4th International Workshop on Quantum and Topological Nanophotonics (QTN)

Nanyang Technological University, Singapore

28-30 April 2022

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | School of Physical and Mathematical Sciences, College of Science

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Thursday 28 Apr 2022	
08:45	**Registration**
09:00	**Welcome: Nader Engheta, Nikolay Zheludev, Cesare Soci** **Opening message: Tze Chien Sum (Director, IAS) & Swee Chuan Tjin (Co-Director, TPI)**
09:15	**QTN group photo**
	QTN1. *Quantum Nanophotonics in low dimensional systems* – Chair: Nikolay Zheludev
09:30	*IAS Speaker:* **Konstantin Novoselov (NUS, Singapore)** *Twist-controlled van der Waals heterostructures for electronic and optical devices*
10:00	**Weibo Gao (NTU, Singapore)** *Optical spectroscopy of excited-state spin defects in hexagonal boron nitride*
10:20	**Gadi Eisenstein (TECHNION, Israel)** *Quantum optics in room temperature quantum dot ensembles*
10:50	**Coffee & Tea Break**
	QTN2. *Lattices and photonic crystals* – Chair: Konstantin Novoselov
11:20	**Harald Giessen (University of Stuttgart, Germany)** *Topological plasmonics: skyrmions, merons and quasicrystals*
11:50	**Yidong Chong (NTU, Singapore)** *Enhancement of photon blockade in photonic lattices*
12:10	**Baile Zhang (NTU, Singapore)** *Magnetic topological photonic crystals*
12:30	**Lunch Break**
13:30	**Poster Presentations Session 1 (PP1)**
	QTN3. *Quantum modelling* – Chair: Javier Aizpurua
14:10	**José Ignacio Latorre (NUS, Singapore)** *Option pricing in a chip*
14:30	**Anton Vetlugin (NTU, Singapore)** *Modelling quantum photonics on the IBM quantum computer*
14:50	**Mile Gu (NTU, Singapore)** *Quantum illumination and the story of non-classical light*
15:10	**Coffee & Tea Break**
	QTN4. *Quantum and topological devices* – Chair: Harald Giessen
15:40	**Val Zwiller (KTH, Royal Institute of Technology, Sweden)** *Quantum hardware for the generation, manipulation and detection of light at the single photon level*
16:10	**Alex Hayat (TECHNION, Israel)** *Superconducting quantum optoelectronics*
16:40	**Qijie Wang (NTU, Singapore)** *Electrically driven topological quantum cascade lasers with polarization controls*
17:00	**End of Day 1**

Friday 29 Apr 2022	
08:45	**Registration** **Auditorium - Nanyang Executive Centre, NTU**
	QTN5. *Quantum and topological systems* – Chair: Amos Martinez
09:00	*IAS Speaker:* **Moti Segev (TECHNION, Israel)** *Photonic time-crystals*
09:30	**Guoqing Chang (NTU, Singapore)** *Theoretical and experimental discovery of topological knot magnets*
09:50	**Yehonadav Bekenstein (TECHNION, Israel)** *Free electron triggered superfluorescence for resolving collective optical properties of quantum materials*
10:10	**Coffee & Tea Break**
	QTN6. Q*uantum optics of atoms* – Chair: Javier García de Abajo
10:40	**Mikhail Ivanov (Imperial College, London)** *Lightwave electronics in trivial and strongly correlated solids*
11:10	**David Wilkowski (NTU, Singapore)** *Atom trapping in subwavelength superoscillatory optical tweezers*
11:30	**Olga Smirnova (Technical University of Berlin, Germany)** *Ultrafast chirality: twisting light to twist electrons*
12:00	**Lunch Break**
13:00	**Poster Presentations Session 2 (PP2)**
	QTN7. *Picophotonics* – Chair: Michal Lipson
13:40	**Javier Aizpurua (Center of Materials Physics, Spain)** *Light emission in extreme nanocavities: from intramolecular resolution to complex single photon emission*
14:10	**Zubin Jacob (Purdue University, USA)** *Pico-electrodynamics inside matter*
14:40	**Nikolay Zheludev (NTU, Singapore & University of Southampton, UK)** *Picophotonics*
15:00	**Coffee & Tea Break**
	QTN8. *Free electron phenomena* – Chair: Gadi Eisenstein
15:30	**Javier García de Abajo (ICFO, Spain)** *Integration of free electrons in nanophotonics*
16:00	**Liang Jie Wong (NTU, Singapore)** *Quantum interference and quantum recoil in free electron-driven nanophotonics*
16:20	**Ido Kaminer (TECHNION, Israel)** *Ultrafast quantum phenomena of photonic quasiparticles*
16:50	**End of Day 2**

