5th International Workshop on Quantum and Topological Nanophotonics (QTN)

Nanyang Technological University, Singapore

19-21 November 2024

CDPT

CENTRE FOR DISRUPTIVE PHOTONIC TECHNOLOGIES

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Tuesday 19 Nov 2024	
08:45	**Registration** **Auditorium - Singapore Hokkien Huay Kuan Building, NTU**
09:00	**Chairs welcome: Romain Quidant, Cesare Soci** **Opening address: Simon Redfern (Dean, CoS) & Nripan Mathews (Associate Director, IAS)**
09:15	**QTN group photo**
	QTN1. *Quantum photonics in nanomechanical systems* – Chair: Nikolay Zheludev
09:30	<u>*IAS Speaker:*</u> **Romain Quidant (ETHZ, Switzerland)** *Levitated optomechanics meets nanophotonics*
10:00	**Albert Schliesser (Niels Bohr Institute, Denmark)** *Quantum and topological phoNonics with ultrasound waves on a chip*
10:30	**Ewold Verhagen (AMOLF, The Netherlands)** *Hermitian and non-Hermitian topology in optomechanical metamaterials*
11:00	**Coffee & Tea Break**
	QTN2. *Lattices and photonic crystals* – Chair: Javier García de Abajo
11:30	**Alexander Khanikaev (University of Central Florida, USA)** *Pseudo-spin transformations for topological edge states and geometrical phases induced by them*
12:00	**Baile Zhang (NTU, Singapore)** *Photonic axion insulator*
12:20	**Bo Zhen (University of Pennsylvania, USA)** *Reciprocity and general reciprocity in driven nonlinear photonic crystals*
12:50	**Lunch Break**
13:50	**Poster Presentations Session 1 (PP1)**
	QTN3. *Quantum and topological nanophotonics* – Chair: Val Zwiller
14:30	**Christian Degen (ETHZ, Switzerland)** *Quantum sensors in diamond: Technology and applications*
15:00	**Daniel Leykam (SUTD, Singapore)** *Photonic flatband resonances in multiple light scattering*
15:20	**Qijie Wang (NTU, Singapore)** *Terahertz semiconductor bound states in the continuum lasers*
15:40	**Coffee & Tea Break**
	QTN4. *Non-Hermitian photonic systems* – Chair: Ewold Verhagen
16:10	**Steven Anlage (University of Maryland, USA)** *Discovery of new scattering singularities in complex non-Hermitian systems*
16:40	**Yidong Chong (NTU, Singapore)** *Non-Hermitian Dirac Quasiparticles*
17:00	**End of Day 1 Technical Programme**

Wednesday 20 Nov 2024	
08:45	**Registration** **Auditorium - Singapore Hokkien Huay Kuan Building, NTU**
	QTN5. *Free electron and atomic systems* – Chair: Romain Quidant
09:00	*<u>IAS Speaker:</u>* **Javier García de Abajo (ICFO, Spain)** *Quantum interactions between free electrons and confined optical modes*
09:30	**Liang Jie Wong (NTU, Singapore)** *Free electron-driven nanomaterials for versatile X-ray generation and quantum science*
09:50	**Uriel Levy (HUJI, Israel)** *Light-Vapor interactions at the nanoscale*
10:20	**David Wilkowski (NTU, Singapore)** *Trapping ultracold atoms in structured light*
10:40	**Coffee & Tea Break**
	QTN6. *Quantum and topological systems* – Chair: Alexander Khanikaev
11:10	**Harald Giessen (University of Stuttgart, Germany)** *Plasmonic twistronics: discovery of plasmonic skyrmion bags*
11:40	**Yijie Shen (NTU, Singapore)** *Optical skyrmions of free space-time*
12:00	**Christos Panagopoulos (NTU, Singapore)** *Quantum hybrids of superconductivity and magnetism via topological solitons*
12:20	**Lunch Break**
13:20	**Poster Presentations Session 2 (PP2)**
	QTN7. *Time dependent photonics 1* – Chair: Ritesh Agarwal
14:00	**Krzysztof Sacha (Jagiellonian University, Poland)** *Time-tronics with photonic systems*
14:30	**Pinaki Sengupta (NTU, Singapore)** *Time crystal of topological magnons*
14:50	**Justin Song (NTU, Singapore)** *Light induced layer ferroelectricity*
15:10	**Coffee & Tea Break**
	QTN8. *Time dependent photonics 2* – Chair: Krzysztof Sacha
15:50	**Nikolay Zheludev (University of Southampton, UK)** *Time crystal active matter*
16:20	**Mordechai Segev (Technion, Israel)** *Light-Matter interactions in time-varying media*
16:50	**Poster Awards**
17:00	**End of Day 2 Technical Programme**

