelength range limited. Here we use the spontaneous parametric down conversion (SPDC) of rhombohedral boron nitride (rBN) as a polarization entangled photon-pair source. We have achieved a generation rate of over 120 Hz (a record-high SPDC coincidence rate with 2D materials), and a high-purity photon-pair generation with a coincidence-to-accidental ratio of above 200. Tunable Bell state generation is also demonstrated by simply rotating the pump polarization, with a fidelity up to 0.93. Our results suggest rBN as an ideal candidate for on-chip integrated quantum devices.

J1: Joint session: Workshop on quantum superpositions for levitatated systems

Time: Wednesday 24 Sept, 2:00pm; Venue: LT 29; Chair: Valerio Scarani
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

J1.112 (KEYNOTE) Bulk-acoustic resonators for quantum technologies with phonons

Matteo Fadel* (ETH Zurich)
2:00pm – 2:30pm

Mechanical resonators are highly versatile tools for hybrid quantum technologies due to their many available bosonic modes with long coherence times. In order to unlock applications such as quantum simulation and sensing, however, it is necessary to develop tools for the preparation and detection of mechanical quantum states. In this talk, I will report our results on realising scalable and programmable approaches to prepare and characterize a variety of non-classical states of motion in the resonator. These techniques will find applications in the simulation of many-body Hamiltonians and in quantum metrology. Moreover, due to its microgram-scale mass, our systems have the potential to explore the interplay between quantum mechanics and gravity.

J1.103 (INVITED) New protocol for creating macroscopic superpositions in an RF trap

Martine Schut* (National University of Singapore)
2:30pm – 2:50pm

Macroscopic spatial quantum superpositions could be used to increase the sensitivity of quantum sensors, explore the boundary between quantum and classical physics and test fundamental physics. In the quest to increase the size of spatially superposed masses, there are several avenues to pursue. We will set out a new protocol for creating superpositions in a dual-frequency linear Paul trap. In this setup an ion that is co-trapped with a nanoparticle is used to manipulate the nanoparticle motional state, resulting in an entangled state of the ion spin/motion with the nanoparticle.

J1.116 (KEYNOTE) Witnessing the Quantum Nature of Spacetime in a Lab

Anupam Mazumdar* (University of Groningen)
2:50pm – 3:20pm

Quantum field theories and classical general relativity accurately model all observations to date. Although theoretically, quantum gravity is much studied, it has no empirical evidence yet. This makes “is spacetime/gravity quantum?” one of our most important open questions. I have pioneered an ambitious idea with my collaborators “spin entanglement witness for quantum gravity,” to test the quantum nature of gravity in a lab. It exploits quantum information ideas and combines a quantum spin with cooling/trapping quantum technologies. It is based on entangling two neutral quantum masses solely by their gravitational interaction while all other interactions are mitigated, e.g. electromagnetic (EM) interactions between the masses. It proves the quantum nature of gravity, as classical gravity cannot mediate quantum correlations (entanglement). The potentially realisable protocol requires meeting a rich set of challenges: mitigating the EM interactions and background, creating spatial quantum superpositions for massive objects, and measuring spin correlations to witness the entanglement. We must also protect the quantum superpositions from heating, recoil, blackbody radiation, acceleration, seismic and gravity gradient noises.

J1.94 (INVITED) Microscopic Dynamics and Generation of Nonclassical States of Levitated Ferromagnets

Xueqi Ni* (NUS Physics, CQT)
3:20pm – 3:40pm

Levitated spinning ferromagnets have been proposed as a platform to surpass the standard quantum limit in magnetometry [Phys. Rev. Lett. 116, 190801 (2016)]. In this talk, I will present a microscopic Hamiltonian framework that captures their intrinsic spin–lattice dynamics. Numerical simulations [arXiv:2503.00728] reveal the origin of the characteristic t-3/2 magnetic field sensitivity scaling and quantify noise from internal spin-lattice interactions. We further show that classical dynamics of a levitated ferromagnet can reproduce the Berry phase in adiabatically rotating fields. Finally, I will discuss how spin–lattice coupling enables the generation of macroscopic spin superposition states, characterized by Wigner negativity and macroscopicity measures, and assess their robustness against decoherence. These results establish levitated ferromagnets as a versatile platform for exploring macroscopic quantum phenomena and advancing quantum sensing technologies.

T5: Quantum Computing

Time: Wednesday 24 Sept, 2:00pm; Venue: Room 1; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T5.160 Microwave-based entanglement and verification on superconducting qubits

Yuanzheng Paul Tan*, Hoang Long Nguyen, Rainer Dumke* (Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University)
2:00pm – 2:15pm

Superconducting circuits are currently one of the leading implementations of a quantum computer. Due to the ability to change the circuit parameters, such qubits are also known as artificial atoms. By sending microwave pulses to the qubit, one is able to realize single qubit gates through the rotation of the qubit about the Bloch sphere. However, there are a myriad of implementations of two qubit gates, ranging from using magnetic fields to shift the qubit frequency into interaction regimes or sending detuned microwave pulses to perform a Raman-based state transfer. Such implementations have varying complexity, fidelity limits and demands on the architecture as well as the control electronics. For this work, we utilize the Speeding up Waveforms by Inducing Phases to Harmful Transitions (SWIPHT) protocol, which utilizes the cross-Kerr splitting of the qubit frequency, to drive the original transition and induce a phase shift on the split transition to realize a controlled-NOT gate. Using this gate on a pair of superconducting qubits in a cavity, we perform tomography and an inequality violation experiment to verify the Bell pair generated.

T5.39 Resource efficient circuit decomposition of the non-hermitian skin effect for a digital quantum computer

Zixiong Liu*, Ching Hua Lee* (National University of Singapore)
2:15pm – 2:30pm

Simulating nonhermitian systems on quantum computers is challenging due to the need for non-unitary operations. In particular, certain phenomena such as the non-Hermitian skin effect (NHSE) require intrinsic non-reciprocity, which do not naturally occur in most spin chain models.

Here, we provide two transpilation techniques for realising the NHSE on a digital quantum computer — 1) we use an analytical-continuation-inspired heuristic to derive an exact circuit for the 2-qubit Hatano-Nelson model, thereby isolating the necessary conditions on the individual gates, and 2) we use a bottom-up approach to generate NHSE by starting from a 2-qubit ansatz matrix as the fundamental building block, thereby providing a novel approach for NHSE simulations.

We demonstrate these techniques by implementing the circuit on IBM Quantum hardware up to a 10-qubit circuit. The results demonstrate the utility of quantum computer simulations even for non-hermitian phenomena, and the techniques can be generalised to other non-hermitian models.

T5.159 Integration and benchmarking of superconducting quantum processors

Christoph Hufnagel*, Yuanzheng Paul Tan*, Rainer Dumke* (Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University)
2:30pm – 2:45pm

With the advent of commercial foundries for superconducting quantum processors, one can realistically purchase such a processor and the equipment needed to control it. This has led to a neutral platform for benchmarking becoming a necessity to validate their performance as well as provide a cross-comparison between different manufacturers. In this work, we detail our work in the setup of the benchmarking

platform at the National Quantum Computing Hub (NQCH) for superconducting processors as well as the integration of a 20 qubit processor for cloud quantum computation usage.

T5.158 Solving graph colouring on QPU

Marina Kolpakova*, Rainer Dumke (CQT)

2:45pm – 3:00pm

Graph colouring is proven to be NP-complete for $K > 2$. However efficient solving is required for many applications including compiler design. Efficient algorithms for graph collaring and similar problems from graph theory allow employing quantum processors to transpose quantum programs for it, self-transpilation.

In this talk, we will investigate the current state of the technology in quantum computing with application to efficiently solving graph colouring problems on quantum processors. First we give an overview of available methods. Second, compare Grover based approach to destroy scheme for graph colouring and colour matrix construction, NK-method. Among few of schemes to solve graph colouring this one can be executed on NISQ device, since doesn't require quantum memory. We encode colourings in a matrix of size N*K where 1 means that n-th vertex has k-th colour. Each row can have only 1 since colouring should be disambiguous. Each row in a matrix can be then be mapped into W-state with reduces search space for Grover. In the end we conclude improvements which are done relative to the original algorithm, clarify resource constraints for the method and suggest optimal circuit design for Grover search, Quantum counting, which is employed to set optimal number of iterations for a search and destroy scheme which requires only one iteration however uses mid circuit measurements.

T6: AMO Physics

Time: Wednesday 24 Sept, 2:00pm; Venue: Room 2; Chair: Michal Parniak
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T6.6 (INVITED) Quantum metrology of microwaves with interacting Rydberg atoms

Michal Parniak* (University of Warsaw)
2:00pm – 2:20pm

Rydberg atoms are extraordinarily sensitive to external electric fields—a property that is both a challenge and a powerful advantage. In our lab, we harness this sensitivity to develop highly responsive microwave sensors and microwave-optical transducers.

Traditionally, simple sensing schemes do not utilise the interactions between Rydberg atoms. We introduce a novel approach that leverages Rydberg-Rydberg interactions to prepare atomic states in a way that reduces susceptibility to losses in the measurement process. Specifically, our method uses long-range dipolar interactions, which remain surprisingly strong even in large and relatively dilute atomic ensembles.

We frame our sensing protocol within a quantum metrology context and show that it offers an optimal solution, under certain bounds, to a problem of quantum error correction under photon loss. Experimentally, we demonstrate that these interactions enable a threefold increase in Fisher information (related to the incident microwave field amplitude) per detected photon. With further improvements, we anticipate reaching sensitivities capable of detecting individual microwave or millimetre-wave photons.

Finally, I will place these results within the broader landscape of Rydberg-atom-based metrology, which we implement in both cold-atom [1,2] and hot-atom systems based on vapour cells [2].

References: [1] S. Kurzyna, B. Niewelt, M. Mazelanik, W. Wasilewski, and M. Parniak, Quantum 8, 1431 (2024) [2] S. Kurzyna, B. Niewelt, M. Mazelanik, W. Wasilewski, R. Demkowicz-Dobrzański and M. Parniak, arXiv:2505.01506 (2025) [3] S. Borówka, U. Pylypenko, M. Mazelanik, and M. Parniak, Nature Photonics 18, 32 (2024)

T6.41 Trapping Yb atoms in optical tweezers

Xiang Ru Xie* (Peking University)
2:20pm – 2:35pm

We build up a new platform of Yb atoms array. We manage to trap single atom in optical tweezer.

T6.7 A High-Efficiency, Broadband Optical delay line for All Optical Memory

Yu Guo*, Anindya Banerji*, Jia Boon Chin, Arya Chowdhury, Alexander Ling (Centre for Quantum Technologies, National Univiersity of Singapore)
2:35pm – 2:50pm

Optical quantum memories are critical components in quantum information processing, enabling storage, synchronization, and routing within quantum networks. While matter-based photonic memories offer long storage times, they often suffer from narrow bandwidths, limited efficiencies, and stringent operational requirements. In this work, we demonstrate a free-space optical delay line composed of nested spherical mirrors with custom-designed, broadband, high-reflectivity coatings. This architecture supports a wide operational bandwidth and enables discrete, controllable storage time ranging from 0 to 687 ns, with a step size of approximately 12 ns. To assess the quantum performance of our system, we store one photon from a polarization-entangled photon source and perform quantum state tomography upon retrieval. After a single round trip corresponding to a 687 ns storage time, the entangled state is preserved with a fidelity of 99.6%, and the photon retrieval efficiency reaches 95.39%. Combining high efficiency, long storage time, and broad bandwidth, our system achieves a time-bandwidth product of $\approx 3.9 \times 10^7$. Our optical delay line lays the foundation for constructing scalable all-optical quantum memory systems. We will also discuss the possibilities to use a polarization-independent optical switch to enable multiplexing of the system, thereby extending the storage time beyond a single loop.

T6.134 Recognising quantum states from the spectrum of a single cavity mode.

Wouter Verstraelen*, Stanislaw Swierczewski, Andrew Haky, Huawen Xu, Andrzej Opala, Oleksandr Kyriienko, Alberto Bramati, Timothy C.H. Liew (NTU and Majulab(cnrs))

2:50pm – 3:05pm

In the upcoming second quantum revolution, the use and thus characterization of optical quantum states is of crucial importance. As this task is a form of pattern recognition, neuromorphic structures comprise a natural candidate to achieve this. In the noisy intermediate-scale quantum era, simple setups may provide more robustness.

In this work [1], we theoretically show that the proper characterization of optical squeezed states can be obtained by coupling them to a single spatial nonlinear mode, and studying the emission spectrum of this mode. In the reservoir computing approach [2], the spectrum can then be used to learn the parameters of the incident states by linear regression or other machine learning techniques. Errors on the squeezing parameters of the order of a percent are attainable in principle. Furthermore, we study a specific example where the the squeezed state is continuously produced by a degenerate Optical Parametric Oscillator [3], illuminated on an exciton-polariton microcavity. Despite vastly different natural timescales, the results still exceed the baseline.

To theoretically model continuous driving with squeezed states, we either use squeezed Lindblad operators coupling to the vacuum, or a combination of the cascaded coupling mechanism with the Positive-P phase space method [4].

[1] W.V. et al, manuscript in preparation [2] S. Ghosh, A. Opala et al., npj Quantum Inf 5, 35 (2019) [3] S. Burks et al., Opt. Express 17, 3777-3781 (2009) [4] S. Swierczewski, W.V et al., arXiv:2507.07684 [quant-ph]

T6.78 New magic wavelength at 477 nm for the strontium clock transition

Xinyuan Ma*, Swarup Das*, David Wilkowski*, Chang Chi Kwong* (Nanyang Technological University)

3:05pm – 3:20pm

Optical lattice for trapping neutral atoms at the magic wavelength induces identical AC-Stark shifts on two internal states, permitting a coherent control of the transition between two states. This is vital for quantum applications based on cooled neutral atoms, such as quantum computing, atom clock and precision metrology.