Saturday 30 Apr 2022	
08:45	**Registration** **Auditorium - Nanyang Executive Centre, NTU**
	QTN9. *Topological photonics for communications* – Chair: Moti Segev
09:00	*IAS Speaker:* **Michal Lipson (Columbia University, USA)** *Next generation silicon photonics enabling novel ideas in topological photonics*
09:30	**Ranjan Singh (NTU, Singapore)** *Topological THz silicon photonics: From 6G communications to high-Q sensors*
09:50	**Alexander Gaeta (Columbia University, USA)** *Quantum photonics in microresonators*
10:20	**Coffee & Tea Break**
	QTN10. *Quantum and Topological Nanophotonics* – Chair: Alexander Gaeta
10:50	**Zexiang Shen (NTU, Singapore)** *Engineering electro-optical properties of hybrid perovskites with pressure*
11:10	**Cheng Wei Qiu (NUS, Singapore)** *Geometric photodetectors for mid-infrared spin light*
11:40	**Cesare Soci (NTU, Singapore)** *Quantum and topological perovskite photonics*
12:00	**Harry Atwater (Caltech, USA)** *Coherent and single photon emission from TMD excitons and color centers in hexagonal boron nitride*
12:30	**Poster presentations Awards**
12:45	**Closing Remarks & End of Technical Programme**

CDPT is glad to announce that IAS will be sponsoring prizes of SGD 250 each for 4 best posters of QTN 2022.

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Kindly join us for the poster awards on 30 April 2022 (Saturday) between 12:30 – 12:45 pm at the NEC auditorium.

Abstracts

Invited Talks

QTN1. Quantum Nanophotonics in low dimensional systems (Thursday 28 Apr, 9:30-10:50)

T1. IAS@NTU Talk: Twist-controlled van der Waals heterostructures for electronic and optical devices
Konstantin Novoselov, National University of Singapore, Singapore

The large number of 2D materials available to us give rise to the possibility of creating complex van der Waals heterostructures. One important knob is the alignment angle between the neighbouring layers, which can be controlled with high precision. This allows strong modification of the properties of such heterostructures.

T2. Optical spectroscopy of excited-state spin defects in hexagonal boron nitride
Weibo Gao, Nanyang Technological University, Singapore

Negatively charged boron vacancy (VB-) centers in hexagonal boron nitride (hBN) are promising spin defects in a van der Waals crystal. Understanding the spin properties of the excited state (ES) is critical for realizing dynamic nuclear polarization (DNP). Here, we report zero-field splitting in the ES of DES = 2160 MHz and its associated optically detected magnetic resonance (ODMR) contrast of 12% at cryogenic temperature. In contrast to nitrogen vacancy (NV-) centers in diamond, the ODMR contrast is more prominent at cryo-temperature than at room temperature. The ES has a g-factor similar to the ground state. The ES photodynamics is further elucidated by measuring the level anti-crossing of the VB- defects under varying external magnetic fields. Our results provide important information for utilizing the spin defects of hBN in quantum technology.

T3. Quantum optics in room temperature quantum dot ensembles
Gadi Eisenstein, TECHNION, Israel

Light matter interactions induced by optical pulses with durations shorter than the coherence time are coherent in nature and hence allow the demonstration of many quantum-coherent effects in room temperature InAs/InP QD ensembles which will be surveyed together with optical control of the QD coherence time in tunneling injection QD structures.

QTN2. Lattices and photonic crystals (Thursday 28 Apr, 11:20-12:30)

T4. Topological plasmonics: skyrmions, merons and quasicrystals
Harald Giessen, University of Stuttgart, Germany

We carry out time-resolved 2-photon vector PEEM on atomically flat, single crystalline gold flakes with nanoscopic structures. Illumination with 13 fs, 800 nm pulses creates surface plasmon polaritons. Depending on the shape and geometrical phase, in combination with the helicity of the excitation beam, topological plasmonic quasiparticles are created: skyrmions, merons, as well as quasicrystalline excitations. We observe their complete field vector dynamics at subfemtosecond time resolution.

T5. Enhancement of photon blockade in photonic lattices

Yidong Chong, Nanyang Technological University, Singapore

An SSH chain of nonlinear quantum optical resonators can greatly enhance photon blockade, in a novel application of lattice effects to quantum optics. This extends "unconventional photon blockade", the interferometric suppression of multi-photon states, by generalizing from two cavities to a lattice. The required nonlinearity diminishes exponentially with lattice size.