Thursday 21 Nov 2024	
08:45	**Special Session on Integrated Quantum and Topological Nanophotonics - iQTN** **Auditorium – Asian Civilisations Museum**
	Welcome: Cesare Soci (Investigator, National Centre for Advanced Integrated Photonics)
	iQTN1. *Integrated Quantum and Topological Nanophotonics 1* – Chair: Harald Giessen
09:00	**Val Zwiller (KTH Royal Institute of Technology, Sweden)** *Single photon generation, manipulation and detection for photonics integration and instrumentation*
09:30	**Cesare Soci (NTU, Singapore)** *Nanophotonic strategies for superconducting single photon detectors*
09:50	**Giulia Tagliabue (EPFL, Switzerland)** *Unraveling nanoscale and quantum effects in plasmonic metals for energy devices*
10:20	**Weibo Gao (NTU, Singapore)** *Quantum entanglement source with 2D materials*
10:40	**Coffee & Tea Break**
	iQTN2. *Integrated Quantum and Topological Nanophotonics 2* – Chair: Steven Anlage
11:10	**Arseniy Kuznetsov, (A*STAR, Singapore)** *Time-variant dielectric metasurfaces*
11:30	**Ranjan Singh (NTU, Singapore)** *Terahertz topological photonic integrated circuits for 6G to XG wireless*
11:50	**Ritesh Agarwal (University of Pennsylvania, USA)** *Incorporating quantum geometry and topology in photonic metamaterials*
12:20	**Closing Remarks & End of Technical Programme**
12:30	**Lunch**

CDPT is glad to announce that IAS will be sponsoring prizes of SGD 250 each for 4 best posters of QTN 2024.

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Institute of Advanced Studies

Kindly join us for the poster awards on
20 November 2024 (Wednesday)
between 16:50 – 17:00 pm
at the SHKK Auditorium, NTU.

Abstracts

Invited Talks

QTN1. Quantum photonics in nanomechanical systems (Tuesday 19 Nov, 9:30-11:00)

T1. IAS@NTU Talk: Levitated optomechanics meets nanophotonics
Romain Quidant, ETHZ, Switzerland

In this work we present our latest progress at the interface of optomechanics and nanophotonics. By integrating optical field engineering through meta-optics with cold damping using planar electrodes we achieve robust levitation and accurate motion control of a levitated nanoparticle on a chip. This fully integrated approach offers promising potential for ultra-sensitive sensing and complex state engineering.

T2. Quantum and topological phoNonics with ultrasound waves on a chip
Albert Schliesser, Niels Bohr Institute, Denmark

We engineer the phonon spectrum of nanomechanical membranes using periodic patterns. Using light or microwaves, we can control the quantum state of isolated phonon modes, and even entangle optical fields. Alternatively, we implement a valley-Hall topological insulator for phonons, with ultralow propagagion loss and quantifyable backscattering protection in edge modes.

T3. Hermitian and non-Hermitian topology in optomechanical metamaterials
Ewold Verhagen, TECHNION, Israel

We study nano-optomechanical networks in which interactions between mechanical modes are induced and fully reconfigured through time-modulated optical forces. By breaking time-reversal symmetry, Hermiticity, and linearity, these metamaterials exhibit topological states including quantum Hall insulators and the bosonic Kitaev chain, a non-Hermitian topological phase with potential for sensing and amplification.

QTN2. Lattices and photonic crystals (Tuesday 19 Nov, 11:30-12:50)

T4. Pseudo-spin transformations for topological edge states and geometrical phases induced by them
Alexander Khanikaev, University of Central Florida, USA

We demonstrate that the unitary transformation between different pseudo-spins, realized by adiabatic geometrical changes in topological metasurfaces, enables a continuum of heterogeneous boundary states carrying both orbital and valley pseudo-spins. When applied adiabatically to topological boundary modes, this transformation enables conversion between the two pseudo-spins, and flipping pseudo-spin without back reflection -- a unidirectional topological X-gate acting on synthetic spins. We show that such adiabatic evolutions give rise to a geometrical phase associated which is directly observed via interferometric Aharonov-Bohm type experiment on a silicon chip.

T5. Photonic axion insulator
Baile Zhang, Nanyang Technological University, Singapore

While still not observed as elementary particles, axions can exist as quasiparticles in topological crystals, whose quantized axion field can induce half Chern numbers on the surfaces of a three-dimensional crystal. We will discuss how to construct an axion insulator in a photonic crystal and demonstrate its topological properties.

T6. Reciprocity and general reciprocity in driven nonlinear photonic crystals
Bo Zhen, University of Pennsylvania, USA

I will present our demonstration of the breaking of reciprocity and the preservation of general reciprocity in driven nonlinear photonic crystals that break time-reversal symmetry. In particular, we show non-reciprocal frequency conversions, where the forward- and backward-conversion efficiencies can differ by >13dB.

QTN3. Quantum and topological nanophotonics (Tuesday 19 Nov, 14:30-15:40)

T7. Quantum sensors in diamond: Technology and applications
Christian Degen, ETHZ, Switzerland

Diamond has emerged as a unique material for a variety of applications, both because it is very robust and because it has defects with interesting properties. One of these defects, the nitrogen-vacancy (NV) center, shows quantum behavior up to above room temperature. In this talk, I will present our group's efforts in exploring diamond as a platform for realizing nanoscale sensors with exquisite sensitivities and new capabilities.