We measured a new magic wavelength at 476.82362(8) nm for Sr-88 clock transition between the ground ${}^1S_0$ and the metastable 3P0 states. Compared to the commonly used 813 nm magic wavelength for the same transition, 477 nm magic wavelength has the advantage of a shorter wavelength and higher polarizability. This makes the 477 nm magic wavelength a good candidate for Bragg pulses to perform matter-wave interferometry involving both ${}^1S_0$ and 3P0 states with potential applications for atomic clock interferometry and quantum test of weak equivalence principle in the optical domain. Moreover, the optical lattice operating at 477 nm also has a smaller lattice constant, making it potentially useful for quantum simulation and studies of cooperative effects.

T7: Photonics II

Time: Wednesday 24 Sept, 2:00pm; Venue: Room 3; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T7.100 Topological photonic crystal fiber

Bofeng Zhu*, Qi Jie Wang, Yi Dong Chong (NTU, SPMS)
2:00pm – 2:15pm

Photonic crystal fibers (PCFs) are optical fibers that guide light using a modulated dielectric medium. Here, we realise a PCF with guided modes produced by photonic bandstructure topology rather than conventional mode-trapping mechanisms. The design, which is compatible with the stack-and-draw fabrication process, consists of a cross- sectional photonic topological crystalline insulator with a disclination. A bulk-defect correspondence produces degenerate topological modes, lying below the cladding light line. We use various theoretical methods to confirm their topological origins, including a spectral localizer that makes minimal assumptions about the bandstructure. Our experiments on the fabricated topological fiber show it transmitting visible to near-infrared light with low losses of 10–20 dB/km, which do not increase much when the fiber is bent.

T7.142 Momentum Conversion Followed by Frequency Conversion in a Spatiotemporally Modulated Optical Metasurface

Daniil Shilkin*, Son Tung Ha*, Ramon Paniagua-Dominguez, Arseniy Kuznetsov* (Institute of Materials Research and Engineering (IMRE), Agency for Science, Technology and Research (A*STAR))
2:15pm – 2:30pm

When light crosses a spatial boundary between two media, its momentum changes while its frequency remains constant. In contrast, when light propagates through a medium with a time-varying dispersion relation, its frequency changes while its momentum remains unchanged. The ability to induce both conversions with the same wave pulse enables the concept of cascade frequency conversion, allowing for significant spectral transformations with minimal perturbations to the medium.

In this study, we explore this capability using a quasi-guided mode in a GaAs metasurface and a two-pump, single-probe experimental setup. By modulating the metasurface with two pump pulses separated in both space and time, we create spatial and temporal interfaces between pumped and unpumped regions. This arrangement enables a two-step process: first, momentum conversion at the spatial interface, followed by frequency conversion at the temporal interface. Our results demonstrate new opportunities for ultrafast control of light's spectrum and propagation direction using optical metasurfaces.

T7.126 Light-cone-proximal quasi-BICs for directional chiral emission at highly oblique angles

Dmitrii Gromyko*, Lin Wu, Kirill Koshelev, Cheng-Wei Qiu (Singapore University of Technology and Design)
2:30pm – 2:45pm

Chiral quasi-BICs (q-BICs) have emerged recently as a new resonant effect in metaphotonics, which combines a very high quality factor and maximal degree of circular polarization [1-2]. Chiral q-BICs are naturally restricted to the Γ-point, or normal light incidence, due to their origin from symmetry-protected BICs. We propose a new mechanism of formation of cone-proximity chiral q-BICs at large oblique angles $> 60^\circ$, enabled by the divergence of the radiative local density of states near the light cone. We provide a robust approach for designing such chiral resonances in dielectric metasurfaces with a monoclinic lattice arrangement and broken in-plane mirror symmetry via the parametric variation of the lattice angle. These resonances manifest themselves with unitary circular dichroism in transmission and a unitary degree of circular polarization of emission spectra at the points of the Q-factor maxima. The physics of cone-proximity chiral q-BICs removes the constraint of normal-incidence operation, while the achieved values of the Q-factors and far-field polarization modulation degree are comparable with those of conventional chiral q-BICs at the Γ-point used for lasing [3]. This concept requires no out-of-plane symmetry; thus, metasurfaces remain entirely planar and compatible with standard fabrication on low-index substrates. Our approach opens a path toward directional chiral lasing at large emission angles and photonic devices that operate at grazing angles in general. [1] M. V. Gorkunov, A. A. Antonov, Y. S. Kivshar, Metasurfaces with maximum chirality empowered by bound states in the continuum, Physical Review Letters 125 (9) (2020) 093903. [2] Y. Chen, H. Deng, X. Sha, W. Chen, R. Wang, Y.-H. Chen, D. Wu, J. Chu, Y. S. Kivshar, S. Xiao, et al., Observation of intrinsic chiral bound states in the continuum, Nature 613 (7944) (2023) 474–478. [3] X. Zhang, Y. Liu, J. Han, Y. Kivshar, Q. Song, Chiral emission from resonant metasurfaces, Science 377 (6611) (2022) 1215–1218.

T7.161 Reconfigurable structured quantum light metasurfaces

Omar Abdelrahman Mohamed Abdelraouf* (IMRE, A*STAR)
2:45pm – 3:00pm

Recent advances in nanophotonics have unlocked unprecedented opportunities to control and reconfigure quantum light at the nanoscale, enabling compact, tunable, and efficient sources for emerging quantum technologies. We developed two reconfigurable metasurfaces for future tunable flat optics single photon devices and telecom entangled photon. First, a hybrid metasurface platform that integrates nanocrystalline silicon quantum dots with amorphous silicon and a low-loss phase change material, Sb2S3, to achieve amplified and tunable photoluminescence. Dual bound states in the continuum resonances allow Q-factors exceeding 200 and a fifteen-fold enhancement of emission, with both geometric and all-optical tunability extending into the near-infrared. Tunable light emitting nonlocal metalens covers more than 28 nm wavelength range.1 Second, a nanostructured $NbOCl_2$ metasurface designed for entangled photon-pair generation in the telecommunication C-band. Leveraging its strong $\chi^{(2)}$ nonlinearity and engineered high-Q resonances, we demonstrate orders-of-magnitude enhancement in photon-pair brightness, with active electrical tuning of emission wavelengths over 250 nm while maintaining high coincidence rates. Together, these works establish a versatile framework for on-demand, reconfigurable quantum light metasurfaces. Looking ahead, these platforms hold strong potential for enabling compact quantum LIDAR, adaptive quantum communication devices, and integrated quantum photonic circuits that are both scalable and field-deployable.2

T7.113 (INVITED) Unconventional light localization in Mie-resonant metasurfaces

Daniel Leykam* (Singapore University of Technology and Design)
3:00pm – 3:20pm

I will present a general framework of Mie-tronics as a powerful tool for understanding and optimizing localization of light in arrays of subwavelength scatterers. By combining the advantageous features of multiple resonances (such as Fabry-Perot, whispering-gallery, and collective Mie modes), hybrid super-resonances can substantially enhance both the Q factor and Purcell effect. Applying this approach to photonic moire structures, twist-induced coupling between degenerate collective modes leads to a giant enhancement of the Purcell factor, analogous to the emergence of flatbands in twisted bilayer graphene. These findings how finely tuned cooperative multiple scattering can surpass conventional limits, advancing the control of wave localization metasurfaces and other subwavelength-structured devices.

T8: Solid State Physics I

Time: Wednesday 24 Sept, 2:00pm; Venue: Room 4; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T8.95 Renewable Cooling and Electricity Harvesting from Coldness of Sky

Jae Suk Hwang* (Centre for Quantum Technologies)
2:00pm – 2:15pm

The sky is not only a source of heat and light, but also an abundant source of coldness. Radiative cooling, taking advantage of net thermal radiation towards the cold sky, do not require any external energy source other than an open view to the sky and remove heat irreversibly from the earthly environment. Therefore, radiative cooling bears a potential to be a sustainable and renewable alternative to meet increasing cooling demands. However, current radiative cooling devices are far from reaching the theoretically predicted performance [1] and limited to the operation near the ambient temperature. With a high degree of thermal insulation obtained with a high-vacuum enclosure, sub-ambient radiative cooling in the equatorial tropics is demonstrated for the first time, where the humid air and the cloudy sky render radiative cooling the most challenging [2]. The future routes for the practical deployment of the enhanced radiative cooling devices, such as the use of aerogels, will be discussed [3]. In addition to cooling, radiative cooling can be exploited to harvest electricity at night, based on the temperature gradient between the cold night sky and the ambient at the terrestrial level [4]. The experimental test of the viability of these concepts is presented using a thermoelectric generator (TEG). The same surface can also be used to radiate towards outer space the excess heat generated in the process of solar energy harvesting [5]. [1] J. Hwang, "Climate-dependent enhancement of radiative cooling with mirror structures," Journal of Photonics for Energy 14 028001 (2024). [2] J. Hwang, "Daytime radiative cooling under extreme weather conditions," Advanced Energy and Sustainability Research, 5 2300239 (2024). [3] X.Y. Goh, J. Hwang, L.T. Nguyen, R.H. Ong, T. Bai, H.M. Duong, "Sub-ambient radiative cooling with thermally insulating polyethylene terephthalate aerogels recycled from plastic waste," Solar Energy, 274 112544 (2024). [4] J. Hwang, D. Narducci, "Electrical and thermal impedance matching for thermoelectric generation via radiative cooling," http://dx.doi.org/10.2139/ssrn.5355615. [5] J. Hwang, "Harvesting solar energy without excess environmental heating," Cell Reports Physical Science, 6, 102345 (2025).

T8.54 Temperature Dependent Spin-Charge Oscillations in High-Tc Cuprate Superconductors

Sai Prashanth Josyula*, Muhammad Avicenna Naradipa, Bin Leong Ong, Vashu Kamboj, Anjali Jain, Xiao Chi, Eng Soon Tok, Andrivo Rusydi* (Advanced Research Initiative for Correlated-Electron Systems, Department of Physics, National University of Singapore)
2:15pm – 2:30pm

The discovery of high-critical-temperature (high-Tc) superconductivity in Ba-La-Cu-O revealed the exotic phase diagram of the cuprate system. The spin-charge dynamics vary across the phase diagram from the undoped Mott-insulator, optimally-doped superconductor, over-doped metallic to ferromagnetic phase. The behaviour of spin-charge oscillations across the phase diagram sheds light on spin-charge dynamics of the CuO_2 plane. Conventionally, the Zhang-Rice singlet model was used to describe the interactions between the intrinsic holes at Cu 3d sites and the doped holes predominantly at the O 2p sites. However, recent optical conductivity based studies presented a mixed-singlet-and-triplet state (MST) model in which the Zhang-Rice singlet is polarised. Utilizing the MST model, the temperature dependent behaviour of a new spin-charge oscillation across the cuprate phase diagram is presented. Loss function obtained from temperature dependent spectroscopic ellipsometry reveals unconventional intra-CuO_2-plane spin-correlated plasmon which show temperature dependence. In the superconducting state, the MST state is singlet-dominated below Tc and the spin-correlated plasmon enhances too. The MST state is triplet dominated in the ferromagnetic cuprates and as ferromagnetism increases, i.e., the MST state becomes triplet dom inated, with decreasing temperature, the spin-correlated plasmon also enhances. Although the plasmons show similar trends in both the phases, trends in the spectral weight of charge carriers participating in these plasmonic excitations varies. These results describe the behaviour of the doped hole within the MST state model in which a singlet dominated MST state leads to superconductivity and a triplet dominated MST state to ferromagnetic cuprates.

T8.111 Realizing selective excitation wavelength-dependent emission in low-dimensional metal-halide hybrids

Benny Febriansyah*, Zexiang Shen* (Nanyang Technological University)
2:30pm – 2:45pm

Materials exhibiting excitation-dependent photoluminescence (PL) offer exciting opportunities in diverse practical applications. Their ability to emit multiple colors or shift emissions based on specific excitation wavelengths makes them especially valuable in technologies where versatility and multifunctionality are required. In this regard, the big family of low-dimensional (LD) organic metal-halide perovskites whose structures exhibit long-range ordering at molecular level have emerged as promising candidates for such purposes owing mainly to large chemical spaces associated to the materials composition. In this seminar, I will share a strategy to realize excitation-dependent PL capability in LD perovskites, mainly achieved by incorporating "electronically-active" cationic organic species within the halometallate lattices. When organic cations carrying similar electronic properties as the inorganic counterparts, the resulting materials' band structures and transitions are distributed across both sublattices, enabling the coupling between them. This allows, for example, the energy of excitons formed in the inorganic lattices to be transferred to the nearby organic chromophores (typically of lower-lying empty states), resulting in emissions from the cations themselves (in the form of either fluorescence or phosphorescence). Such behavior is intrinsic and derived from the interaction of each component at the molecular level, which do not require a uniform distribution and precise control of parameters as seen in dopant-assisted strategy. Various experimental photophysical and theoretical results will be presented to understand the possible mechanism underlying the observation.