T6. Magnetic topological photonic crystals

Baile Zhang, Nanyang Technological University, Singapore

The field of topological photonics started with the first photonic topological insulator that was implemented in a magnetic photonic crystal. Despite tremendous progress in topological photonics, the development in magnetic topological photonic crystals has been relatively limited. Here I will introduce some of our recent works in this direction.

QTN3. Quantum modelling
(Thursday 28 Apr, 14:10-15:10)

T7. Option pricing in a chip

José Ignacio Latorre, National University of Singapore, Singapore

Option pricing can be performed using single photons on a photonic chip. The circuit cast all operations on a unary basis and adds amplitude amplification. Furthermore, other probability distribution can be delivered by the same chip using the ideas of Generative Adversary Networks.

T8. Modelling quantum photonics on the IBM quantum computer

Anton Vetlugin, Nanyang Technological University, Singapore

A methodology of analog modelling of phenomena and devices of quantum photonics on a quantum computer is demonstrated. Instead of solving the equations of light propagation and light-matter interaction, this methodology relies on the analogous evolution of quantum light and a transmon, superconducting charge device of the IBM quantum computer.

T9. Quantum illumination and the story of non-classical light

Mile Gu, Nanyang Technological University, Singapore

Quantum illumination – the capacity for quantum-enhanced detection of remote objectives - presented a scientific curiosity. Whereas traditional wisdom dictated quantum technologies require care isolation from noise, quantum illumination thrived in noisy environments where no entangled can survive. In this presentation, I will give tour of research surrounding this this scientific curiosity, illustrating how fundamental impacted our understanding what is quantum, and led to new proposals of quantum-enhanced sensing.

QTN4. Quantum and topological devices
(Thursday 28 Apr, 15:40-17:00)

T10. Quantum hardware for the generation, manipulation and detection of light at the single photon level
Val Zwiller, KTH, Royal Institute of Technology, Sweden

We develop single photon sources based on semiconductor quantum dots to generate single photons as well as entangled photon pairs at telecom wavelengths to enable the implementation of long distance quantum communication.Single photon detectors with high detection efficiency, low noise and high time resolution are required to realize quantum applications, for this purpose, we develop superconducting nanowire single photon detectors.

T11. Superconducting quantum optoelectronics
Alex Hayat, TECHNION, Israel

We demonstrate photon pair correlations from injected Cooper-pairs in superconductor-semiconductor structures, which enable enhanced two-photon gain, heralded single-photon sources, entangled-photon pair generation and Bell-state analyzers. We also show high-Tc Cooper-pair injection into semiconductors, and demonstrated ultrafast high-Tc superconducting photodetectors, paving the way for more practical applications.

T12. Electrically driven topological quantum cascade lasers with polarization controls
Qijie Wang, Nanyang Technological University, Singapore

Topological lasers are promising candidates for novel semiconductor lasers. Here, we experimentally demonstrate the electrically pumped topological lasers, implemented monolithically on a quantum cascade chip, showing a cylindrical vector beam emission in the Terahertz regime.

QTN5. Quantum and topological systems
(Friday 29 Apr, 09:40-10:10)

T13. IAS@NTU Talk: Photonic time-crystals
Moti Segev, TECHNION, Israel

Photonic Time Crystals (PTCs) are dielectric media whose refractive index is modulated periodically in time at time scales of an optical cycle. These systems conserve momentum but not energy, and are characterized by momentum bands and bandgaps, where the amplitudes of their eigenmodes can increase (or decrease) exponentially. I will introduce the fundamentals of PTCs, discuss the topological features of waves propagating in PTCs, localization in PTCs containing disorder, and spatiotemporal photonic crystals. But more interesting than all the rest - I will discuss the classical and quantum features of light emission in PTCs from various radiation sources, such as free electrons, classical dipoles, quantum fluctuations, and the emission by atoms. The latter opens new avenues for making widely tunable lasers that extract energy from the temporal modulation of the medium.

T14. Theoretical and experimental discovery of topological knot magnets
Guoqing Chang, Nanyang Technological University, Singapore

Knot semimetals are a new type of topological phase. We discover the Hopf-link-like band crossings in the momentum space of Co2MnGa. We further reveal their remarkable Seifert bulk-boundary correspondence. Our work quantitatively accounts for the giant anomalous Hall from Berry curvature of the observed linked loops.

T15. Free electron triggered superfluorescence for resolving collective optical properties of quantum materials

Yehonadav Bekenstein, TECHNION, Israel

Superfluorescence triggered by free electrons is demonstrated for superlattices of lead-halide perovskite quantum dots. These new materials have a significant interaction cross-section with electrons, efficient emission, and fast radiative rates. By controlling the excitation area, the emission is toggled between spontaneous to superfluorescence, with applications for non-classical light sources.