T8. Photonic flatband resonances in multiple light scattering
Daniel Leykam, Singapore University of Technology and Design, Singapore

Bound states in the continuum (BICs) attract enormous interest as a means of designing cavities with theoretically infinite Q factors. However, observed Q factors in real finite structures fall far below theoretical expectations. I will critically examine the BIC concept in finite structures from the viewpoint of multiple scattering theory and highlight the importance of fine-tuning instead of BIC modes in achieving ultrahigh Q resonances.

T9. Terahertz semiconductor bound states in the continuum lasers
Qijie Wang, Nanyang Technological University, Singapore

Highly compact laser sources with low threshold, exceptional directivity, and single-mode operation are in great demand for on-chip integrated photonics. Photonic bound states in the continuum (BIC) are peculiar nonradiative localized modes that have theoretically infinite lifetime within the radiation continuum, making it a favorable candidate for pursuing single-mode, low-threshold, and surface-emitting lasers. In this presentation, I will introduce several electrically pumped Terahertz semiconductor lasers we have developed based on the BIC concepts for achieving high Q and low laser thresholds in compact cavities while achieving single mode operations, which would be promising as monolithically integrated laser sources.

QTN4. Non-Hermitian photonic systems (Tuesday 19 Nov, 16:10-17:00)

T10. Discovery of new scattering singularities in complex non-Hermitian systems
Steven Anlage, University of Maryland, USA

By taking active control over the boundary conditions in complex scattering environments, we demonstrate via microwave experiments the ability to manipulate the spectrum of the scattering operator; thus creating, destroying and repositioning in a 2D parameter space exceptional point degeneracies as well as newly discovered scattering singularities, all displaying remarkable topological properties.

T11. Non-Hermitian Dirac quasiparticles
Yidong Chong, Nanyang Technological University, Singapore

Quasiparticles in certain lattices, such as graphene, are known to behave like relativistic Dirac particles. However, this property is usually spoiled by non-Hermiticity, which tends to turn Dirac points into exceptional points or exceptional rings. Here, I describe how gain and loss in a non-Hermitian lattice can produce stable massive Dirac quasiparticles. Using a looped optical fiber apparatus, we have implemented a synthetic lattice with a "semi-Hermitian" bandstructure that hosts Dirac quasiparticles with a gain/loss-induced real mass. We show that these quasiparticles can undergo an anomalous form of Klein tunnelling, as well as gain/loss-induced temporal reflection

QTN5. Free electron and atomic systems (Wednesday 20 Nov, 09:00-10:40)

T12. IAS@NTU Talk: Quantum interactions between free electrons and confined optical modes
Javier García de Abajo, ICFO, Spain

Free electrons can strongly interact with nanoscale optical fields, leading to the reshaping of electron wave functions and the generation of appealing quantum light states. We will show how these advances enable free-electron-based sensing of vacuum fluctuations, the efficient sources of quantum light, and the control of atomic-scale electronic states, as well as promising applications.

T13. Free electron-driven nanomaterials for versatile X-ray generation and quantum science
Liang Jie Wong, Nanyang Technological University, Singapore

I will present our investigations into accelerated free electrons interacting with van der Waals single-crystals and heterostructures. Exploring these processes, we demonstrate the potential for generating X-rays with quantum characteristics and enhanced versatility compared to conventional X-ray tubes. Our results hold promise for advancing safer, more robust and more efficient X-ray imaging and diagnostic modalities.

T14. Light-Vapor interactions at the nanoscale
Uriel Levy, Hebrew University of Jerusalem, Israel

In this talk we will present our latest results related to light-vapor interactions at the nanoscale, going all the way from spectroscopy and magnetometry to chirality, nonreciprocity and electromagnetic induced transparency.

T15. Trapping ultracold atoms in structured light
David Wilkowski, Nanyang Technological University, Singapore

Quantum processors using neutral atom architecture is based on an array of optical tweezers. Due to conventional diffraction limit of optical systems, the separation between neighbouring tweezers remains large (couple of um) preventing tunnelling and limiting the dipole-dipole interaction in the Rydberg state. In this talk, I will present our current experimental effort to address this issue using structured light. I will also present our project toward quantum processors with neutral atoms arrays.

QTN6. Quantum and topological systems (Wednesday 20 Nov, 11:10-12:20)

T16. Plasmonic twistronics: discovery of plasmonic Skyrmion bags

Harald Giessen, University of Stuttgart, USA

We combine the concepts of twistronics with plasmonic topological excitations and demonstrate that the topology of moiré skyrmion lattices contains skyrmion bags as complex topological quasiparticles. The size of plasmonic skyrmion bags can be controlled by the twist angle and its center of rotation.

T17. Optical skyrmions of free space-time

Yijie Shen, Nanyang Technological University, Singapore

Skyrmions, topologically stable quasiparticles demonstrated in condensed matter and recently in optical waves, giving access to nontrivial light-matter interactions and information transfer. Here I introduce an extended family of optical skyrmions within a unified framework, from theories to experimental generation and topological control in free space-time. I will further highlight generalized classes of topological waves beyond skyrmions and outline their exotic properties, emerging applications, and open challenges.