T8.68 Emerging Surface Magnetic and Electronic Orderings in Cuprates

Anjali Jain*, Caozheng Diao, Bin Leong Ong, Andrivo Rusydi* (National University of Singapore)
2:45pm – 3:00pm

Bednorz and Mueller discovered high-temperature oxide superconductors, La-Ba-Cu-O (LBCO) in 1986 and received the Nobel Prize in 1987. This class of materials exhibits a plethora of exotic phases as a function of temperature and doping. Understanding the intricate behavior of these doped compounds necessitates a deep insight into the parent compound, La_2CuO_4 (LCO). Central to the intriguing properties of high-temperature superconductors is the CuO_2 plane, a structural feature that forms the foundation of their unique electronic and magnetic behaviors. In compounds such as LCO, the CuO_2 plane consists of copper ions in square planar coordination. Strong hybridization between the Cu 3d and O 2p orbitals give rise to highly correlated electronic states, which are believed to be important for the exotic phases observed in these materials. Furthermore, the interplay of charge, spin, and orbital degrees of freedom in the CuO_2-plane drives the emergent phenomena, however, a complete understanding of the CuO_2-plane remains elusive. To probe the elusive magnetic and electronic properties of the CuO_2-plane in cuprates, we utilize an advanced experimental technique called Resonant Soft X-ray and Magnetic Scattering (RSXMS). In RSXMS, soft X-rays are tuned to the absorption edges of specific elements, allowing for element, site, and spin-selective sensitivity to their electronic and magnetic structures. By tuning the angle of X-ray incidence, we achieve depth-resolved measurements. At grazing angles, the technique is highly surface-sensitive, while at higher angles, the X-ray penetration depth increases, enabling access to subsurface or bulk layers. This tunability allows comparing the magnetic and electronic structures of surface and sub-surface CuO_2 layers of cuprates. We observe a novel surface magnetic and electronic orderings in the CuO_2-plane.

T8.32 Origin of the metal-to-insulator (MIT) transition in $Pr_{0.6}Sr0.4Co_{1-x}Mn_xO_3$ perovskite oxides

Anindita Chaudhuri*, Amit Chanda, Xiao Chi, Xiaojiang Yu, Diao Caozheng, Mark B H Breese, Ramanathan Mahendiran, Andrivo Rusydi (National University of Singapore)
3:00pm – 3:15pm

The scope to play with the various degrees of freedom including spin, lattice, charge, orbital as well as scope to customize the over-all disorder in the structure makes perovskite-oxides a group of fascinating solid-state materials for numerous basic scientific research. While these oxides are popular for their attractive multiferroic properties, the other aspects are not fully explored. Herewith, we demonstrate a metal-to-insulator transition (MIT) in $Pr_{0.6}Sr_{0.4}Co_{1-x}Mn_xO_3$ ($x =$ 0-0.4) oxide system at room temperature. Using advanced spectroscopic techniques, namely XAS and XPS we identify the charge-, spin states of Co and Mn ions and change in hybridization of O as a function of x. Interestingly, we see the formation of Co^{4+}, which remains controversial for decades. We confirm Co^{4+} systematically changes their spin-state (from high-, intermediate- and to low-spin) which sequentially transform the metallic cobaltite into Mott-insulator. The change in Co spin states are also associated with tunable spin correlated-plasmon, ranging from IR to UV at room temperature.

T9: Quantum Algorithms II

Time: Wednesday 24 Sept, 4:00pm; Venue: Room 1; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T9.23 (INVITED) Double-bracket quantum algorithms for quantum imaginary-time evolution

Marek Gluza*, Jeongrak Son*, Bi Hong Tiang*, René Zander, Raphael Seidel, Yudai Suzuki, Zoë Holmes, Nelly H. Y. Ng* (Nanyang Technological University)
4:00pm – 4:20pm

When not disturbed, systems follow the real-time evolution, where the exponent of the evolution operator is proportional to the time that has passed. If we formally replace the time (a real number) with an imaginary number, an imaginary-time evolution operator is obtained. As the name suggests, imaginary-time evolution does not naturally occur in physical systems, as it is no longer unitary. However, if successfully implemented, it unlocks challenging tasks such as preparing Gibbs and ground states or measuring partition functions.

We introduce a quantum algorithm that coherently implements effective imaginary-time evolution; that is, given any initial pure state, our algorithm outputs a normalised imaginary-time evolved state. This effective version is unitary, unlike the original imaginary-time evolution operator, but it is nonlinear, making it still hard to implement on quantum computers. We resolve this problem by designing a quantum algorithm to be recursive, which effectively encodes the nonlinearity of the evolution. Our algorithm is unitary and deterministic, meaning that it circumvents the heavy classical optimisation cost of variational algorithms and the post-selection of quantum signal processing approaches, which are conventionally used for implementing imaginary-time evolution. We also numerically show that our algorithm outperforms the leading quantum algorithm (phase estimation) in preparing the ground state, which is one of the primary applications for quantum computing that can be solved by imaginary-time evolution.

T9.22 Grover's algorithm is an approximation of imaginary-time evolution

Yudai Suzuki*, Marek Gluza*, Jeongrak Son*, Bi Hong Tiang*, Nelly Ng*, Zoe Holmes* (Institute of Physics, ´Ecole Polytechnique F´ed´erale de Lausanne (EPFL), Lausanne, Switzerland)
4:20pm – 4:35pm

We reveal the power of Grover's algorithm from thermodynamic and geometric perspectives by showing that it is a product formula approximation of imaginary-time evolution (ITE), a Riemannian gradient flow on the special unitary group. This viewpoint uncovers three key insights. First, we show that the ITE dynamics trace the shortest path between the initial and the solution states in complex projective space. Second, we prove that the geodesic length of ITE determines the query complexity of Grover's algorithm. This complexity notably aligns with the known optimal scaling for unstructured search. Lastly, utilizing the geodesic structure of ITE, we construct a quantum signal processing formulation for ITE without post-selection, and derive a new set of angles for the fixed-point search. These results collectively establish a deeper understanding of Grover's algorithm and suggest a potential role for thermodynamics and geometry in quantum algorithm design.

T9.88 Certifying Optimality of VQA Solutions via Sparse Trigonometric SOS Hierarchies

Georgios Korpas*, Wayne Lin*, Iosif Sakos*, Antonios Varvitsiotis* (Singapore University of Technology and Design; Centre for Quantum Technologies; Archimedes Research Unit on AI)
4:35pm – 4:50pm

We propose a certification framework for Variational Quantum Algorithms (VQAs) based on sparse Sum-of-Squares (SOS) relaxations. For a broad class of ansätze that includes Quantum Approximation Optimization Algorithms (QAOA), we show that the VQA cost function admits a sparse Hermitian trigonometric polynomial representation. This structure enables the construction of sparse SOS hierarchies that yield two-sided bounds on the suboptimality of any candidate parameter of the VQA. The error in the suboptimality gap at the d-th level of the hierarchy scales as $\mathcal{O}(\frac{1}{d^2})$. To our knowledge, this provides the first certified suboptimality guarantees for VQAs in a broad class of ansätze and offers a tractable post hoc validation method for VQA solutions.

T9.135 Petz recovery maps of single-qubit decoherence channels in an ion trap quantum processor

Wen Han Png*, Valerio Scarani* (Centre for quantum technologies, National University of Singapore, Department of Physics, NUS)
4:50pm – 5:05pm

The Petz recovery map provides a near-optimal reversal of quantum noise, yet proposals for its implementation are only recent. We propose a physical realization of the exact state-specific Petz map in an ion trap for qubit decoherence channels. Our circuit constructions require at most $1(2)$ ancilla qubits and $3(20)$ CNOT gates for channels with Kraus rank $2(>2)$. We analyze typical ion trap errors and construct corresponding Petz maps, simulating their performance under realistic noise modeled by residual spin-motion coupling. Quantum circuits are provided for depolarizing, dephasing, and amplitude damping channels. Focusing on single-shot recovery, suited for present-day devices, we also quantify the precision of prior knowledge required to achieve a recovery error below 0.01 across varying decoherence levels and state purities.

T9.18 Variational quantum algorithms for nonlinear partial differential equations

Muhammad Umer*, Eleftherios Mastorakis, Dimitris G. Angelakis (Centre for Quantum Technologies, National University of Singapore)
5:05pm – 5:20pm

The simulation of nonlinear partial differential equations (PDEs) is fundamental to modeling a broad spectrum of phenomena, ranging from fluid dynamics to quantum finance. In this talk, I will begin with an overview of key nonlinear PDEs relevant to fluid dynamics. I will then introduce variational quantum algorithms (VQAs) tailored for computational fluid dynamics on quantum hardware. Building on this foundation, I will highlight several of our recent contributions, including the design of resource-efficient quantum circuit architectures and the development of robust optimization strategies to enhance convergence and accuracy. Finally, I will present results from our implementation of nonlinear Burgers' dynamics on a trapped-ion quantum device, demonstrating both the capabilities and current limitations of NISQ hardware for fluid dynamics applications. Reference: [1]. Muhammad Umer, Eleftherios Mastorakis, Sofia Evangelou, and Dimitris G. Angelakis, "Probing the limits of variational quantum algorithms for nonlinear ground states on real quantum hardware: The effects of noise", Physical Review A, 111, 012626 (2025) [2]. Muhammad Umer, Eleftherios Mastorakis, and Dimitris G. Angelakis, "Efficient estimation and sequential optimization of cost functions in variational quantum algorithms", Quantum Sci. Technol. 10 035022 (2025) [3]. Eleftherios Mastorakis, Muhammad Umer, Milena Guevara-Bertsch, Juris Ulma-

nis, Felix Rohde, and Dimitris G. Angelakis, ”Resource-Efficient Hadamard Test Circuits for Nonlinear Dynamics on a Trapped-Ion Quantum Computer” arXiv 2507.19250

T10: Quantum Optics

Time: Wednesday 24 Sept, 4:00pm; Venue: Room 2; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T10.13 (INVITED) Uncovering a Family of Solutions for Concentric, Circular Reflection Patterns in Nested Herriott cells

Arya Chowdhury*, Pranay Tiwari*, Anindya Banerji*, Yu Guo*, Alexander Ling* (Centre for Quantum Technologies, National University of Singapore)
4:00pm – 4:20pm

Multipass cells are strong candidates for stable, free-space optical delay lines for quantum memory due to their low dispersion, relaxed wavelength and bandwidth requirements and room-temperature operability. The standard multipass cell, the Herriott cell, comprises 2 coaxial, spherical mirrors where the input beam follows an elliptical path before exiting the cavity. However, while Herriott cells offer a stable optical path length, they under-utilise the mirror surface area, limiting the optical path length.

Nested Herriott cells implement a smaller, concave mirror within the larger one with a differing radius of curvature. The elliptical beam path in the nested cells is rotated upon each inner mirror reflection, producing many semi-elliptical paths that form concentric circular reflection patterns composed of multiple rings. This utilises a greater surface area of the mirrors, significantly increasing the optical path length while maintaining the stability and re-entrant condition of the Herriott cell. This makes them better suited as optical delay lines for quantum memory than the Herriott cells. A solution for a concentric circular reflection pattern for a desired number of rings and fixed radii of curvatures exists.

Our work utilises ellipse symmetry to derive a numerical model that finds all possible concentric-ring reflection patterns for a fixed number of rings and mirror curvatures, for a given mirror design. This generalises the earlier work, which reported a single solution for the same fixed parameters. Therefore, we can form a family of solutions for the concentric circular reflection patterns in nested Herriott cells, similar to the Herriott cell. This family of solutions outlines all physically possible concentric solutions for a selected number of rings and radii of curvatures, given that there are no restrictions on the mirror sizes. This family of solutions can aid in the design and optimisation of these nested cells, enabling stable, long optical path lengths in compact setups.

T10.132 Dielectric metasurfaces for polariton condensation and superbunched emission

Marco Marangi, Alexander M. Dubrovkin, Andrea Zacheo, Anton N. Vetlugin, Giorgio Adamo, Cesare Soci* (Nanyang Technological University)
4:20pm – 4:35pm

Sources of highly correlated or coherent photons are critical for emerging quantum information, communication, and sensing technologies, as well as fundamental studies of light–matter interactions. Traditional photon-pair sources based on spontaneous parametric processes face inherent limitations in brightness and scalability. Here we use dielectric metasurfaces supporting bound-state-in-the-continuum (BIC) resonances with high quality factors, delocalized modes that, when hybridized with excitons in $MAPbI_3$ perovskite and TDBC J-aggregates films, enable strong coupling and controlled photon statistics. We demonstrate low-threshold BIC-polariton condensation in solution-processed perovskite films and room temperature superbunched emission in J-aggregates, establishing a scalable silicon-based metasurface platform that spans near-Poissonian condensate light to strongly bunched photons for quantum photonics.

T10.141 Inline quantum light detection with SNSPDs coupled to photonic bound states

Filippo Martinelli*, Anton Vetlugin, Shuyu Dong, Darren Koh, Maria Sidorova, Christian Kurtsiefer, Cesare Soci* (Nanyang Technological University)

4:35pm – 4:50pm

We present a scheme for quantum light characterization based on inline waveguide-integrated superconducting nanowire single-photon detectors (SNSPDs). We developed a photonic bound states in the continuum (BIC) platform based on etchless polymer waveguides to mitigate the parasitic losses at the detector termination, while ensuring compatibility with standard photonic circuits. We demonstrate integrated detectors with on-chip efficiency exceeding 80%, recovery time of less than 2 ns, and intrinsic jitter of less than 70 ps. As a proof of principle, we implement Hanbury Brown and Twiss interferometry and photon number resolution with two inline detectors. With a footprint as small as $60\times6\,\mathrm{mm}^2$, this device represents one of the smallest demonstrations of their kind reported to date. The concept of inline quantum measurements could be further developed to support more complex circuit functionalities, such as higher-order correlation measurements, quantum state tomography, and multi-photon subtraction, within a compact architecture.

T10.83 Phenomenological Model of Sidewall Participation to Predict LNOI Resonator Q Factor

Pavel Dmitriev*, Kah Jen Wo, Karthik Dasigi, Fumiya Hanamura, Steven Touzard (MSE, NUS; CQT, NUS)

4:50pm – 5:05pm

Thin film Lithium Niobate-on-Insulator (LNOI) integrated photonics is a rapidly developing field because of the versatility of the material platform. As such, there are many reports of high-Q factor resonators fabricated on LNOI, but because of the variability of the design of the resonators, it is difficult to compare fabrication techniques from different research groups and predict outcomes based on methods. Here we present a phenomenological model based on sidewall losses as the limiting factor for Q factor for LNOI resonators. The model allows us to predict Q factors for different resonator designs based on fabrication limitations and compare fabrication processes between different research groups. Using this model we are able to demonstrate that we have state of the art fabrication of LNOI waveguides and resonators.