QTN6. Quantum optics of atoms
(Friday 29 Apr, 10:40-12:00)

T16. Lightwave electronics in trivial and strongly correlated solids

Mikhail Ivanov, Technical University of Berlin, Germany

Light pulses shaped on the time-scale of individual oscillations of the electric field open unique opportunities in controlling electron motion in solids at the single-femtosecond time scale. I will review our recent results on sub-cycle control of electron dynamics in various solids, from trivial to strongly correlated.

T17. Atom trapping in subwavelength superoscillatory optical tweezers

David Wilkowski, Nanyang Technological University, Singapore

We use superoscillatory fields to trap a single cold atom in subwavelength trap beyond the Abbe's limit. We characterize the system measuring the effective temperature and the lifetime of the atom as well as the trap frequency. Extreme control of the atom position are useful for quantum technologies.

T18. Ultrafast chirality: twisting light to twist electrons

Olga Smirnova, Technical University of Berlin, Germany

I will introduce a new concept of synthetic chiral light, which is chiral already in the electric dipole approximation, and show how structuring its handedness in space can lead to new extremely efficient enantio-sensitive optical observables. If time permits, I will also introduce a concept of chiral topological light.

QTN7. Picophotonics
(Friday 29 Apr, 13:40-15:00)

T19. Light emission in extreme nanocavities: from intramolecular resolution to complex single photon emission

Javier Aizpurua, Center of Materials Physics, Spain

Plasmonic picocavities enable very efficient light emission from single organic molecules in tuneling junctions. We model and interpret the intensity, Purcell effect, and Lamb shift of intramolecular photonic maps. Furthermore, the role of dark states to interpret the complex dynamics of quantum dot emission coupled to a nanoantenna is unveiled.

T20. Pico-electrodynamics inside matter
Zubin Jacob, Purdue University, USA

The concept of photonic frequency (ω) - momentum (q) dispersion has been extensively studied in artificial dielectric structures such as photonic crystals and metamaterials. However, the ω−q dispersion of electrodynamic excitations hosted in natural materials at the atomistic level is far less explored. Here, we develop a Maxwell Hamiltonian theory of matter combined with the quantum theory of atomistic polarization to obtain the electrodynamic dispersion of natural materials interacting with the photon field. First, we apply the theory to Graphene with repulsive Hall viscosity to discover new topological electrodynamic invariants inside matter. Second, we apply the theory to Silicon and discover the existence of anomalous atomistic waves. These waves occur in the spectral region where propagating waves are conventionally forbidden in a macroscopic theory. Our findings demonstrate that natural media can host a variety of yet to be discovered waves and topological phases with sub-nano-meter effective wavelengths in the pico-electrodynamics regime.

T21. Picophotonics
Nikolay Zheludev, NTU, Singapore & University of Southampton, UK

We report on recent advances in applications of deep learning and topologically structured light to far-field non-destructive imaging with deep subwavelength resolution and atomic scale metrology that open a new field of picophotonics - the emerging science of interactions of picometer-scale objects and events with light.

QTN8. Free electron phenomena
(Friday 29 Apr, 15:30-16:50)

T22. Integration of free electrons in nanophotonics
Javier García de Abajo, ICFO, Spain

Advances in the ultrafast manipulation of electron beams allow us to examine optical excitations in quantum systems at unprecedentedly small length and time scales. We will discuss recently developed applications in the study of previously inaccessible phenomena, such as the determination of light statistics and nonlinear response at the nanoscale.

T23. Quantum interference and quantum recoil in free electron-driven nanophotonics
Liang Jie Wong, Nanyang Technological University, Singapore

We present a general framework for quantum interference and recoil in interactions between free-electrons, bound-electrons and photons. We show that waveshaping is key to enabling interference between fundamentally different quantum processes, and that unprecedented regimes of substantial quantum recoil in Smith-Purcell radiation are accessible with van der Waals structures.

T24. Ultrafast quantum phenomena of photonic quasiparticles

Ido Kaminer, TECHNION, Israel

Until recently, work in quantum optics focused on light interacting with bound-electron systems such as atoms, quantum dots, and nonlinear optical crystals. In contrast, free-electron systems enable fundamentally different physical phenomena, as their energy distribution is continuous and not discrete, allowing for tunable transitions and selection rules. We have developed a platform for studying free-electron quantum optics at the nanoscale. We demonstrated it by observing the first coherent interaction of a free electron with a photonic cavity and first interaction with the quantum statistics of photons. These capabilities open new paths toward using free electrons as carriers of quantum information and for measurement of quantum coherence of individual quantum systems.