T18. Quantum hybrids of superconductivity and magnetism via topological solitons

Christos Panagopoulos, Nanyang Technological University, Singapore

I will demonstrate the viability of using spin topology to influence a superconductor at selective length scales through a completely new material architecture namely, a stack of magnets and a superconductor that shows stable vortices above elongated chiral spin textures, as well as isolated skyrmions.

QTN7. Time dependent photonics 1 (Wednesday 20 Nov, 14:00-15:10)

T19. Time-tronics in photonic systems

Krzysztof Sacha, Jagiellonian University, Poland

We introduce a versatile approach which empowers emulating various condensed matter phases in the time dimension in a traveling wave resonator. This is achieved by utilizing temporal modulation of permittivity and the spatial shape of a small segment of the resonator where permittivity is modulated in time. The required frequency and depth of the modulation are experimentally achievable, opening a pathway for research into the practical realisation of crystalline structures in time utilising microwave and optical systems.

T20. Time crystal of topological magnons

Pinaki Sengupta, Nanyang Technological University, Singapore

We report the emergence of time-crystalline behavior in the π-Berry phase protected edge states of a Heisenberg ferromagnet driven by an external driving field. The driving field results in a finite density of magnons at the magnetic Brillouin zone edges through magnon amplification and spontaneously breaks the discrete time-translational symmetry. We show that the resulting edge state oscillates in time with a period that is twice that of the applied electromagnetic field. In other words, it behaves as a discrete time crystal. We discuss the nature and symmetry protection of the time crystalline edge states and their stability against various perturbations that are expected in real quantum magnets. We propose an experimental signature to demonstrate the time crystalline behavior and identify two recently discovered quasi-two-dimensional magnets as potential hosts. Our results can be generalized to other bosonic quasiparticle systems that exhibit parametric pumping and topological edge states.

T21. Light induced layer ferroelectricity

Justin Song, Nanyang Technological University, Singapore

I will describe how optical nonlinearities lead to a new "dynamical phases of matter" where photoexcitation of 2D layers transforms a dielectric (e.g., multilayer graphene) into a ferroelectric; it even turns screening (reduces fields) into antiscreening (amplifies fields). This demonstrates how nonlinearities sustains broken symmetries in quantum matter out-of-equilibrium.

QTN8. Time dependent photonics 2 (Wednesday 20 Nov, 15:50-16:50)

T22. Time crystal active matter

Nikolay Zheludev, University of Southampton, UK

Nonreciprocal processes in systems out of equilibrium are attracting growing interest across the entire domain of scientific research from sociology to chemistry, materials science, and nanotechnology, including a recent suggestion that nonreciprocal interactions may have played a critical role in the origin of life, i.e. the matter-to-life transition. Recently a new class of photonic nano-opto-mechanical metamaterial structures was demonstrated that exhibit transition to the Time Crystal state driven by nonreciprocal forces of light. Such crystals are a new form of Active Matter defined as matter made up of out-of-equilibrium constituents, which convert a source of energy into work, for example in the form of motion. This form of time crystal active matter breaks time translation symmetry, and ergodicity and exhibits local entropy decrease which are characteristic features of life. The life-mimicking dynamics of such metamaterials is of interest to optical "timetronics" – an information and communications technology relying on the unique functionalities of time crystals.

T23. Light-Matter interactions in time-varying media

Mordechai Segev, Technion, Israel

Time-varying media are materials whose electromagnetic properties are varied considerably (order of unity) within 1-2 cycles of the waves propagating within them. Recent progress with transparent conductive oxides [Lustig et. Al, Nanophotonics 2023] has shown that this is indeed possible also at optical frequencies. I will describe the recent progress, experimental and theoretical, on light-matter interactions and nonlinear frequency conversion in these media.

iQTN1. Integrated Quantum and Topological Nanophotonics 1 (Thursday 21 Nov, 09:00-10:40)

T24. Single photon generation, manipulation and detection for photonics integration and instrumentation

Val Zwiller, KTH Royal Institute of Technology, Sweden

We develop quantum devices to enable the implementation of quantum technologies based on controlling light at the single photon level with the aim of on-chip integration and novel instrumentation. Future quantum communication and sensing will require high-performance quantum devices able to generate and detect light one photon at a time. Schemes to manipulate light on-chip, based on integrated photonics are carried out in our group. Our single photon sources based on semiconductor quantum dots can generate single photons as well as entangled photon pairs at telecom wavelengths to enable implementation of long distance quantum communication. We operate a quantum network made of deployed optical fibers in the Stockholm area and demonstrate single photon transmission and quantum key generation over 34 km.

Single photon detectors with high detection efficiency, low noise and high time resolution are major enabling techniques, we develop superconducting nanowire single photon detectors with applications in quantum communication, integrated quantum circuits as well as for lidar and quantum microscopy. We will discuss these applications along with the specific detector requirements for technologies based on single photon detection. Further improvements in terms of time resolution, photon number resolution and extended detection ranges will also be discussed. New instruments such as a quantum spectrometer able to acquire spectra, lifetimes and photon statistics in one single measurement will be presented.