T10.61 Ultra-silicon-rich nitride Bragg grating for efficient photon-pair and energy–time entanglement generation

Jinyi Du*, Ju Won Choi, En Teng Lim*, George Chen, Hongwei Gao, Dawn Tan*, Alexander Ling* (Centre for Quantum Technologies, NUS; Department of Physics, NUS)

5:05pm – 5:20pm

We report the realization of a high-brightness photon-pair source based on an ultra-silicon-rich nitride (USRN) Bragg grating chip. The USRN platform completely eliminates two-photon absorption at 1550 nm and offers a nonlinear refractive index approximately seven times higher than that of crystalline silicon. The integrated Bragg grating enables precise dispersion engineering and slow-light enhancement, thereby boosting the efficiency of spontaneous four-wave mixing. In our experiment, we achieve an on-chip photon-pair generation rate exceeding 1.6×10^8 pairs/s with a high coincidence-to-accidental ratio. Measuring the photons with Franson interferometers, we achieve a raw two-photon interference visibility exceeding 98% without background subtraction, confirming the high entanglement fidelity of the generated energy–time entangled state. Furthermore, we demonstrate entanglement distribution over 50 km of optical fiber. Owing to the broadband emission of the USRN source, dense wavelength-division multiplexing (DWDM) can be implemented to simultaneously serve multiple users, paving the way for scalable, CMOS-compatible quantum networks.

T10.138 Integrated Platforms for Polarimetry and Quantum State Tomography

Pierre Brosseau*, Jiawei Wang, Mohammed Alqedra, Anton Vetlugin, Giorgio Adamo, Ruixiang Guo, Val Zwiller, Cesare Soci* (Nanyang Technological University)

5:20pm – 5:35pm

Polarization states of light provide a versatile platform for encoding and manipulating quantum information and are widely used in quantum optics experiments and demonstrations of quantum communication protocols. Conventional polarization state tomography, however, often relies on free-space optics with multiple components and careful alignment, which adds complexity, losses and limits compatibility with fiber-based quantum networks. Here we present a fully fiber-integrated setup that enables polarization tomography of single photons and entangled photon pairs in an arbitrary, user-defined measurement basis, without the need to physically reconfigure the system. The same single-pixel architecture can flexibly implement standard tomography (e.g., 16 or 36 bases) as well as adaptive protocols with dynamically optimized measurement settings. In the second part, we introduce multi-pixel polarimetry based on superconducting nanowire single-photon detector (SNSPD) arrays. By integrating intrinsic polarization sensitivity directly within the detector, this platform alleviates the need for additional optical elements while extending functionality beyond conventional counting. We report both simulation and experimental validation of these approaches and discuss their potential for scalable quantum state characterization in quantum communication and sensing networks.

T11: 2D materials II

Time: Wednesday 24 Sept, 4:00pm; Venue: Room 3; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T11.90 (INVITED) Evidence of air-induced surface transformation of atomic step-engineered sapphire in relation to epitaxial growth of 2D semiconductors

Wei Fu*, Kuan Eng Goh* (1.IMRE@A*STAR; 2. CQT; 3. Physics@NUS; 4. SPMS@NTU)
4:00pm – 4:20pm

Engineering sapphire substrates with specific surface characteristics is crucial for the epitaxial growth of high-quality wafer-scale transition metal dichalcogenides, essential for integration with semiconductor industry processes. Here, we report that atomic-step-engineered sapphire surfaces undergo structural and chemical changes upon air exposure, which may be associated with surface hydrolysis and the formation of aluminum (oxy)hydroxides as revealed by a self-developed charge-contrast enhanced X-ray photoelectron spectroscopy technique. We suggest these species transform into oxygen-deficient Al_2O_{3-x} under typical growth conditions, associated with disrupted domain alignment. We further demonstrate that ultraviolet light irradiation in air appears to mitigate this degradation, restoring surface stoichiometry and promoting epitaxial alignment. The grown monolayer WS_2 films exhibit high crystalline quality, good uniformity, and low defect density. Statistical analysis of 100 field-effect transistors shows a device yield $>95\%$ and a mobility variation $<20\%$. These findings provide relevant insights for the consistent production of industrial-scale, high-quality 2D semiconductors.

T11.35 Stacking-Engineered Ferroelectricity, Topological Polarization and Multiferroic Order in Two-Dimensional Materials

Daniel Bennett* (NTU Singapore, Harvard University)
4:20pm – 4:35pm

Two-dimensional (2D) materials are a promising element in nanotechnology due to their compact size and versatile properties. By combining different materials, manipulating stacking arrangements, or twisting layers, one can finely tune the electronic properties of 2D materials, and even induce new ones. In addition to remarkable electronic, optical, thermal, and mechanical properties, 2D materials, when manipulated in the right way, can also exhibit novel polar and magnetic properties, possibly simultaneously, opening new avenues for the creation of multifunctional nanodevices.

I will discuss how electronic structure theory and first-principles methods have led to the prediction, understanding, and experimental discovery of many interesting polar phenomena in 2D materials, including sliding ferroelectricity [1,2], topological polarization in twisted bilayers [3,4] and stacking-engineered multiferroic order and magnetoelectric coupling [5]. These discoveries have already led to the fabrication of the world's thinnest and fatigue-free ferroelectric field-effect transistor [2], and will pave the way for many more advances in nanotechnology.

[1] K. Yasuda et. al., Science 372,1458-1462 (2021). [2] K. Yasuda, E. Zalys-Geller, X. Wang, D. Bennett, et. al., Science 385, 53-56 (2024). [3] D. Bennett et. al., Nature Communications 14, 1629 (2023). [4] T. Vu, D. Bennett et. al., arxiv:2405.15126. [5] D. Bennett et. al., Physical Review Letters 133, 246703 (2024).

T11.69 Complementary Atomristors: High-Throughput Discovery of Intrinsic SET and RESET-Type 2D Monolayers

Sanchali Mitra*, Yee Sin Ang* (Singapore University of Technology and Design)
4:35pm – 4:50pm

'Atomristors',memristive devices based on atomically thin monolayers of two-dimensional (2D) materials, are promising building blocks for ultrafast, energy-efficient non-volatile memory and neuromorphic computing. However, progress has been constrained by a narrow material landscape, limited primarily to MoS_2 and h-BN. In this work, we vastly expand that landscape through high-throughput computational screening that integrates density functional theory (DFT), machine-learning-accelerated molecular dynamics, and quantum atomistic device simulations. We uncover 17 monolayers with atomristor functionality, falling into two distinct functional classes. Class 1 devices follow the well-known "normally SET" route: metal adsorption at native vacancies drives the transition from a high-resistance state (HRS) to a low-resistance state (LRS). Class 2 devices-reported here for the first time-exhibit the reverse, "normally RESET" behaviour: they start in a conductive LRS due to defect-induced delocalized states, but metal adsorption re-localizes these states, suppressing conduction and inducing an LRS→HRS transition. This mechanism is fundamentally opposite to conventional memristors, where metal incorporation typically boosts conductivity. Proof-of-concept quantum transport simulations on GaS (Class 1) and BiOCl (Class 2) confirm their switching behaviour. Our findings not only expand the catalogue of viable materials for atomristor design but also introduce a previously missing reverse-switching subtype, opening the door to complementary integration of "normally SET" and "normally RESET" devices for next-generation memory and non-von Neumann computing.

T11.59 Van der Waals Integration of 2D Semiconductors with Ferroelectric Oxides for Future Electronics

Reshmi Thottathil*, Jiangbo Luo, Zhi Shiuh Lim, Zhaoyang Luo, Junxiong Hu, Ariando Ariando* (National University of Singapore)
4:50pm – 5:05pm

The integration of two-dimensional (2D) materials with functional oxides has significant potential for exploring intriguing physics and developing multifunctional devices [1,2]. Devices based on ferroelectrics integrated with 2D materials extend the possibilities for tuning various electronic properties of semiconductors through the virtue of ferroelectric polarization switching. The interfaces between 2D materials and these oxides suffer from traps and defects and are restricted by lattice matching constraints. Recently, van der Waals (vdW) integration of 2D materials and free-standing complex oxides has been shown to be a promising solution [3,4]. In this work, we explored the potential of vdW integration of 2D semiconductors with free-standing functional oxides for 2D field-effect transistors (FETs). Thin films of various oxides, including $SrTiO_3$ (STO) and $BiFeO_3$ (BFO), were successfully grown using pulsed laser deposition, producing high-quality free-standing films. These free-standing films were integrated into FET device heterostructures where MoS_2 was used as the channel. The MoS_2 FETs with free-standing STO gate dielectric showed notable performance and a low subthreshold swing of 74 mV/dec compared to those prepared on conventional SiO_2 , due to the high dielectric environment provided by STO. Preliminary work on STO provided insights into incorporating free-standing ferroelectric oxides into the gate stack to realize Ferroelectric FET (FeFET) and Negative Capacitance FET (NCFET). Ferroelectricity in free-standing films was demonstrated using piezo force microscopy. Subsequently, all vdW integrated MoS_2 FETs were fabricated with free-standing ferroelectric oxide gate dielectric. The fabricated devices showed remarkable dielectric stability (4 MV/cm) and ferroelectric switching. Further, they exhibited sub-60 mV/dec operation with low operation voltage and on-off current ratio greater than 10^6. This approach of vdW engineering of 2D materials with free-standing oxides demonstrates the feasibility of achieving good interface quality and various property tunability for future electronic applications.

References [1]. Yang, AJ., Wang, S-X., Xu, J., Loh, XJ., Zhu, Q. et al. ACS Nano 17 (2023), 9748–62 [2]. Hu, J., Luo, J., Zheng, Y., Chen, J., Omar, GJ. et al. J. Alloys Compd. 911 (2022), 164830 [3]. Huang, JK., Wan, Y., Shi, J. et al. Nature 605 (2022), 262–267. [4]. Puebla, S., Pucher, T., Rouco, V. et al. Nano Letters, 22,18 (2022), 7457–7466.

T12: Solid State Physics II

Time: Wednesday 24 Sept, 4:00pm; Venue: Room 4; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T12.74 Superconducting Berry Curvature Dipole

Oles Matsyshyn*, Giovanni Vignale, Justin Song (NTU, SPMS)
4:00pm – 4:15pm

Superconductivity and Bloch band Berry curvature responses represent two distinct paradigms of quantum coherent phenomena. The former relies on the collective motion of a many-body state while the latter proceeds from the momentum-space winding of Bloch wavefunctions. Here we reveal a superconducting Berry curvature dipole (BCD) that arises as a collective many-body phenomena in noncentrosymmetric superconductors. Strikingly, we find the superconducting BCD is sensitive to the phase of the superconducting gap and depends on the noncentrosymmetric structure of its pairing. This unusual property enables a BCD proximity effect in hybrid quantum materials that induces nonreciprocity even in a target centrosymmetric metal. We find superconducting BCD naturally produces nonreciprocal electromagnetic responses that includes a giant second-order nonlinearity. This renders noncentrosymmetric superconductors an exciting platform for realizing pronounced nonlinearities and its BCD responses a novel diagnostic of the superconducting gap.

T12.12 Scaling anomalous Hall effect: opposite contributions of Fermi sea and Fermi surface

Xiaona Di*, Weiwei Lin* (Southeast University)
4:15pm – 4:30pm

Anomalous Hall effect (AHE) is a fundamental topic and of renewed interest in condensed matter physics in the last decades. It has been generally accepted that the mechanisms of AHE include intrinsic (Berry curvature) and extrinsic (skew scattering and side jump) contributions due to spin-orbit coupling [1]. The conventional scaling of AHE presents the magnitude of the anomalous Hall conductivity $|\sigma_{xy}|$ as a function of conductivity σ_{xx}. The sign of σ_{xy} which may vary with composition and temperature, however, is not usually shown in the scaling. In this work, we report a simple scaling of AHE including the sign reversal of σ_{xy}. We measured the thickness and temperature dependence of AHE in polycrystalline ferromagnetic metal Co with positive σ_{xy}, Ni with negative σ_{xy}, $Co_{27}Ni_{73}$ alloy with sign reversal of σ_{xy} and amorphous ferromagnetic $Co_{40}Fe_{40}B_{20}$. The σ_{xy} of all the studied ferromagnetic metals can be well fitted by the scaling σ_{xy} = σ_{xy} 0 + aσ_{xx} + bσ_{xx} 2. The fitting results show that the contribution of aσ_{xx} dominates σ_{xy} and is opposite to both σ_{xy} 0 and $b\sigma_{xx}^2$. Notably, the contribution of Fermi sea with the quadratic term of σ_{xx} is opposite to that of the Fermi surface, which is consistent to the theory. Both the contributions from the Fermi surface and Fermi sea depend on the relaxation time and disordered potential. Figure 1 shows the $|\sigma_{xy}|$ of our experiments and the fitting of our scaling as a function of conductivity σ_{xx}, indicating the unrevealed behavior different from the convention scaling. Our scaling of AHE is applicable to various materials and reveals the key mechanisms of AHE.

T12.33 Beyond symmetry protection: Robust feedback-enforced edge states in non-Hermitian stacked quantum spin Hall systems

Mengjie Yang*, Chinghua Lee* (Institute of High Performance Computing)
4:30pm – 4:45pm

Conventional wisdom holds that strongly coupling two QSH layers yields a trivial $\mathbb{Z}_2$ phase and no protected topological edge states. We demonstrate that, in a regime with intermediate inter-layer coupling (neither in the strong or weak coupling regimes) and competitive non-Hermitian directed amplification, bulk modes are suppressed while arbitrary bulk excitations inevitably accumulate into robust helical edge transport modes - without relying on any symmetry protection. Our feedback-enforced mechanism persists over broad parameter ranges and remains robust even on fractal or irregular boundaries. These findings challenge the traditional view of stacked QSH insulators as inevitably trivial, and open up new avenues for designing helical topological devices that exploit feedback-enforced non-Hermitian engineering, instead of symmetry-enforced robustness.