QTN9. Topological photonics for communications
(Saturday 30 Apr, 09:00-10:20)

T25. IAS@NTU Talk: Next generation silicon photonics enabling novel ideas in topological photonics
Michal Lipson, Columbia University, USA

The field of silicon photonics is rapidly evolving and is now enabling completely new applications, ranging from Lidar to novel computing systems. This is partly due to the development of novel chip-scale technologies, novel devices and novel materials compatible with silicon photonics. Many of these technologies and devices can manipulate light across the whole VIS, IR and the Mid IR spectrum. I will discuss these emerging applications, some of the physics innovations brought by these areas as well as the advancement brought by these novel devices and materials..

T26. Topological THz silicon photonics: From 6G communications to high-Q sensors
Ranjan Singh, Nanyang Technological University, Singapore

The existing 5G communication architecture cannot fulfill present data demands due to bandwidth scarcity, which has stimulated innovative technologies with a vision of 6G communication. Terahertz (THz) technologies have been identified as a critical candidate for the emerging 6G communication with the potential to provide ubiquitous connectivity and remove the barrier between physical, digital, and biological worlds. Here, I will describe a new class of active, low-loss, on-chip THz topological photonic devices consisting of a single broadband channel 160 Gbit/s communication link, built on Silicon Valley Photonic Crystal.

T27. Quantum photonics in microresonators
Alexander Gaeta, Columbia University, USA

Nanophotonics represents an ideal platform for realizing quantum processes due to the combination of high confinement to produce high effective nonlinearities and strong dispersion for phase matching parametric processs. I describe how a nanophotonic microresonator can be used to produce a wide range of processes including quantum random numbers, squeezed states, and quantum frequency conversion.

QTN10. Quantum and Topological Nanophotonics
(Saturday 30 Apr, 10:50-12:30)

T28. Engineering electro-optical properties of hybrid perovskites with pressure
Zexiang Shen, Nanyang Technological University, Singapore

Hybrid perovskites are a new class of functional materials with potential applications in various technologically important areas, such as solar cells, LED and lasing. Compared with their 3D counterparts, 2D perovskites exhibit special properties, e.g. their natural quantum-well structure yields stable excitons, able to interact more strongly with phonons, spins and defects. Layered perovskites are also more structurally stable. High pressure induces a rich variety of phenomena in the electronic and optical properties in the hybrid Perovskite materials, including enhancement of photoluminescence (PL) by at least two orders of magnitude, narrow to white light emission, rich PL energy and lifetime changes. The optical properties of 2D perovskites are mainly governed by excitons, and the investigation of intrinsic and extrinsic, radiative and nonradiative exciton recombination pathways is essential. The intrinsic pathways are related to exciton-phonon interactions. Lattice vibrations create spatial and temporal potential fluctuations, where the first one causes scattering of excitons and broadening of excitonic peaks in optical spectroscopy, while the second leads to the fine structure of the spectra, known as Frank-Condon

shape. Besides, a moving exciton is able to create vibrations around it, inducing lattice distortions .

T29. Geometric photodetectors for mid-infrared spin light

Cheng Wei Qiu, National University of Singapore, Singapore

We will report zero-bias, uncooled, filterless photodetectors in mid-infrared exhibiting colossal discrimination ratio, close-to-perfect CPL-specific response, a zero-bias responsivity of 392 V/W, and a detectivity of ellipticity down to 0.03-degree Hz-1/2. Our approach employs plasmonic nanostructures array with judiciously designed symmetry, assisted by graphene ribbons to electrically read their near-field optical information. It highlights the potential of hybridizing metasurface and semimetals for miniaturized polarimetry .

T30. Quantum and topological perovskite photonics

Cesare Soci, Nanyang Technological University, Singapore

We will present recent results on quantum and topological metaoptics in the halide perovskite platform, including light-emitting BIC metasurfaces for tunable polarization singularities, optical Rashba effect and polaritonics in the strong-coupling regime, as well as compositionally-tunable perovskite quantum dot single photon emitters and their incorporation into topological cavities.

T31. Coherent and single photon emission from TMD excitons and color centers in hexagonal boron nitride

Harry Atwater, Caltech, USA

TBA

Posters

PP1. Poster Presentations Session 1 (Thursday 28 Apr, 13:30 – 14:10)

P1. Terahertz Topological Photonic Integrated Circuits for 6G Communication
Abhishek Kumar *et al.,* Nanyang Technological University

Terahertz (0.1-10 THz) technology has been identified as a critical enabler for 6G communications with the prospect of massive capacity and connectivity. Nonetheless, existing terahertz on-chip communication devices suffer from crosstalk, scattering losses, limited data speed, and insufficient tunability. We demonstrate on-chip topological terahertz devices, exhibiting single-channel 160 Gbit/s communication link and channel demultiplexing functionality, crucial for developing integrated circuits.