T25. Nanophotonic strategies for superconducting single photon detectors

Cesare Soci, Nanyang Technological University, Singapore

We implement nanophotonic strategies to tackle current issues in superconducting nanowire single photon detector (SNSPD) technologies, namely the use of BIC waveguides for SNSPD heterointegration in planar photonic circuits, distributed coherent absorption for photon number resolution, and metamaterials approaches for polarization control and quantum-state tomography.

T26. Unraveling nanoscale and quantum effects in plasmonic metals for energy devices

Giulia Tagliabue, EPFL, Switzerland

I will discuss nanoscale details of photoluminescence in plasmonic metals as well as photoexcited charge carrier transfer at metal/molecule.

T27. Quantum entanglement source with 2D materials

Weibo Gao, Nanyang Technological University, Singapore

2D materials serves as great quantum light source. On one side, they are ultrathin therefore the emitter residing inside will not be limited by total reflection when the emitted light comes out. On the other side, the ultrathin nature makes it convenient to manipulate the properties of the light source by external stimuli. In this talk, I will report our recent development of near-unity efficiency WSe_2 quantum emitters and quantum entangled light source based on 2D materials.

iQTN2. Integrated Quantum and Topological Nanophotonics 2 (Thursday 21 Nov, 11:10-12:20)

T28. Time-variant dielectric metasurfaces

Arseniy Kuznetsov, Agency for Science, Technology and Research, Singapore

In this talk, I will show two examples of time-variant metasurfaces. First, using electrical voltages provided by CMOS circuit we create a single-pixel tunable metasurface with 480×640 individually controlled pixels with ~1µm pixel pitch. Second, we induce ultra-fast effects in a quasi-BIC GaAs metasurface using spatially structured femtosecond laser pulses.

T29. Terahertz topological photonic integrated circuits for 6G to XG wireless

Ranjan Singh, Nanyang Technological University, Singapore

Terahertz topological photonic integrated circuit is a rapidly evolving platform for developing high-speed on-chip interconnects, beamformers, modulators and leaky wave antennas for 6G and beyond (XG) communication systems. In this presentation, I will discuss our latest findings on compact topological devices built on a silicon photonic platform, which have enabled novel THz technologies for both on-chip and wireless communication applications.

T30. Incorporating quantum geometry and topology in photonic metamaterials

Ritesh Agarwal, University of Pennsylvania, USA

We will discuss our efforts in understanding and incorporating nontrivial topology in photonic systems where the excitations are bosonic in nature. Our efforts and challenges to realize fragile topological photonic and polaritonic lattices in a variety of systems such as layered and twisted systems will be discussed.

Posters

P1. Anderson localization in photonic time crystals
Karthik Eswaran, Jagiellonian University, Poland

Solutions of the wave equations for time-independent disordered media can exhibit Anderson localization where instead of wave propagation we observe their localization around different points in space. Photonic time crystals are spatially homogeneous media in which the refractive index changes periodically in time, leading to the formation of bands in the wave number domain. By analogy to Anderson localization in space, one might expect that the presence of temporal disorder in photonic time crystals would lead to Anderson localization in the time domain. Here, we show that indeed periodic modulations of the refractive index with the addition of temporal disorder lead to Anderson localization in time.

P2. Observation of disorder-induced boundary localization
Zheyu Cheng et al., Nanyang Technological University, Singapore

We challenge the long-standing framework of Anderson localization by experimentally showing that bulk disorder can localize waves at a boundary rather than in the bulk. As disorder increases, waves initially localized at one boundary switch to the opposite boundary, redefining the behavior of wave localization.

P3. Electrically tunable Floquet Weyl photon emission from Dirac semimetal Cd_3As_2
Sobhan Subhra Mishra et al., Nanyang Technological University, Singapore

We have shown electrically tunable Chiral THz emission from 3D Dirac semimetal Cd_3As_2. By breaking its time reversal symmetry through circularly polarized light, a Floquet Weyl semimetal state was achieved, generating an anomalous photocurrent, and consequently an electrically tunable helicity dependent THz wave. Our work paves the way for the development of energy-efficient chiral THz sources based on 3D Dirac semimetal.

P4. Lighting up nonemissive azobenzene derivatives by pressure
Shuhe Hu et al., Nanyang Technological University, Singapore

We achieve the first pressure-induced emission (PIE) in initially nonemissive organic materials. The pressure-activated emission of the azobenzene derivatives originate from local-excitation promotion within the excited state, breaching the conventional perception. Our work marks a significant breakthrough within the PIE paradigm, providing a potentially universal approach for high-efficiency azobenzene emission.

P5. Metasurface-induced superbunching at room temperature
Marco Marangi et al., Nanyang Technological University, Singapore

In this work, we couple J-aggregates films and dielectric metasurfaces supporting high-Q bound state in the continuum resonances to induce the strong coupling regime and foster superradiant emission. We explore how the hallmark properties of superradiance depend on Rabi splitting, demonstrating the suitability of metasurfaces as platforms to develop bright, ultrafast, and superbunched sources at room temperature.