T12.70 Two-Dimensional Critical Non-Hermitian Skin Effect

Wei Jie Chan*, Wen Tan Xue, Hui Jiang, Ching Hua Lee (NUS)
4:45pm – 5:00pm

Critical systems, known for their unique properties at phase transition boundaries, have traditionally been studied in Hermitian models. However, the advent of non-Hermitian physics has introduced the critical non-Hermitian skin effect, characterized by discontinuous changes in eigenenergies and eigenstates. This phenomenon typically occurs when a pair of anti-parallel chains with different non-reciprocal accumulations are weakly coupled. In particular, we find that the critical non-Hermitian skin effect can be induced not only in two (or more) dimensions, but it can also introduce the higher-order critical non-Hermitian skin effect. Unlike the usual critical non-Hermitian skin effect, this higher-order criticality can be toggled on and off by adjusting the number of coupled chains. Our work provides insights into the intricate interplay between criticality at phase boundaries and higher-order systems.

T13: Quantum Theory I

Time: Thursday 25 Sept, 11:00am; Venue: Room 1; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T13.46 Optimal Conversion Rates of Pairs of Flat Quantum States in Terms of α-z Relative Entropies

Frits Verhagen*, Marco Tomamichel, Erkka Haapasalo (Centre for Quantum Technologies, National University of Singapore)
11:00am – 11:15am

We offer the first operational interpretation of the α-z relative entropies, a measure of difference between two quantum states. Namely, we show that these relative entropies appear in the conditions for large-sample or catalytic relative majorization of pairs of flat quantum states and certain generalizations of them. In this setting, the α and z parameters are truly independent from each other. Additionally, we show that the optimal rate of converting one such pair into another may be formulated in terms of the α-z relative entropies.

T13.91 Irreversibility as Subjectivity (the Dependence on Bayesian Priors)

Clive Aw*, Valerio Scarani, Lizhuo Liu (Centre for Quantum Technologies)
11:15am – 11:30am

In both classical and quantum physics, irreversible processes are described by maps that contract the space of states. The change in volume has often been taken as a natural quantifier of the amount of irreversibility. In Bayesian inference, loss of information results in the retrodiction for the initial state becoming increasingly influenced by the choice of reference prior. Here, we import this latter perspective into physics, by quantifying the irreversibility of any process with its Bayesian subjectivity—that is, the sensitivity of its retrodiction to one's prior.

We show that this measure not only coheres with other figures of merit for irreversibility, but also has joint monotonicities with physically noteworthy, information geometric measures. We also discuss briefly some recent findings and open questions relating to how Bayesian subjectivity is monotonic to Markovian concatenations as well as how it behaves under non-Markovian ones.

T13.3 Retrodiction with extended prior

Mingxuan Liu*, Ge Bai, Valerio Scarani (Centre for Quantum Technologies)
11:30am – 11:45am

A mixed quantum state can be taken as capturing an unspecified form of ignorance; or as describing the lack of knowledge about the true pure state of the system (”proper mixture”); or as arising from entanglement with another system that has been disregarded (”improper mixture”). These different views yield identical density matrices and therefore identical predictions for future measurements. But when used as prior beliefs for inferring the past state from later observations (”retrodiction”), they lead to different updated beliefs. This is a purely quantum feature of Bayesian agency. Based on this observation, we establish a framework for retrodicting on any quantum belief and we prove a necessary and sufficient condition for the equivalence of beliefs. In this presentation, I will talk about the consequences of implementing prior-extended retrodiction and show its significance in quantum state estimation and recovery.

T13.145 Near-Term Pseudorandom and Pseudoresource Quantum States

Andrew Tanggara*, Mile Gu, Kishor Bharti (Centre for Quantum Technologies)
11:45am – 12:00pm

Quantum computational indistinguishability is a phenomenon where two quantum state ensembles looks identical to observers with access only to efficient quantum computers. It imposes a computational barrier in accessing the entire resource contained in a quantum state, leading to many interesting phenomenons and applications in quantum cryptography, black hole physics, quantum learning theory, quantum chaos, many-body thermalization, entanglement theory, coherence, and magic. Two objects play a central role in computational indistinguishability: (1) *pseudorandom quantum states (PRS)*, a quantum state ensemble that is indistinguishable from Haar-random ensemble to efficient observers, and (2) *pseudoresource* pairs, two quantum state ensembles consisting of a high-resource ensemble and a low-resource ensemble that are indistinguishable to efficient observers. However existing results on PRS and pseudoresources equate the notion of efficiency to quantum computers which runtime is bounded by a polynomial in its input size, which is too demanding for near-term quantum computers. In this work we propose the notion of $\mathbf{T}$-*indistinguishability*, where two n-qubit quantum state ensembles are indistinguishable to observers with quantum computers with runtime bounded by some function $O(\mathbf{T}(n))$. This allow one to tune the computational capability of the observer by choosing different $\mathbf{T}(n)$. We build a framework that allows us to characterize and construct (1) $\mathbf{T}$-*PRS*, an ensemble that is $\mathbf{T}$-indistinguishable from Haar-random ensemble, and (2) $\mathbf{T}$-*pseudoresource* pair, two $\mathbf{T}$-indistinguishable ensembles with different amount of resource. Then we derive general bounds on the amount of resources in a $\mathbf{T}$-pseudoresource pairs for any choice $\mathbf{T}(n)$. We demonstrate how the necessary amount of resource decreases as the observer's computational power $\mathbf{T}(n)$ is more limited, giving a $\mathbf{T}$-pseudoresource pair with larger resource gap for computationally weaker observers for entanglement, coherence, and magic.

T13.31 Cluster state model with non-invertible (weak) Hopf symmetry

Zhian Jia* (Centre for Quantum Technologies, National University of Singapore)
12:00pm – 12:15pm

Cluster states are essential resources for measurement-based quantum computation (MBQC) and exhibit symmetry-protected topological (SPT) order, making them crucial for the study of topological phases. In this work, we present a construction of cluster states based on Hopf algebras. By generalizing the finite-group-valued qudit to a Hopf-algebra-valued qudit, and introducing a generalized Pauli-X operator defined via the regular action of the Hopf algebra and a generalized Pauli-Z operator defined via its irreducible representation action, we develop a comprehensive theory of Hopf qudits. We demonstrate that non-invertible symmetry arises naturally in the context of Hopf qudits. For a bipartite graph—termed the cluster graph—we assign the identity state and the trivial representation state to even and odd vertices, respectively. Introducing the edge entangler as a controlled regular action, we provide a general construction of Hopf cluster states. To ensure the commutativity of edge entanglers, we propose a method for constructing cluster lattices on arbitrary triangulable manifolds. Using the one-dimensional cluster state as a concrete example, we illustrate our construction and show that it serves as a promising candidate for realizing SPT phases. We construct a gapped Hamiltonian for this setting and give a detailed analysis of its non-invertible symmetries. Furthermore, we show that the one-dimensional Hopf cluster state model is equivalent to a quasi-one-dimensional Hopf quantum double model with one rough boundary and one smooth boundary. We also explore the generalization to the Hopf ladder model using symmetry topological field theory. Lastly, we introduce a Hopf tensor network representation of Hopf cluster states by integrating tensor representations of structure constants with the string diagram formalism of Hopf algebras, providing a powerful framework for analyzing and solving the Hopf cluster state model.

T13.24 Robust Catalysis and Resource Broadcasting: The Possible and the Impossible

Jeongrak Son*, Ray Ganardi, Shintaro Minagawa, Francesco Buscemi, Seok Hyung Lie*, Nelly H. Y. Ng* (Nanyang Technological University)

12:15pm – 12:30pm

In many practical scenarios, a particularly scarce resource—such as entanglement, coherence, or magic—limits the operations we can perform. Catalysis offers a way to overcome these limitations: by using an auxiliary state (the catalyst), we can enable previously infeasible operations while preserving the catalyst's original state. Hence, catalysts are reusable for an indefinite number of times, which justifies the employment of catalysts.

However, catalytic transformations typically depend on the initial state of the transformation and assume that this initial state can be prepared without any error. We investigate the feasibility of catalytic transformations in realistic setups where small errors in state preparation are present. We define two classes of catalysis: fragile and robust. If the catalysis is fragile, the catalytic transformation is no longer catalytic even with the smallest error in preparing the initial state; otherwise, it is robust. We show that robust catalyses are catalytic regardless of the initial state, i.e. they can tolerate arbitrarily large errors. Then, we show that in a wide class of theories, any catalytic transformation is fragile. Finally, we find the necessary and sufficient condition for robust catalysis in another class of theories. Our results reveal that most catalytic transformations break down in realistic settings and provide an alternative definition that remains valid in such settings. We additionally prove an equivalence between robust catalysis and another interesting process called resource broadcasting—the ability to transfer a resource to another system without altering the original.

T14: Astro- and Biophysics

Time: Thursday 25 Sept, 11:00am; Venue: Room 2; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T14.67 (INVITED) Challenges in Gravitational Wave Data Analysis with LISA EMRIs

Shubham Kejriwal* (National University of Singapore)
11:00am – 11:20am

Gravitational waves from binary black-hole systems known as EMRIs are expected to be detected by the upcoming space-based observatory, LISA. The accuracy and precision with which EMRIs can be inferred depends on the availability of reliable models and bespoke data analysis techniques. In this talk, I will briefly talk about my work that tackles some outstanding data analysis challenges, especially focusing on beyond-vacuum-GR effects in EMRIs.

T14.40 Identification of Extreme Mass Ratio Inspirals (EMRIs) in LISA via the one-stop function

Davendra Shayna Hassan*, Alvin J. K. Chua* (National University of Singapore)
11:20am – 11:35am

Extreme mass ratio inspirals (EMRIs) will be one of the most important sources in the upcoming space-based gravitational wave detector, LISA. However, it poses a challenging data analysis problem in gravitational-wave astronomy due to the phenomenon of strong non-local correlations in the EMRI signal search space, which severely hinders reliable source identification. The recently proposed one-stop function by Chua (2022) offers unified approach to detection, identification and inference of EMRI signals. Particularly in the context of identification aspect of the search, it provides a beneficial effect of suppressing both secondary peaks and noise. In this project, I talk regarding the recent progress in translating this novel function into a more realistic working analysis pipeline.

T14.42 Evolutionary random graph networks and quantum gravity

Medeu Abishev* (Al Farabi Kazakh National University / NUS)
11:35am – 11:50am

In this work, we study the dynamics of evolutionary random graphs constructed iteratively from an initial closed structure via probabilistic identification of points on edges, depending on the distance between those edges. The evolution is governed by an infinite-dimensional probability parameter that depends on the geometric and topological characteristics of the current graph state, such as edge-to-edge distances, local curvature, and vertex degrees. The focus is on analyzing the asymptotic behavior of such graphs in the limit of many iterations, including degree distributions, connectivity fluctuations, the emergence of critical regimes, and fractal dimensionality.

It is shown that under certain probabilistic control regimes, the model exhibits behavior analogous to that found in discrete approaches to quantum gravity. We discuss the conditions under which the graphs transition into regimes supporting particles and fields on quasi-continuous geometries, including possible phase transitions similar to spacetime condensates in Group Field Theory (GFT).

The results can be interpreted as a step toward constructing a probabilistic-geometric model for the emergence of spacetime from discrete dynamical processes. The proposed approach bridges methods from random graph theory, statistical physics, and quantum gravity models within a unified computable paradigm.

T14.129 Efficient Intracellular Delivery of Macromolecules and mRNA via Cell Deformation in Viscoelastic Microfluidics

Partha Pratim Sarkar*, Qiang Zhao, Ye Ai* (Singapore University of Technology and Design (SUTD))
11:50am – 12:05pm

Intracellular delivery is fundamental to the advancement of gene editing, regenerative medicine, and cell-based therapies. However, commonly used methods such as viral transduction, lipofection, and electroporation are constrained by cytotoxicity, poor efficiency, and limited cargo capacity. These challenges highlight the need for alternative strategies that are safe, effective, and scalable. Here, we present a microfluidic platform that enables high-throughput, non-viral intracellular delivery through parallel-periodic mechanoporation in viscoelastic media. The device design incorporates periodic constrictions larger than the cell diameter, enabling repeated, contact-free deformation of cells as they flow through the channel. This controlled hydrodynamic stress induces transient and reversible membrane openings, thereby facilitating efficient cytosolic entry of biomolecules while preserving cell viability. We systematically evaluated three non-Newtonian fluids—methylcellulose, polyethylene oxide, and xanthan gum—at identical concentrations. Among these, methylcellulose consistently achieved superior delivery performance compared with the others. Under optimized fluid conditions and device geometry, the platform achieved 95.4% delivery efficiency, 95.7% viability, and 91.5% recovery, with throughputs above 50,000 cells per second. Importantly, the system demonstrated 2.5-fold higher transfection efficiency than lipofection, highlighting its superiority over conventional chemical methods. The platform successfully delivered a wide range of cargoes, from 4 kDa to 2,000 kDa fluorescein isothiocyanate (FITC)–dextran, as well as functional mRNA, into both suspension cells (Jurkat) and adherent cells (MDA-MB-231). This work establishes a versatile microfluidic strategy for intracellular delivery, providing a foundation for future breakthroughs in gene editing, therapeutic development, and personalized medicine.

T14.26 Geometry and Sequence Dependence in a DNA-Based Mechanosensor

Jingzhun Liu*, Yan Jie* (Department of Physics, National University of Singapore)
12:05pm – 12:20pm

Tension Gauge Tethers (TGTs) are short DNA-based force sensors widely used in mechanobiology to study cellular tension during processes such as adhesion and migration. Each TGT includes a shear-stretch and an unzip-stretch region, but no prior model has captured their combined effect on the force-dependent lifetime $\tau(f)$. We introduce a theoretical model that integrates both regions and reveals a critical switching force ($\approx$13 pN) where the energy barrier shifts, markedly altering $\tau(f)$. Validated by experimental data, the model enables $\tau(f)$ prediction from DNA sequence alone at physiological temperature. This work enhances the design and interpretation of TGT-based assays and supports broader applications in cell mechanosensing and mechanotransduction.