P2. Quantum metric plasmons and bulk plasmonic nonreciprocity in parity-violating magnets
Arpit Arora *et al.,* Nanyang Technological University, Singapore

We unveil a new class of non-reciprocal bulk collective resonances, namely quantum metric plasmons, driven by quantum metric dipole of strongly interacting electron liquid. We anticipate the plasmons can be realised in wide range of parity-violating magnets including moire' heterostructures where both quantum geometry and interactions are pronounced.

P3. High-power single-mode lasing based on nonlinearity and the non-Hermitian skin effect
Bofeng Zhu *et al.,* Nanyang Technological University, Singapore

We propose a laser with unusual behavior: multi-mode lasing occurs at low output powers, but pumping beyond a certain value produces a single lasing mode. This behavior arises in a lattice of coupled optical resonators with asymmetric couplings, and is caused by an interaction between nonlinearity and the non-Hermitian skin effect.

P4. High Pressure Response in Two-Dimensional Perovskites with Fluorinated Organic Spacer
Brandon Ong *et al.,* Nanyang Technological University, Singapore

In this work, the structural and optoelectronic effects of the presence of a fluorine atom in a Two-dimensional Organic-Inorganic Halide Perovskites, $(PEA)_2PbI_4$, is studied under high pressure conditions. The substitution of the fluorine atom has strengthened the intermolecular bonds between each molecule conditions and narrow the bandgap of the perovskite.

P5. Localized Quantum Dots Coupled to Hybrid Silicon-Particle-on-Gold-Mirror Nanoantenna for Out-of-Plane Directivity
Emmanuel Lassalle *et al.,* IMRE, A*STAR, Singapore

A single subwavelength hybrid dielectric-plasmonic optical antenna coupled to localized quantum dot emitters, that constitutes an efficient and bright unidirectional photon source under optical pumping, is realized with a silicon nanoring sitting on a metallic (gold) mirror with a 10nm nanogap in-between, where the assembly of quantum dots is embedded.

P6. Light-matter interaction engineering with topological insulator metamaterials
Harish Krishnamoorthy *et al.,* Nanyang Technological University, Singapore

Subwavelength nanostructures provide an efficient avenue to engineer light-matter interaction owing to strong confinement of electromagnetic fields. Such an approach is particularly relevant to exotic material systems such as topological insulators which are characterized by electromagnetic features such as negative permittivities and strong polarizability arising from both topological surface states as well as the semiconducting bulk. By adopting

nanophotonic strategies to fabricate designer metamaterials in topological insulator materials, we show engineering of light-matter interaction through different effects across the electromagnetic spectrum – enhancement of the circular photogalvanic effect, interband polaritonics, and complex mode structures for optically coupling to Dirac surface states.

P7. Chirality controlled broadband spintronic terahertz emitter

Piyush Agarwal *et al.,* Nanyang Technological University, Singapore

Light-matter interactions to generate broadband chiral terahertz waves hold a potential solution for ultrafast information encryption. Here, we demonstrate a route to control the terahertz chirality using synthetic-antiferromagnetic by tailoring the relative magnetization orientation of coupled ferromagnets. This provides a route for achieving next-generation spintronic-photonic devices.

P8. Hybrid perovskite containing copper clusters $[Cu(O_2C–(CH_2)_3-NH_3)_2]PbBr_4$: new type of interlayer bonding and its prospects.

Ksenia Chaykun *et al.,* Nanyang Technological University, Singapore

Hybrid halide perovskites are promising materials for optoelectronic applications. Introducing metal complexes instead of conventional organic cations into the layered structure improves the environmental stability. A new type of metal-perovskite bond enhances the optical properties due to the contribution of the metal orbitals to the near band gap energy levels.

P9. Topological memory in nonlinear driven-dissipative photonic lattices

Subhaskar Mandal *et al.,* Nanyang Technological University, Singapore

While nonlinearity is necessary for realizing efficient optical communications components, the robustness associated with the topological systems has been predicted to play an important role in optical communications. Here we realize theoretically a topological memory, where the system remembers its topological phase, based on the Bogoliubov fluctuations in a finite 2D lattice of nonlinear lossy resonators subjected to a coherent drive. The underlying linear lattice as well as the fluctuations are trivial. However, after the application of an additional coherent pulse, the nonlinearity induces topological phase, which remains even after the effect of the pulse dies out. By properly designing the system, a pulse at the bulk can amplify the topological corner modes, representing a robust transfer of intensity. Our work paves the way for optically tunable and topologically protected optical communication devices.