P6. Topological exciton-polaritons in halide perovskite microcavity
Jin Feng et al., Nanyang Technological University, Singapore

Topological exciton-polaritons, a growing class of topological photonic systems characterized by their hybrid nature as part-light, part-matter quasiparticles, represent a promising platform for exploring novel topological phenomena. Here, we report the experimental observation of valley-polarized topological exciton-polaritons and their valley-dependent propagation at room temperature employing a two-dimensional (2D) valley-Hall perovskite lattice. Additionally, we investigate the topological polaritonic state in an aperiodic lattice design and realize a C_{4v} symmetric topological disclination (TD) laser protected by the real-space topology.

P7. Room-temperature optically detected magnetic resonance of telecom single-photon emitters in GaN

John J.H. Eng et al., Nanyang Technological University, Singapore

Solid-state defects susceptible of spin manipulation hold great promise for scalable quantum technology. We report that telecom single-photon emitters in GaN exhibit optically detected magnetic resonance at room temperature. We determined the spin quantization axis with respect to the GaN's crystal axis, giving us insights into the origin of the telecom SPEs in GaN.

P8. Electrically tunable photon pairs in 3R-stacked MoS_2

Omar A. M. Abdelraouf, A*STAR, Singapore

Entangled photon-pair sources are pivotal for quantum technologies like quantum key distribution, sensing, and imaging. In applications such as satellite-based and mobile communications, where space and weight are limited, reconfigurable, compact and reliable entanglement sources are critical. Here, we demonstrate an electrically tunable entangled photon-pair source based on a nanopatterned 3R-stacked MoS_2 crystal, optimized for operation in the telecommunication regime. The natural symmetry of the 3R-MoS_2 crystal allows for the direct generation of polarization-entangled bell states. By leveraging the strong light-matter interactions within the nanopatterned structure, photon-pair generation efficiency is amplified by more than two order of magnitude through the formation of bound states in the continuum (BIC). Additionally, we incorporate an electrically tunable mechanism using liquid crystals, enabling continuous spontaneous parametric down-conversion (SPDC) over a broad telecommunication wavelength range. Notably, the decoupling of generation rate and state tunability ensures that the efficiency of photon-pair generation is maintained without sacrificing entanglement quality. Our results mark significant progress toward the development of scalable, tunable, on-demand entangled photon-pair sources, advancing their use in integrated quantum communication, sensing, and imaging systems.

P9. Fourier tomography of quantum states of light

Pierre Brosseau et al., Nanyang Technological University, Singapore

We report the first experimental demonstration of Fourier tomography of polarization states of single photons and photon pairs. Unlike conventional tomography, which relies on discrete measurement settings, Fourier tomography employs a continuous scan through the measurement space. This method requires fewer components, potentially enhancing measurement speed and simplifying alignment. For polarization state measurements, we utilize a single rotating quarter-wave plate, a linear polarizer, and a superconducting nanowire single-photon detector per photon. The Fourier components of the single photon counting rate (for single photon states), and coincidence rate (for multi-photon states) enable accurate reconstruction of the state's density matrix. We explore the implications of this method for practical quantum state characterization and its potential applications in quantum technologies.

P10. Development of a comprehensive workflow for SNSPD fabrication and characterization

Shuyu Dong et al., Nanyang Technological University, Singapore

In this study, we introduce a comprehensive end-to-end workflow for SNSPD fabrication and characterization, covering all stages from superconducting film deposition and nanowire patterning to integration with electrical readout and optical characterization systems. A key focus of this work was to pinpoint critical workflow parameters and establish robust procedures for their optimization. Our results reveal SNSPDs with performance metrics on par with commercial devices, featuring a reset time of 16 ns, timing jitter of 74 ps, sub-Hz dark count rate at 90% efficiency, 20 kHz dark count rate at maximum efficiency, and an internal detection efficiency of approximately 95%. These characteristics make our SNSPDs well-suited for both fundamental research and practical applications.

P11. AI driven vectorial structured light analysis in complex media

Trishita Das et al., Nanyang Technological University, Singapore

Structured light has shown its impact felt across dimensions, disciplines and applications, but the challenge comes with increasing complexity when making the design, analysis, and recognition of vector structures in disordered media. By employing a deep neural network, we create vector beams and use speckle patterns from scattering through disordered media to retrieve key light field properties, for developing an intelligent, multi-dimensional light field sensor, simplifying the setup and overcoming alignment challenges in traditional methods.

P12. Unsupervised learning of topological non-Abelian braiding in non-Hermitian bands

Yang Long et al., Nanyang Technological University, Singapore

The topological classification of energy bands has laid the foundation for the discovery of various topological phases of matter in recent decades. Here we present a machine learning algorithm for the unsupervised identification of non-Abelian braiding within multiple complex-energy bands.

P13. Topological neural network for optical super-resolution imaging without priori assumptions

Benquan Wang et al., Nanyang Technological University, Singapore

We report a novel optical super-resolution imaging technique achieving $\lambda/11$ deeply sub-diffraction resolution on a Siemens star by analyzing the diffracted light illuminated by a diffraction-limited beam spot. We show that details that cannot be resolved optically can be imaged by a topological artificial neural network trained with random arrangements of subwavelength-scale objects. The method we demonstrate enables image reconstruction of arbitrary large binary objects without a priori assumptions on the sizes and shapes of the imaging objects. Our method is scalable to samples with different materials, representing a significant advancement in super-resolution imaging and offering potential applications across multiple fields including nanophotonics, biological imaging, and material characterization.