T15: Many-body Physics

Time: Thursday 25 Sept, 11:00am; Venue: Room 3; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T15.117 (INVITED) 2D Anderson Localization and KPZ sub-Universality Classes: sensitivity to boundary conditions and insensitivity to symmetry classes

Nyayabanta Swain*, Shaffique Adam, Gabriel Lemarie (CQT)
11:00am – 11:20am

We challenge two foundational principles of localization physics by analyzing conductance fluctuations in two dimensions with unprecedented precision: (i) the Thouless criterion, which defines localization as insensitivity to boundary conditions, and (ii) that symmetry determines the universality class of Anderson localization. We reveal that the fluctuations of the conductance logarithm fall into distinct sub-universality classes inherited from Kardar-Parisi-Zhang (KPZ) physics, dictated by the lead configurations of the scattering system and unaffected by the presence of a magnetic field. Distinguishing between these probability distributions poses a significant challenge due to their striking similarity, requiring sampling beyond the usual threshold of $\approx 10^{-6}$ accessible through independent disorder realizations. To overcome this, we implement an importance-sampling scheme - a Monte Carlo approach in disorder space - that enables us to probe rare disorder configurations and sample probability distribution tails down to 10^{-30}. This unprecedented precision allows us to unambiguously differentiate between KPZ sub-universality classes of conductance fluctuations for different lead configurations, while demonstrating the insensitivity to magnetic fields.

T15.36 (INVITED) Extensive entanglement between 1D quantum many-body systems: from theory to experiment

Taufiq Murtadho*, Marek Gluza, Nelly Ng* (Nanyang Technological University)
11:20am – 11:40am

Quantum entanglement exists in nature but is absent in classical physics, hence it fundamentally distinguishes quantum from classical theories. While entanglement is routinely observed for few-body systems, it is significantly more challenging to witness in quantum many-body systems. Here we theoretically study entanglement between two spatially separated quantum many-body systems—two parallel Tomonaga-Luttinger liquids (TLLs) partitioned along the longitudinal axis. In particular, we focus on two experimentally relevant situations: tunnel-coupled TLLs at finite temperatures and after coherent splitting. In both scenarios, we analytically calculate the logarithmic negativity and determine the threshold temperature below which the system is entangled. We show that this threshold temperature is accessible in near-term coherent splitting experiments. We further investigate the crossover between quantum and classical correlations in the vicinity of the threshold temperature by comparing logarithmic negativity with mutual information. We argue that the initial mutual information established by the coherent splitting is conserved in TLL dynamics, thus preventing certain generalized Gibbs ensembles from being reached during prethermalization. Despite local interaction, both logarithmic negativity and mutual information across the longitudinal partition scale extensively with the subsystem's length. While previous studies have theorized the ground-state entanglement between coupled TLLs to be extensive, this setting has been largely overlooked compared to other partitions. Our work extends the study of entanglement between coupled TLLs to finite temperatures and out-of-equilibrium regimes, and demonstrates that observing extensive entanglement in quantum many-body systems at finite temperatures is within experimental reach.

T15.57 Novel dopant-free ferromagnetic Mott-like insulator and high-energy correlated-plasmons in unconventional strongly correlated s band of low-dimensional gold

Muhammad Avicenna Naradipa*, Angga Dito Fauzi, Bin Leong Ong, Muhammad Aziz Majidi, Caozheng Diao, Ganesh Ji Omar, Ariando Ariando, Mark B. H. Breese, Eng Soon Tok, Andrivo Rusydi* (National University of Singapore)

11:40am – 11:55am

Ferromagnetic insulators and plasmons have attracted a lot of interest due to their rich fundamental science and applications. Recent research efforts have been made to find dopant-free ferromagnetic insulators and unconventional plasmons independently both in strongly correlated electron systems. However, our understanding of them is still lacking. Existing dopant-free ferromagnetic insulator materials are mostly limited to complex d- or f-systems with extremely low Curie temperature, low-symmetry structure, and strict growth conditions on specific substrates, limiting their compatibility with industrial applications. Unconventional plasmon is, on the other hand, a quasiparticle that originates from the collective excitation of correlated-charges, yet they are rarely explored, particularly in ferromagnetic insulator materials. Herewith, we present a novel, room temperature dopant-free ferromagnetic Mott-like insulator with a high-symmetry structure in unconventional strongly correlated s band of low-dimensional highly oriented single-crystal gold quantum dots (HOSG-QDs) on MgO(001). Interestingly, HOSG-QDs show new high-energy correlated-plasmons with low-plasmonics-loss. With a series of state-of-the-art experimental techniques, we find that the Mott-insulating state is tunable with surprisingly strong spin-splitting and spin polarization accompanied by strong s–s transitions, disappearance of Drude response, and generating new Mott-like gap. Supported with a series of theoretical calculations, the interplay of quantum confinement, many-body electronic correlations, and hybridizations tunes electron–electron correlations in s band and determines the ferromagnetism, Mott-like insulator, and high-energy correlated-plasmons. Our result shows a new class of room temperature dopant-free ferromagnetic Mott-like insulator and high-energy correlated-plasmons with low-loss in strongly correlated s band and opens unexplored applications of low-dimensional gold in spin field-effect transistors and plasmonics.

T15.30 Many-body critical non-Hermitian skin effect

Yi Qin, Ching Hua Lee*, Yee Sin Ang (NUS)

11:55am – 12:10pm

Criticality in non-Hermitian systems unveils unique phase transitions and scaling behaviors beyond Hermitian paradigms, offering new insights into the interplay between gain/loss, non-reciprocity, and complex energy spectra. In this paper, we uncover a new class of many-body critical non-Hermitian skin effect (CSE) originating from the interplay between multiple non-Hermitian pumping channels and Hubbard interactions. In particular, criticality in the real-to-complex transitions can selectively emerge within the subspace of bound states or scattering states, as well as their interacting admixtures. These mechanisms possess no single-particle analog and can be diagnosed through a specially defined correlation function. As more particles are involved, higher-order CSEs naturally arise, with greatly enhanced effective coupling strengths and hence greater experimental accessibility. Our results reveal an enriched landscape of non-Hermitian critical phenomena in interacting many-body systems, and pave the way for investigating unconventional non-Hermitian criticality in the context of various interaction-induced particle clustering configurations.

T15.72 Correlated quantum shift vector of particle-hole excitations

Xu Yang*, Ajit Srivastava, Justin Song* (Nanyang Technological University)
12:10pm – 12:25pm

Electron interactions play a critical role in optical response. A prime example is excitonic transitions with energies that peel away from the single particle-hole continuum. We demonstrate that, beyond spectral properties, strong electron-hole interactions produce a correlated excitonic quantum geometry with optical properties distinct from weakly interacting particle-hole excitations. Strikingly, we find excitonic shift vectors are insensitive to light polarization; vertical excitonic transitions produce vanishing shift vectors in non-polar space groups zeroing excitonic shift photocurrents. These features are not shared by weakly interacting delocalized interband transitions rendering the quantum shift vector a sharp optical diagnostic of the bound nature of photoexcitation. This provides an instructive non-pertubative example of how interactions radically transform excited state quantum geometry.

T16: Solid State Physics III

Time: Thursday 25 Sept, 11:00am; Venue: Room 4; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T16.130 Feature-Extended Descriptor Construction for Prediction of Consecutive Elementary Reaction Energies in Methane Oxidation

Wangqiang Lin, Fangting Liu, Zhilong Song, Yehui Zhang, Qionghua Zhou, Chongyi Ling, Qiang Li*, Jinlan Wang* (Southeast University)
11:00am – 11:15am

Conventional descriptor construction approaches are fundamentally limited by their narrow focus on predicting adsorption energies for structurally similar intermediates, failing to address the complexity of real catalytic systems involving multiple active sites and elementary reactions. To overcome these limitations, we develop a general feature extension approach that systematically expands descriptor functionality through two key innovations: structure extension for diverse active site and reaction extension for consecutive elementary reactions, enabled by comparative analysis of active site characteristics. Applying this approach to methane oxidation to methanol with consecutive three elementary reactions and six possible active sites (totaling 1,026 metal-exchanged zeolite catalysts), we successfully map the complete reaction pathways, identifying optimal bimetallic catalysts (including experimentally verified Ag and Cu bimetallic active sites) and extracting fundamental structure-activity relationships. Proof-of-concept verification supports the generalizability of the feature extension approach, establishing a paradigm shift in descriptor discovery that transcends traditional single-site/single-step limitations, offering a powerful framework for complex catalytic pathways analysis and rational catalyst design.

T16.63 Active Phase Controlled Synthetic Antiferromagnetic Spintronic Terahertz Emitter

Avinash Chaurasiya*, Piyush Agarwal*, Hasibur Rahaman, S.N. Piramanayagam, Karen Ke Lin, Rajdeep Singh Rawat (Institute of Materials Research and Engineering, A*STAR, Singapore 138634, Singapore)
11:15am – 11:30am

Conventional spintronic terahertz (THz) emitters operate predominantly via the inverse spin Hall effect (ISHE), relying on ultrafast spin current generation and conversion into broadband THz radiation. Advancing beyond this paradigm, we demonstrate a multifunctional THz emitter based on a synthetic antiferromagnetic (SAF) trilayer structure comprising Co/Ru/Co. This design integrates two back-to-back spintronic emitters, where the relative magnetization orientation of the Co layers can be precisely tuned through interlayer exchange coupling (IEC) by varying the Ru spacer thickness, as well as by external stimuli such as optical pump fluence, magnetic field, and electric field. The engineered control over the magnetization alignment and switching between antiparallel and parallel configurations leads to tunable phase modulation of the emitted THz pulses. The tunability arises from the constructive and destructive interference of THz transients generated by the two ferromagnetic layers, enabling dynamic control over the emission characteristics. Our findings establish a pathway toward actively controllable, multifunctional spintronic THz sources, leveraging IEC as a key mechanism for advanced emitter functionality.

T16.65 Unifying GHz and THz spin-currents led superdiffusion in Ferromagnet/Heavy Metal heterostructures

Piyush Agarwal, Avinash Chaurasiya, Hrittik Kumar Roy, Mukundadev Behera, Chandrasekhar Murapaka, Yogesh Kumar Srivastava, Rajdeep Singh Rawat*, Ke Lin* (A*STAR Singapore)
11:30am – 11:45am

Out-of-equilibrium photoexcitation in ferromagnet/heavy metal (FM/HM) heterostructures has revolutionized spintronics by enabling the generation of ultrafast spin currents, reaching terahertz frequencies. These spin currents, driven by femtosecond laser excitation, fundamentally differ from those produced near equilibrium through ferromagnetic resonance. However, both processes originate from the same underlying electronic interactions, but are governed by different excitation scales and spin diffusion dynamics, making it elusive to unify their mechanisms. Upon spin diffusion within the HM, the ultrafast spin current from the FM undergoes the inverse spin Hall effect, leading to the emission of broadband terahertz radiation. As such, in this work, we experimentally investigate ultrafast terahertz generation to bridge the relation between the spin diffusion lengths of the spin generated at gigahertz and terahertz frequencies. Additionally, we develop analytical models to investigate the microscopic mechanisms and quantitatively determine spin diffusion lengths in different heavy metals, including platinum, tungsten, and tantalum. The in-depth study of spin transport will not only enhance our fundamental understanding of ultrafast phenomena but also unveil contact-free optical estimation of spin properties. By unifying GHz and emerging THz spin dynamics, our findings contribute to the advancement of next-generation ultrafast data processing technologies.

T16.34 Unconventional tunnel magnetoresistance scaling with altermagnets

Zongmeng Yang, Shibo Fang*, Yee Sin Ang* (SUTD)
11:45am – 12:00pm

In conventional magnetic tunnel junctions (MTJs), the tunnel magnetoresistance (TMR) typically increases with barrier thickness as electron transmission in the antiparallel configuration decays faster than that of the parallel configuration. In this work, we reveal an anomalous scaling effect in altermagnetic tunnel junctions (AMTJs), where the TMR decreases anomalously with an increasing barrier thickness. The anomalous scaling originates from the overlapping spin-split branches forming a transmission path that cannot be suppressed in the antiparallel state. Such phenomenon is explained by a double-barrier model and is further demonstrated using ab initio quantum transport simulations in 2D $V_2Te_2O/Cr_2Se_2O/V_2Te_2O$-based AMTJ, where the TMR anomalously decreases from 220% to 40% as the layer number of Cr_2Se_2O increases from 1 to 5. Our work identifies a peculiar unexpected transport characteristic of AMTJ, providing a fundamental limit on AMTJ device design and illustrating the potential optimal design of AMTJ at the ultrascaled monolayer limit.

T16.25 Theoretical design of novel spintronic devices based on altermagnets

Shibo Fang*, Yee Sin Ang* (Singapore University of Technology and Design)
12:00pm – 12:15pm

Altermagnets are a new class of materials that simultaneously exhibit characteristics of both antiferromagnets and ferromagnets, and they have become a research focus in condensed matter physics over the past three years. We have carried out a series of material screenings and device designs based on the unique properties of altermagnets. On the materials side, we proposed the first pentagonal altermagnetic higher-order topological insulator MnS_2 and a ferroelastic altermagnet RuF_4. On the device and control-mechanism side, we proposed the anomalous scaling behavior in altermagnet-based tunneling junctions, all-electrical layer-spintronics, altermagnet spin photovoltaic devices, and edge-MTJ in altermagnets. Our work provides inspiring insights for the development of next-generation spintronics based on altermagnets.