PP2. Poster Presentations Session 2 (Friday 29 Apr, 13:00 – 13:40)

P10. On-Chip Topological THz Beamformers
Wenhao Wang *et al.,* Nanyang Technological University, Singapore

We demonstrate on-chip terahertz beam steering with robust topological valley Hall waveguides. We achieve neural network-driven 1D beam steering with wide arbitrary angles of up to 92° and could tailor the beam into five different lobes of the desired directivity.

P11. Non-Hermitian topological systems with eigenvalues that are always real
Yang Long *et al.,* Nanyang Technological University, Singapore

The effect of non-Hermiticity in band topology has sparked many discussions on non-Hermitian topological physics. However, sufficiently strong non-Hermiticity will destroy the reality of energy spectra. Here, we show a systematic strategy to construct non-Hermitian topological systems exhibiting energy spectra that are always real, regardless of weak or strong non-Hermiticity.
cascade structure of multipole moments and topology.

P12. Layer-engineered infrared interlayer excitons
Qinghai Tan *et al.,* Nanyang Technological University, Singapore

The moiré superlattices made from transition metal dichalcogenides (TMDs) open a new area of engineered photonic materials and provide an ideal platform to study correlated physics and quantum simulation. However, layers, a natural degree of freedom of van der Waals materials, so far rarely reported to be used to modulate their properties. Here, we reported the infrared interlayer excitons in multilayer WSe_2/MoS_2 heterostructures and found they can be used to probe the evolution of band-extreme-point of few-layer WSe_2 and MoS_2. Furthermore, we found that in multilayer heterostructures, the lifetime, valley polarization, and valley lifetime of the infrared interlayer excitons can all be substantially improved as compared with that in the monolayer-monolayer heterostructure.

P13. Non-vertical quantum geometric photocurrents in centrosymmetric non-magnetic materials
Ying Xiong *et al.,* Nanyang Technological University, Singapore

Accessing quantum geometric properties in high symmetry materials has been a challenge. Here we propose that polariton-drag processes enable non-vertical interband transitions and selective photoexcitations in the k-space. This unblocks non-vertical quantum geometric photocurrents that are typically forbidden in centrosymmetric non-magnetic materials and enables probing of momentum resolved quantum geometric quantities along the Fermi surface.

P14. Broadband Integrated Silicon Topological Devices for 6G communications
Yi Ji Tan *et al.,* Nanyang Technological University, Singapore

Silicon photonic devices potentially offer seamless connectivity with the sixth-generation (6G) wireless network that could satisfy the exponentially growing data rate demands. Here, we design silicon photonic waveguides with topological edge states of more than 100 GHz bandwidth, paving the way towards realizing broadband photonic integrated circuits for 6G communications.

P15. Variable Photoluminescence Energy from 2D Perovskite under High Pressure
Yulia Lekina *et al.,* Nanyang Technological University, Singapore

Two dimensional hybrid perovskites (2D) exhibit enhanced environmental stability and efficient excitonic emission. High pressure can cause conformational transitions in the aliphatic chains of the organic component; particularly the long hexadecylammonium (HDA) cation adapts multiple conformations causing variable photoluminescence energy from the $(HDA)_2PbI_4$ perovskite crystal under pressure.

P16. NbTiN superconducting single photon detectors for near-infrared applications

Shuyu Dong *et al.,* Nanyang Technological University, Singapore

Increasing demand for single photon detection at wavelengths corresponding to the third telecom window, makes superconducting nanowire detectors (SNSPDs) and superconducting micron-scale bridges (SMSPDs) an attractive choice for such applications. Within the framework of near-infrared single photon detection, SNSPDs are known to outperform their conventional semiconductor-based counterparts, particularly in the terms of efficiency, speed and timing resolution. Similarly, SMSPDs also exhibit short recovery times and good temporal resolution, allowing prospective integration into photon circuits where high response rate is desirable. We explore both of these designs in respect to photon detection at 1550nm, using NbTiN as a superconducting material of choice.