P14. Super-resolution Imaging of Limited-size Objects

Taeyong Chang et al., Nanyang Technological University, Singapore

We experimentally realize a label-free far-field super-resolution imaging using prior knowledge of the object size limit, which has remained a challenging problem for more than 50 years. Our breakthrough is the determination of the required number of repetitions and a proper filter based on information theory, which we apply to a shot-noise-limited measurement.

P15. Universality of topological modes in glide-symmetric waveguides

Nikhil Navaratna et al., Nanyang Technological University, Singapore

In this work, we establish the existence of topological transport in glide-symmetric waveguides with photonic crystal claddings where the electromagnetic eigenstates exhibit phase vortices and non-zero Berry curvatures. We also experimentally illustrate the cladding unit cell criteria for topological transport by reporting high transmission across a glide symmetric defect waveguide with two bends and a defect width similar to that of a photonic crystal line-defect waveguide.

P16. On-chip topological beamformer for multi-link terahertz wireless

Wenhao Wang et al., Nanyang Technological University, Singapore

We present an on-chip topological beamformer for multi-link terahertz 6G to XG wireless communication, achieving complete 360° azimuthal beamforming with gains of up to 20 dBi. The topological beamformer radiates on-chip THz signals into free space with neural-network-driven customizable beams enabling up to eight simultaneous 40-Gbps wireless links.

P17. Chiral detection and holography based on non-Hermitian topological metasurfaces

Zhuolin Wu, Nanjing University, China

Efficient detection of circular polarization chirality is crucial, yet the pursuit of enhanced device chiral characteristics can be overly stringent for detection. We propose a non-Hermitian metasurface-based scheme that leverages topological properties to make weakly chiral devices capable of effectively chiral detection and holography, unlocking the reliance on strong chirality.

P18. Valley-Hall photonic crystal waveguides under non-Hermitian active defect

Shrinivas Jayaram et al., Nanyang Technological University, Singapore

Optically induced loss in silicon is utilised to implement an active defect – a local, actively-tunable, dissipative perturbation in the path of a terahertz valley photonic crystals waveguide. Our study highlights the superior performance of low index waveguide modes, and strong modulation of high index modes, facilitating advancements in on-chip modulators.

P19. Three-dimensional flat Landau levels in an inhomogeneous acoustic crystal

Zheyu Cheng et al., Nanyang Technological University, Singapore

Our work challenges the long-standing belief that flat Landau levels exist only in 2D, demonstrating for the first time flat bands in three-dimensional geometries. This breakthrough marks a significant advancement in flat band physics, expanding the understanding of band structures beyond two dimensions.

P20. Observation of embedded topology in projectively symmetric acoustic lattices

Hau Tian Teo et al., Nanyang Technological University, Singapore

Contrary to dimension increment for weak topology, we demonstrate dimension reduction in insulators with projective crystal symmetry to construct embedded topology. Based on one-dimensional strong topology at interfaces between higher-dimensional trivial insulators, we realize two-dimensional trijunction-induced and three-dimensional quadrijunction-induced topological states in tight-binding and acoustics, thus enriching band topology in subdimensions.

P21. Topological momentum skyrmions in multipole scattered fields

Tim Colin Meiler et al. , Nanyang Technological University, Singapore

We construct skyrmions and merons in Poynting momentum, canonical momentum, and optical spin fields using multipole Mie-scattered fields. These textures exhibit topological stability against source shifts, revealing new properties in multipole scattered fields. This work advances understanding for optical forces, metamaterial design, and light-matter interactions in optics.

P22. Hybridization of topological interface modes

Yuhao Wang et al., National University of Singapore, Singapore

The Jackiw-Rebbi state is the simple topological mode in 1D photonics system. In this work, we will create two JR modes and make them overlap by changing the separation distance. The coupling of two JR modes will cause the splitting of the energy as well as the generation of bonding and antibonding modes. From the simulation, the bonding and antibonding modes have specific features which are experimentally proved. By extracting the parameters from simulation and experiment, we construct a theoretical mode which can explain the physics behind this energy splitting of the topological interface mode and show its potential for further application in beam shaping, lasing and other quantum computation.

P23. Superoscillatory tweezer arrays for subwavelength trapping and manipulation of cold atoms

Vincent Mancois et al., Nanyang Technological University, Singapore

Spatial control of atoms with subwavelength accuracy is a crucial tool for quantum computing and quantum simulations. Using superoscillatory structured light we plan on extending the recent work on single atom subwavelength trapping to few atoms superoscillatory tweezer arrays, where trap sizes and interdistances are dynamically tuned below diffraction limit.

P24. Precision-driven holographic tweezer arrays for quantum simulators

Vasu Dev et al., Nanyang Technological University, Singapore

We aim to generate an ultra-precise holographic tweezer array using SLM, optimizing for uniform intensity, shape, and spatial location (transverse and longitudinal) via iterative feedback. We also aim to expand the number of tweezers to enable quantum simulations with larger sample sizes.