T16.15 Transverse charge current in nonrelativistic collinear altermagnets

Yajun Wei*, Juan Juan Wang, Jun Wang (Southeast University)

12:15pm – 12:30pm

The spin collinear altermagnet (AM) material RuO_2 was shown to exhibit a time-odd transverse spin current driven by a longitudinal electric field [Phys. Rev. Lett. 126, 127701 (2021)]. In this work, we demonstrate theoretically that there exists a time-even transverse charge current besides the spin current in the same AM material without involving any spin orbit interaction, which is crucially dependent on the angle between the crystalline axis and the applied electric field. The origin is the nonrelativistic alternating spin-momentum coupling as well as the spin-dependent anisotropic group velocity of electrons. The transverse charge current is weaker than the spin counterpart but can be enhanced by introducing time-symmetry-broken ingredients such as external magnetization.

T17: Nuclear Safety Physics

Time: Friday 26 Sept, 11:00am; Venue: Room 1; Chair: Adolphus Lye
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T17.27 A Distribution-free Physics-guided Reliability Analysis of a Nuclear Material under Limited Data

Adolphus Lye*, Scott Ferson, Sicong Xiao (Singapore Nuclear Research and Safety Institute, National University of Singapore)
11:00am – 11:15am

The work proposes a distribution-free stochastic model updating approach to address a physics-guided reliability problem based on the 2008 Sandia thermal problem involving a material used for the safety-critical components in a nuclear reactor. One of the challenges involves quantifying the thermal reliability of the material, along with its uncertainties, given only limited experimental data. To achieve this, the proposed methodology involves the moment-matching staircase density function to characterise the variability of the aleatory input model parameters based on limited data. To calibrate the staircase density function on the respective aleatory parameters, the approximate Bayesian computation technique is implemented, along with the Jensen-Shannon divergence as the distance function and the Transitional Ensemble Markov Chain Monte Carlo to provide posterior estimates on the parameters of the staircase density function. In doing so, it removes the assumption on the distribution class associated with the aleatory characteristics of the input model parameters. This yields a probability box on the aleatory parameters which is then propagated through the physics-guided performance function of the material which yields an imprecise probability on the thermal reliability of the material. To demonstrate the feasibility and verify the proposed method, the results are compared against published results to the problem.

T17.127 High Purity Germanium (HPGe) Calibration: Bulletisation Parameter Studies with Monte Carlo Simulation

Joyce W.L. Ang*, Shimin Tan, Ling Ying Diane Tiong* (Singapore Nuclear Research and Safety Institute (SNRSI))
11:15am – 11:30am

High purity germanium (HPGe) detectors are valuable in identifying radionuclides and quantifying radioactivity using gamma spectroscopy. For accurate quantification of measured samples, efficiency calibration of the detector is imperative. Traditional efficiency calibration of HPGe systems requires the use of multiple certified radioactive sources, which are costly, generate radiological waste, and pose handling challenges. Alternatively, Monte Carlo simulations offer the option of source-less calibration while keeping costs low and allowing more versality in sample type and radionuclides used [1]. With this approach, the detector function response is modelled using the interactions between the gamma radiation and the detector. Therefore, the simulated efficiencies are sensitive to input detector parameters. However, the exact detector geometry disclosed by manufacturers is not comprehensive. An often-overlooked parameter is the bulletisation (rounding at the top of the HPGe crystal). Bulletisation can affect the accuracy of simulated efficiency, especially at lower gamma energies [2]. In this presentation, we highlight the capabilities of Monte Carlo simulation with a GEANT4 (version 4.11.1.1) [3] toolkit and potential application to detector studies. The effects of bulletisation on detector efficiency are characterised with an ad hoc GEANT4 code. A systematic evaluation of bulletisation parameters was performed to assess their influence on simulation accuracy and computational efficiency. Using this study, we propose a method to optimise the bulletisation parameter in the simulation with a known calibration standard.

By replacing or complementing traditional source-based calibration with validated Monte Carlo approaches, this work highlights a sustainable pathway for gamma spectroscopy-based laboratories. Minimising reliance on sealed radioactive sources not only reduces procurement and disposal costs but also enhances radiological safety and environmental sustainability in long-term operations.

REFERENCES [1] T. Vidmar, "EFFTRAN - A Monte Carlo efficiency transfer code for gamma-ray spectrometry," Nucl Instrum Methods Phys Res A, vol. 550, no. 3, pp. 603–608, Sep. 2005, doi: 10.1016/j.nima.2005.05.055. [2] T. Vidmar and J. Gasparro, "Crystal rounding and the efficiency transfer method in gamma-ray spectrometry," Applied Radiation and Isotopes, vol. 67, no. 11, pp. 2057–2061, Nov. 2009, doi: 10.1016/j.apradiso.2009.07.015. [3] S. Agostinelli et al., "GEANT4—a simulation toolkit," Nucl Instrum Methods Phys Res A, vol. 506, no. 3, pp. 250–303, Jul. 2003, doi: 10.1016/S0168-9002(03)01368-8.

T17.115 Underground transport of radionuclides

Darryl Foo* (SNRSI)
11:30am – 11:45am

Proposals for underground siting of nuclear power plants have been put forth, both to enhance safety and to effectively maximise land use. We consider the transport of radionuclides in a beyond-worst-case accident scenario, where there are no safety measures besides the ground surrounding the reactor. An initial subdiffusive regime $x \approx t^{1/4}$ is identified, where the radionuclides are transported by the advective flow of other gaseous discharge such as vaporised coolant, and the crossover time between subdiffusive and diffusive regimes determined. We further compute numerically exact solutions, to which our analytical approximations compare favourably.

T17.92 Dispersion of Radionuclides in Water Bodies

Kelvin Horia*, Xiangming Sun* (Singapore Nuclear Research and Safety Institute)
11:45am – 12:00pm

We develop a three-dimensional Lagrangian water dispersion model to simulate the transport and dispersion of radioactive substances. In this framework, the discharge of radionuclides is represented by a large number of particles. The trajectory of the particles is then computed by solving an appropriate stochastic differential equation. Particle decay is achieved by randomly removing particles based on a half-life-dependent probability. The model is applied to simulate the dispersion of 137Cs in Singapore water bodies and in the Fukushima release scenario.

T17.93 Biodosimetry at SNRSI

Jonathan Jian Wei Yeo*, Christelle En Lin Chua (Singapore Nuclear Research and Safety Institute)
12:00pm – 12:15pm

Accurate dosimetry is critical for the reproducibility and interpretation of experiments involving ionising radiation. While physical dosimeters provide direct measurements of delivered dose, biological endpoints offer an independent and integrative means of assessing the actual impact of irradiation on biological samples. In this work, we present biological dose estimates derived from a biodosimetry technique, the dicentric chromosome assay, applied to peripheral blood mononuclear cells (PBMC) from human blood samples irradiated with our X-ray irradiator to build a dose response curve. Physical dosimetry of the X-ray irradiator was performed using calibrated ionization chambers traceable to primary standards. Dicentric chromosome yields were scored in metaphase spreads and analysed across 0.1–5 Gy photon exposures. To validate our dicentric assay dose response calibration, we participated in the Running the European Network of Biological and Physical Retrospective Dosimetry (RENEB) inter-laboratory comparison in 2021 [1] and the Health Canada inter-laboratory comparison in 2023, where our results demonstrated strong concordance with the host laboratory. This highlights the value of incorporating biodosimetry into routine quality assurance for radiobiological studies, offering a physics-grounded, biologically validated framework for dose verification. The agreement between physical and biological dosimetry not only strengthens confidence in experimental data but also provides a model for cross-disciplinary standardisation in radiation research. [1] RENEB Inter-Laboratory Comparison 2021: Inter-Assay Comparison of Eight Dosimetry Assays, Radiation Research, 199(6):556-570 (2023). https://doi.org/10.1667/RADE-22-00202.1

T18: Mathematical and Computational Physics

Time: Friday 26 Sept, 11:00am; Venue: Room 2; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T18.29 Multiple Descents in Deep Learning as a Sequence of Order-Chaos Transitions

Wenbo Wei, Nicholas Jia Le Chong, Choy Heng Lai, Ling Feng* (Institute of High Performance Computing, A*STAR Singapore and National University of Singapore)
11:00am – 11:15am

Comprehending the behavior of deep learning models during training is vital for boosting their ability to generalize, optimize, and withstand challenges. The training of deep neural networks entails exploring complex, high-dimensional parameter landscapes, driven by factors like model intricacy, dataset features, and optimization techniques. The established concept of double descent during training process defies traditional understanding, and showed that the performance of the model will improve-degrade-improve again during the training process on certain problems, though its underlying causes and relevance to diverse architectures are still not fully understood. In this work, we identify a unique "multiple-descent" pattern in Long Short-Term Memory (LSTM) networks, where test loss undergoes repeated cycles of gradual increases followed by sudden drops throughout training. Our findings reveal that these cycles are tied to shifts between ordered and chaotic states in the network's dynamics, with sharp reductions in test loss often linked to rapid transitions from chaos to order. We investigate an LSTM trained on the Large Movie Review Dataset for sentiment classification, discovering that the best performance emerges at the first phase change from order to chaos, where the network's "critical boundary" is most expansive, allowing for the most effective exploration of weight configurations. arXiv:2505.20030

T18.51 Topological 5d N=2 Gauge Theories: Mirror Symmetry and Langlands Duality of A-infinity-categories of Floer Homologies

Arif Er*, Meng-Chwan Tan (NUS)
11:15am – 11:30am

In this talk, I will explain why on certain five-manifolds, topological 5d N=2 gauge theory of Haydys-Witten twist with gauge group G, is dual to that of Geyer-Mülsch twist with gauge group LG, where G is a real, compact Lie group with Langlands dual LG. In turn, this allows us to obtain mirror symmetries and Langlands dualities amongst the A-infinity-categories physically realized from these theories. This work furnishes purely physical proofs and generalizations of the mathematical conjectures by Bousseau and Doan-Rezchikov, and more.

T18.168 Explaining the Bias Between Reanalysis Data and Observations During Heat Waves in East and Southeast Asian Cities: The Role of Urbanization and Urban Entropy

Po-Yen Lai* (Agency for Science Technology and Research (A*STAR), Institute of High Performance Computing (IHPC))
11:30am – 11:45am

Reanalysis weather data, such as ERA5-Land, is difficult to accurately capture urban temperatures during heat waves, leading to significant forecast errors, especially at night. This study investigates whether this bias can be explained by two key factors: the level of urbanisation (or urbanicity) and "urban entropy" - a metric quantifying a city's structural disorder. Analysing long-term air temperature data (1991–2025) from 551 stations across East and Southeast Asia, we compared reanalysis data with quality-controlled observations. Our preliminary results show that in highly urbanised cities with high entropy, reanalysis data tend to underestimate both peak daytime and nighttime temperatures. More significantly, the bias in

nighttime temperatures can be linked to urban entropy. While these findings are preliminary and require more research to confirm causality, they point toward a physics-informed method for correcting data biases. This approach has practical potential for improving the accuracy of heat wave evaluations and guiding urban planning strategies to mitigate heat stress by managing structural complexity.

T18.139 Continuous-time parametrization of neural quantum states for quantum dynamics

Dingzu Wang* (Singapore University of Technology and Design)
11:45am – 12:00pm

Neural quantum states are a promising framework for simulating many-body quantum dynamics, as they can represent states with volume-law entanglement. As time evolves, the neural network parameters are typically optimized at discrete time steps to approximate the wave function at each point in time. Given the differentiability of the wave function stemming from the Schrödinger equation, here we impose a time-continuous and differentiable parameterization of the neural network by expressing its parameters as linear combinations of temporal basis functions with trainable, time-independent coefficients. We test this ansatz, referred to as the smooth neural quantum state (s-NQS) with a loss function defined over an extended time interval, under a sudden quench of a non-integrable many-body quantum spin chain. We demonstrate accurate time evolution using simply a restricted Boltzmann machine as the instantaneous neural network architecture. Furthermore, we demonstrate that the parameterization is efficient in the number of parameters and the smooth neural quantum state allows us to initialize and evaluate the wave function at times not included in the training set, both within and beyond the training interval.

T18.119 Scale-invariant dynamics in a purely deterministic Game of Life model

Hakan Akgün*, Xianquan Yan*, Tamer Taskıran*, Muhamet Ibrahimi*, Ching Hua Lee*, Seymur Jahangirov* (Bilkent University)
12:00pm – 12:15pm

Scale invariance is a key feature that characterizes criticality in complex dynamical systems, which often organize into structures exhibiting no typical size and/or lifespan. While random external inputs or tunable stochastic interactions are typically required for showcasing such criticality, the question of whether scale-invariant dynamics can emerge from purely deterministic interactions remains unclear. In this work, we discover highly affirmative signatures of critical dynamics in equal-state clusters that emerge in the logistic Game of Life (GOL): an extension of Conway's GOL into a Cantor set state space that is nevertheless deterministic. We uncover at least three types of asymptotic behavior, i.e., phases, that are separated by two fundamentally distinct critical points. The first critical point—associated with a peculiar form of self-organized criticality—defines the non-analytic boundary between a sparse-static and a sparse-dynamic asymptotic phase. Meanwhile, the second point marks an enigmatic deterministic percolation transition between the sparse-dynamic and a third, dense-dynamic phase. Moreover, we identify distinct power-law distributions of cluster sizes with unconventional critical exponents that challenge the current paradigms for critical behavior. Overall, our work concretely paves the way for studying emergent scale invariance in purely deterministic systems.