P17. High-Tc THz Superinductors

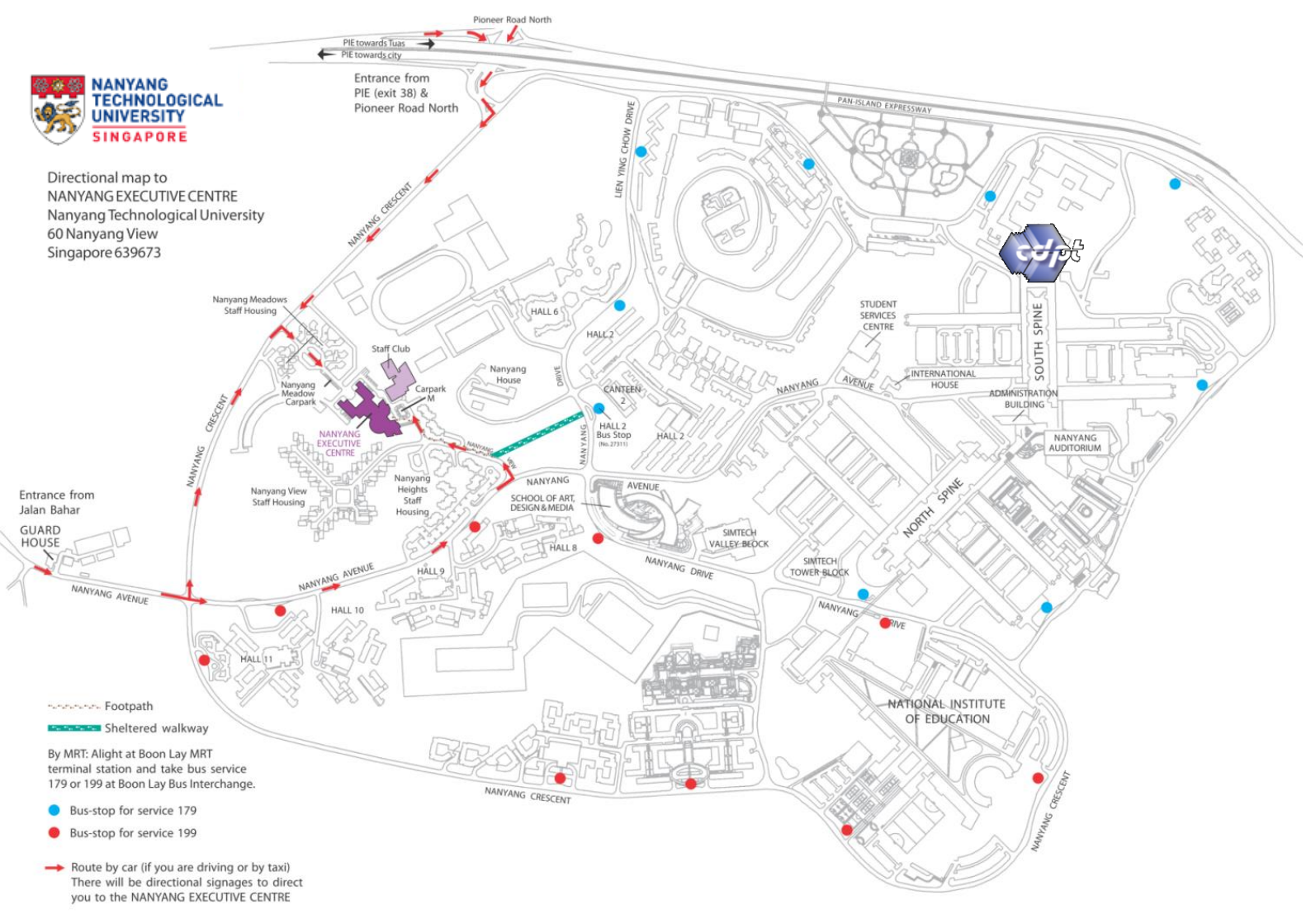
Yogesh Kumar Srivastava *et al.,* Nanyang Technological University, Singapore

Superinductors, defined by characteristic impedance exceeding resistance quantum [$R_Q=h/(2e)^2$ = 6.5kΩ], are needed for suppressing charge offset fluctuations. However, self-capacitance and internal losses limit the realization of superinductors. Here, we demonstrate the first terahertz superinductor built from 25 nm thin high-Tc YBCO metamaterials possessing giant kinetic inductance and record frequency agility.

P18. Projectively enriched symmetry and topology in acoustic crystals

Haoran Xue *et al.,* Nanyang Technological University, Singapore

Symmetry plays a key role in modern physics, as manifested in the revolutionary topological classification of matter in the past decade. So far, we seem to have a complete theory of topological phases from internal symmetries as well as crystallographic symmetry groups. However, an intrinsic element, *i.e.,* the gauge symmetry in physical systems, has been overlooked in the current framework. Here, we show that the algebraic structure of crystal symmetries can be projectively enriched due to the gauge symmetry, which subsequently gives rise to new topological physics never witnessed under ordinary symmetries. We demonstrate the idea by the experimental realization of a topological acoustic lattice with projective translation symmetries under a Z_2 gauge field, which exhibits unique features of rich topologies, including a single Dirac point, Möbius topological insulator, and graphene like semimetal phases on a rectangular lattice.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