P25. Unleashing giant Förster resonance energy transfer by bound state in the continuum

Zhiyi Yuan et al., National University of Singapore, Singapore

Förster resonance energy transfer (FRET), driven by dipole-dipole interactions (DDIs), is widely utilized in chemistry, biology, and nanophotonics. However, conventional FRET is ineffective at donor-acceptor distances exceeding 10 nm, and measurements suffer from low signal-to-noise ratios. In this study, we demonstrate significant FRET enhancement and extended interaction distances under ambient conditions by utilizing a bound state in the continuum (BIC) mode within a dielectric metasurface cavity. This enhancement is achieved by leveraging the ultrahigh quality factors, minimal material absorption, and nonlocal effects associated with the BIC mode. Spectrally and angularly resolved photoluminescence (PL) lifetime measurements reveal that the BIC mode significantly increases FRET rate and interaction distance. The FRET rate is enhanced by up to 70-fold, and the interaction distance is significantly boosted by over an order of magnitude, reaching ~100 nm. These findings offer valuable insights for achieving long-range, high-efficiency FRET and collective DDIs using loss-less dielectric metasurfaces.

P26. Optical detection of small polarons in vanadium dioxide

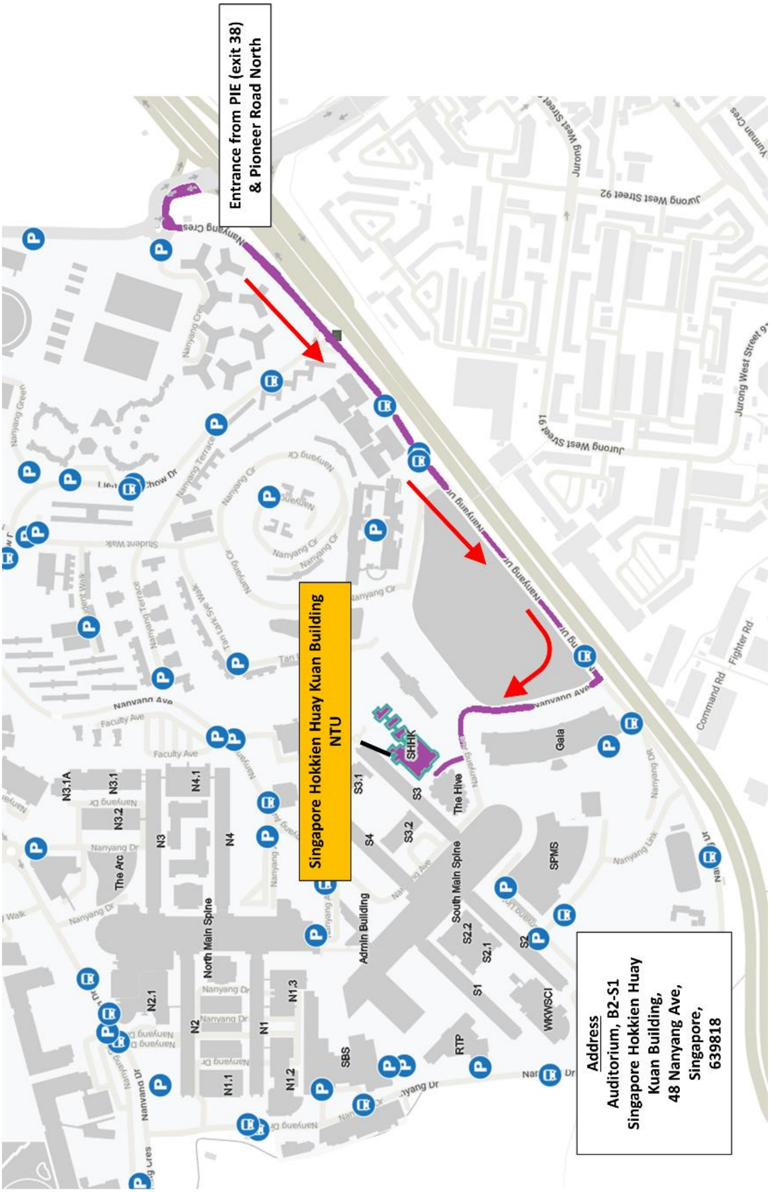
Xiongfang Liu et al., National University of Singapore, Singapore

We present direct evidence of appearance of polaron state in insulating VO_2 and its disappearance in metallic VO2 using spectroscopic ellipsometry. The finding reveals polaron dynamics facilitate structural and electronic transitions during the metal-insulator transition (MIT), which enhances understanding of MIT mechanisms through the roles of polarons, lattice distortions, and electron correlations in correlated systems.

P27. Unraveling the long-range magnetic ordering in hole-doped cuprates

Anjali Jain et al., National University of Singapore, Singapore

With large uniaxial c-axis tensile strain, we observe a robust ferromagnetism of quasiparticle-doped-holes in cuprates. By utilizing resonant soft X-ray and magnetic scattering, we demonstrate the emergence of ferromagnetism at O K-edges and Cu L_3' edge. With the decrease in the c-axis, a ferromagnetism-to-unconventional superconductivity transition is observed.



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