T18.87 Neural Network Detection and Classification of Hidden Patterns in Directed Bounded Percolation

Vitalii Kapitan*, Konstantin Soldatov*, Danil Parkhomenko, Pavel Ovchinnikov, Gennady Chitov (Far Eastern Federal University)

12:15pm – 12:30pm

We study a directed bounded percolation (BDP) process in 1+1 dimensions, where percolation patterns are defined as spanning clusters of renormalized lattice nodes. Using raw configuration data from numerical simulations, we develop a multihead deep learning model combining convolutional (CNN), temporal convolutional (TCN), and recurrent (GRU) layers to detect phase transitions and classify hidden patterns: dipolar, quadrupolar, and plaquette, without manual feature extraction. Each head performs binary classification for a specific pattern, with class imbalance leading to systematic shifts in predicted scores. We compare two calibration methods: a secondary nonlinear transformation trained with cross-entropy loss, and per-head threshold tuning via precision–recall curves. Both approaches improve phase diagram consistency, though with different trade-offs in flexibility and bias. The method accurately reconstructs the phase diagram and reveals hierarchical structure in the BDP configurations, enabling reliable pattern identification and transition localization. KV acknowledges support from RCE IFIM, NUS (funded by MoE, Singapore); others from RSF grant
#25-21-00286.

T19: Quantum Theory II

Time: Friday 26 Sept, 11:00am; Venue: Room 3; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

T19.75 Progress towards an accurate enough semiclassical approximation for quantum gases and electronic structure

Martin-Isbjoern Trappe*, Jun Hao Hue, Michael Tsesmelis, Berge Englert (Centre for Quantum Technologies)
11:00am – 11:15am

We have set up code infrastructure that enables the efficient deployment of a semiclassical density approximation ('n7'), within density-potential functional theory (DPFT), whose accuracy may eventually prove comparable to that of Kohn–Sham DFT calculations—at least for large particle numbers. n7 is a systematic improvement over a lower-order-approximation, which itself can already reach Hartree–Fock accuracy in some cases, for example, for ultracold Fermi gases. Until recently, n7 could only be deployed for 1D (or isotropic) systems. But a new contour integral representation reduced the computational cost by orders of magnitude, and additional speedups may come from GPU usage as well as adaptive spatial grids and quadratures. We show first results on the electronic structure of single atoms. Subsequent benchmarking on interacting Fermi gases in 2D (and, eventually, molecular electronic structure in 3D) is planned.

T19.104 Reversal & Inversion by Iterating Bayesian Updates, for Classical and Quantum Maps

Clive Aw*, Jinyan Chen, Valerio Scarani (Centre for Quantum Technologies)
11:15am – 11:30am

It is well known that for the statistical inference of probability functions, large samples asymptotically recover the "actual" state. This occurs even under a Bayesian lens for such protocols as such estimators are consistent. A question arises about whether this also obtains more generally for the Bayesian inversions of transformations (that is, with stochastic matrices and CPTP channels).

In this work, we show that this does obtain via analytic and numerical results. Namely, we show that Bayes rule does go to inversion asymptotically if one iteratively nests the update of priors with respect to output evidence. This occurs also for the Petz Recovery Map with respect to CPTP channels. These findings make this "embedded inversion" feature a viable necessary condition for candidates for any proposed "quantum Bayes' rule".

Finally, we note the insightful geometric characteristics of the update trajectories under iteration, which act like geodesics under some informational metric.

T19.148 Quantum thermal machines and the emergence of different thermodynamic functioning regimes from finite coupling to a load

Gauthameshwar S*, Noufal Jaseem, Dario Poletti (SUTD)
11:30am – 11:45am

Autonomous quantum thermal machines are particularly suited to understand how correlations between thermal baths, a load, and a thermal machine affect the overall thermodynamic functioning of the setup. Here, we show that by tuning the operating temperatures and the magnitude of the coupling between machine and load, the thermal machine can operate in four modes: engine, accelerator, heater, or refrigerator. In particular, we show that as we increase the coupling strength, the engine mode is suppressed, and the refrigerator mode is no longer attainable, leaving the heater as the most pronounced functioning modality, followed by the accelerator. This regime switching can be amplified by quantum effects, such as the bosonic enhancement factor for a harmonic oscillator load, which effectively modifies the machine-load coupling, making the thermodynamic functioning sensitive to the initial preparation of the load.

T19.44 Aperiodic Dissipation as a Mechanism for Steady-State Localization

Shilpi Roy* (NUS)
11:45am – 12:00pm

Dissipation is traditionally regarded as a disruptive factor in quantum systems because it often leads to decoherence and delocalization. However, recent insights into engineered dissipation reveal that it can be tuned to facilitate various quantum effects, from state stabilization to phase transitions. In this work, we identify aperiodic dissipation as a mechanism for inducing steady-state localization, independent of disorder or a quasiperiodic potential in the Hamiltonian. This localization arises from long-range phase correlations introduced by a spatially varying dissipation phase parameter, which enables nontrivial interference in the steady-state. By systematically comparing two classes of aperiodic dissipation (defined as commensurate and incommensurate cases), we find that incommensurate modulation plays the most efficient role in stabilizing a localized steady-state. Our analysis, based on coherence measures, purity, and participation ratio, reveals a direct link between eigenstate coherence and real-space localization, showing that dissipation can actively shape localization rather than simply causing decoherence. These findings highlight aperiodic dissipation as a viable approach to controlling localization in open quantum systems, potentially enabling new ways to manipulate quantum states and design dissipation-driven phases.

T19.49 Quantum state-agnostic work extraction (almost) without dissipation

Josep Lumbreras*, Ruocheng Huang*, Yanglin Hu*, Mile Gu, Marco Tomamichel (National University of Singapore)
12:00pm – 12:15pm

In this work, we address a fundamental question in quantum thermodynamics: How much work can be extracted from a finite sequence of unknown quantum states? Extracting work requires a physical interaction tailored to the state of the system, but without prior knowledge of the state, such an interaction cannot be properly designed. On the other hand, gaining information about the state through measurements consumes part of the total free energy we can extract, reducing the amount that can be converted into useful work. Existing approaches typically rely on state tomography, which uses a portion of the states purely for estimation and discards their work potential. Our key innovation is a fully-adaptive, state-agnostic protocol that leverages the exploration–exploitation trade-off from reinforcement learning to achieve an exponential reduction in wasted free energy. Here, exploration refers to acquiring information about the unknown quantum state, while exploitation involves using this information to extract work efficiently. Our protocol performs minimally invasive tomography on the fly, using every copy both as a source of information and of energy. We prove that for N copies of the unknown quantum state, the cumulative dissipation incurred by our protocol scales only polylogarithmically with N, in contrast to the square-root(N) scaling of any approach based on tomography. This exponential improvement demonstrates a fundamental advancement in energy harvesting from unknown states. Our results also establish a novel conceptual link between quantum thermodynamics and reinforcement learning by framing work extraction as a sequential learning problem.

T19.151 Sub-Bath Cooling in Bosonic Systems: Gaussian Constraints and Non-Gaussian Enhancements

Xueyuan Hu*, Wen Han Png*, Valerio Scarani* (National University of Singapore)
12:15pm – 12:30pm

Algorithmic cooling with Gaussian operations plays a central role in preparing high-purity states for bosonic quantum information processors, including trapped ions, superconducting qubits, and photonic platforms. However, it is well established that Gaussian thermal operations (GTO) alone cannot reduce the target entropy below that of the bath. The potential of Gaussian operations beyond GTO, however, remains largely unexplored. We investigate the framework of Heat-Bath Algorithmic Cooling (HBAC) with Gaussian operations, where the recharging step is implemented via Gaussian unitaries and the thermalizing step via GTO. Assuming the system and machine are initially in equilibrium with the reservoir, we derive necessary and sufficient conditions for sub-bath cooling using Gaussian operations, showing that it is possible only if the machine gap is larger than the system gap. To assess the efficiency of Gaussian cooling, we analyze entropy production over a finite number of HBAC steps. We identify SWAP as the optimal unitary for the recharging routine and determine the optimal machine gap required at each iteration to minimize entropy production. In the large-iteration limit, our finite-step optimization converges to the trajectory predicted by minimizing thermodynamic length. Finally, we examine enhancements enabled by non-Gaussian resources. We provide analytical and numerical evidence that spontaneous parametric down-conversion (SPDC) achieves sub-bath cooling even when the machine gap is smaller than the system gap. Ongoing work focuses on establishing the precise necessary and sufficient conditions under which non-Gaussian operations enable sub-bath cooling.

J2: Joint session: Workshop on POSTECH-SG collaboration in Quantum Physics

Time: Friday 26 Sept, 11:00am; Venue: ; Chair: (TBD)
Time allocated for invited talks is 15 min speaking time, plus 5 min Q&A, and time allocated for contributed talks is 12 min speaking time plus 3 minutes Q&A.

J2.172 Overview of POSTECH Quantum Graduate School and Global Partnership Program

Yoon-Ho Kim* (POSTECH)
11:00am – 11:10am

Pohang University of Science and Technology (POSTECH) hosts both the Quantum Graduate School and the Quantum Global Partnership Leading University Program, funded by the Ministry of Science and ICT of Korea. These initiatives advance quantum science and technology through education, research, and international collaboration, with the Centre for Quantum Technologies (CQT) as one of the key global partners.

J2.169 Integrated Quantum Light Sources on Thin-Film Lithium Niobate

Di Zhu* (NUS)
11:10am – 11:25am

Integrated photonics offers a scalable solution for realizing complex photonic quantum systems, which are essential for practical computing and simulation applications. Recently, thin-film lithium niobate (TFLN) has emerged as a promising material platform for integrated nonlinear and quantum photonics. It offers many attractive properties that are critically missing in traditional silicon photonics, such as large electro-optic and piezoelectric coefficients, strong second-order nonlinearity, and engineerable ferroelectric domains. In this talk, we will discuss our recent efforts in developing nonlinear-based quantum light sources on TFLN, including photon-pair generation using new ferrielectric engineering strategies, squeezed-light generation in high-quality periodically poled TFLN waveguides, bi-photon frequency comb generation through cavity integration, and other related topics.

J2.171 Quantum interference using optical fiber and photonic integrated circuits

Heedeuk Shin* (POSTECH / Dept of Physics)
11:25am – 11:40am

Quantum interference serves as a fundamental resource for quantum information processing and secure communication. In this work, we present our studies of quantum interference realized both in optical fiber systems and on photonic integrated circuits. Fiber-based platforms provide flexible and low-loss environments for exploring quantum interference effects, while integrated photonic devices enable scalable, stable, and reconfigurable implementations on a compact chip. By bridging these two approaches, we demonstrate high-visibility two-photon interference and versatile quantum state manipulation, paving the way toward practical quantum networks that combine the strengths of optical fiber links and integrated quantum photonics.

J2.166 Development of a Quantum Communication Network

Alexander Ling* (CQT/ NUS)
11:40am – 11:55am

In this talk I will describe the broader infrastructure in Singapore for testing quantum communication protocols and concepts, and provide a summary of recent progress made by my research group in developing devices that could be used toward development of a global quantum network.

J2.165 Interfacing, integrating, and interacting quantum emitters for quantum photonics

Je-Hyung Kim* (Ulsan National Institute of Science and Technology)
11:55am – 12:10pm

Solid-state quantum emitters have emerged as a key resource for generating photonic and spin qubits and thus serve as fundamental building blocks for a range of quantum applications. To function effectively in quantum technologies, quantum emitters must simultaneously achieve high brightness, efficient integration with photonic structures, and scalability for large-scale quantum systems. Recent advances in the interfacing and integrating of these emitters with photonic cavities and waveguides have enabled the development of compact, high-performance quantum devices for quantum communications and sensors. Furthermore, such photonic structures open pathways for the collective many-body interaction, giving rise to collective phenomena such as superradiance and subradiance. Given their high performance and scalability, quantum emitters are taking the next steps towards scalable, integrated quantum systems on photonic integrated chips or fiber optics. Therefore, all quantum operations are efficiently possible in real-world photonic platforms. In this talk, I will present recent progress and future challenges in scalable, integrated quantum resources based on solid-state quantum emitters.

J2.80 Engineering Quantum Light at the Nanoscale: From Multi-Dimensional Control towards On-Chip Integration

Zhaogang Dong* (Singapore University of Technology and Design)
12:10pm – 12:25pm

Quantum light sources are at the heart of emerging quantum technologies, spanning secure communication, quantum computation, and advanced sensing. In this talk, I will present our recent advances in engineering quantum light at the nanoscale through tailored nanophotonic and metasurface platforms. Specifically, we investigate the role of dielectric resonances in significantly improving processes, such as engineering the emission wavelength from perovskite quantum dots,[1] as well as the corresponding electrical control.[2] [3] Moreover, we have designed and fabricated the nanophotonic cavities with the quasi-bound-state-in-the-continuum (quasi-BIC) resonance,[1] Fano resonances,[4] and twisted bilayer metasurfaces for engineering and control to realize the unidirectional chiral emissions.[5] Collectively, these findings underscore the transformative potential of nanophotonics in driving the development of quantum light source from multi-dimensional control towards on-chip integrations.[6]

J2.167 Topological Quantum Device Lab at DGIST

Youngwook Kim* (DGIST)
12:25pm – 12:40pm

In this talk, I will briefly introduce the Topological Quantum Device Laboratory at DGIST. Our research has been primarily focused on quantum Hall and fractional quantum Hall effects, and we are now expanding into two-dimensional quantum dot devices, including both bilayer graphene and TMDC quantum dots. These systems provide an exciting platform to explore spin and valley quantum dots. With the support of the POSTECH Global Partnership Fund and the Centre for Quantum Technologies (CQT), we are initiating new collaborative efforts, and we look forward to developing this direction together.

J2.170 Recent progress of Quantum light sources with 2D materials

Weibo Gao* (NTU, EEE)

12:40pm – 12:55pm

In this talk, I will talk about the recent development of quantum entangled sources with 2d materials in our group. I will report quantum-entangled photon pair generation through van der Waals engineering with two-dimensional materials. We align two van der Waals thin layers perpendicular to each other, yielding polarization-entangled photon pairs through the interference of biphoton emission in the two flakes. In addition, I will report the rhombohedral BN based entanglement generation. Lastly, I will talk about how to enhance such entangled source brightness.

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