Nov 18 (Tue)

Bohm Jung Yang (Seoul Nat. Univ.)

Title: How to measure the quantum geometry of Bloch electrons in solids?

Abstract: Understanding the geometric properties of quantum states and their implications in fundamental physical phenomena is at the core of modern physics. The Quantum Geometric Tensor (QGT) is a central physical object in this regard, encoding complete information about the geometry of the quantum state. The imaginary part of the QGT is the well-known Berry curvature, which plays a fundamental role in the topological magnetoelectric and optoelectronic phenomena. The real part of the QGT is the quantum metric, whose importance has come to prominence very recently, giving rise to a new set of quantum geometric phenomena, such as anomalous Landau levels, flat band superfluidity, excitonic Lamb shifts, and nonlinear Hall effect. Despite the central importance of the QGT, its experimental measurements have been restricted only to artificial two-level systems. In this talk, I am going to present two recent progresses in the QGT measurement of Bloch states in solids. First, I will propose a general method to extract the QGT by introducing another geometrical tensor, the quasi-QGT, whose components, the band Drude weight and orbital angular momentum, are experimentally accessible and can be used for extracting the QGT [1]. In the second part, I will report the first direct measurement of the full quantum metric tensors using black phosphorus as a representative material [2].The key idea is to extract the momentum space distribution of the pseudospin texture of the valence band from the polarization dependence of angle-resolved photoemission spectroscopy measurement.

References:

[1] M. Kang et al., Nature Physics 21, 110-117 (2025).

[2] S. Kim et al., Science. 388, 1050-1054 (2025).

Yuto Ashida (Univ. of Tokyo)

Title: Quantum magic and conformal field theory

Abstract: Nonstabilizerness or quantum "magic" is a crucial resource for universal quantum computation. I will talk about universal aspects of quantum magic in critical many-body systems. We develop a field-theoretical framework that connects the stabilizer Renyi entropy (SRE), a computable measure of magic, to partition functions in a replicated conformal field theory. This mapping allows us to provide analytical predictions of the universal behavior of the SRE. I will present tensor network calculations of the Ising model that validate these results. I will also briefly talk about how the SRE can be used as an information-theoretic probe of conformal defects, which might allow for exploring the physics of noninvertible symmetries.

Based on Hoshino, Oshikawa, YA, arXiv:2503.13599; Hoshino & YA, arXiv:2507.10656

Yoichi Yanase (Kyoto Univ.)

Title: Meron state and topological superconductivity in multiphase superconductor CeRh2As2

Abstract: Superconductors with multicomponent order parameters are platforms for exotic symmetry breaking and topological superconductivity. Multiple superconducting phases and topological superconductivity in a heavy fermion CeRh2As2 are discussed. I will also discuss the vortex phase diagram, which indicates a fractional vortex phase identified as a topological meron state.

Bo Yang (NTU)

Title: Geometric excitations of topological quantum fluids in partially filled Chern bands

Abstract: Topological quantum fluids in partially filled Chern bands have rich dynamical properties emerging from the interplay between quantum geometry and universal topological properties. In Landau levels multiple graviton-like spin-2 geometric excitations can emerge from fractional quantum Hall phases [1], as the quantum geometric fluctuations of conformal Hilbert spaces. Such excitations have been recently detected in experiments (Nature 628, 78-83, 2024). We show geometric excitations can also help us

understand the fundamental similarities and differences between Landau levels and generic Chern bands (e.g. from lattice models or moire systems). One can show with newly developed analytical tools the surprising emergence of “guiding center" continuous rotational invariance of the ground states and the geometric excitations with well-defined spins in moire systems, despite the explicit breaking of rotational symmetry. Nevertheless, they generally have short lifetime (in contrast to finite size numerical computations) due to strong scattering by the anisotropic gapped excitations. We propose experimental tuning strategies to lower the graviton mode energy below the gapped continuum, and argue this is a necessary condition enabling the observation of graviton modes and geometric excitations in realistic moire systems [2,3].

[1] Yuzhu Wang and Bo Yang, Nat. Commun. 14, 2317 (2023)

[2] Yuzhu Wang, J. Huxford, DX. Nguyen, G. Ji, YB. Kim, Bo Yang, arXiv:2502.02640

[3] Bo Yang, arXiv: 2503.19017

Kwang-Yong Choi (SKKU)

Title: Quantum geometry and topological excitations in Kitaev magnets

Abstract: Quantum geometry, encoded in the quantum metric and Berry curvature, shapes the geometric and topological properties of quantum states in Hilbert space. The Kitaev spin model offers a paradigmatic platform to explore such physics, hosting distinct topological phases tunable by magnetic fields, anisotropies, and the sign of Kitaev exchange interactions. Under a magnetic field, the Majorana spinon bands acquire nontrivial topological invariants, driving a transition from a trivial Z_2 spin liquid to a Chern Majorana insulator with chiral edge modes and quantized thermal Hall conductance. In the field-polarized regime, magnons also develop nontrivial Chern numbers across a broad field range, enabling the exploration of bosonic topology.

In this talk, I will present the evolution of low-energy quasiparticle excitations in the Kitaev candidate material α-$RuCl_3$ across magnetic fields up to 29 T, revealing how sharp magnon modes emerge from the fractionalized Majorana continuum within the partially polarized phase. By combining Raman circular dichroism with in-plane angular measurements, we identify Chern number changes in magnons and two-magnon excitations manifested

through their sixfold symmetry, together with emergent topological phonons arising from magnon–phonon hybridization. These findings offer fresh insights into the underlying quantum geometry and intertwined topological structures of phonon and magnon excitations in real Kitaev materials.

SungBin Lee (KAIST)

Title: Exotic entanglement switching and many body physics in quasiperiodic systems

Abstract: We show that quasiperiodic order enables controllable nonlocal correlations and unconventional many-body phases. In generalized Aubry–André chains with tunable mobility edges, critical states near the edge mediate long-range correlations, enabling both adiabatic routing and abrupt switching of entanglement between distant sites by sweeping the edge through the Fermi level. Building on this entanglement control in 1D, we turn to 2D dodecagonal order: Bogoliubov–de Gennes studies of the attractive Hubbard model reveal pattern-selective superconductivity, where the gap and transition temperature follow local motifs, yielding field-free coexistence of superconducting and normal regions—and even suppression of pairing when the Fermi level enters fragmented Hartree-shifted gaps. Together these results establish quasiperiodicity as a platform for engineering nonlocal entanglement and many-body responses inaccessible in periodic or amorphous media.

Changyoung Kim (Seoul Nat. Univ.)

Title: Electronic structure evidence for spin nematic bond order in single unit cell thick iridate films

Abstract: A 2D system can be quite distinct from the 3D system of the same material as the dimension can profoundly affect the physical properties. Atomically thin systems further allow control/manipulation of their properties. While these novel 2D systems are mostly obtained through exfoliation of van der Waals materials, a more conventional approach is through thin film growth. In this presentation, I wish to introduce our research efforts to measure and manipulate electronic properties of one unit-cell (UC) thick thin films by using thin film growth and in-situ angle resolved photoemission (ARPES). More

specifically, I will discuss the results of single UC SrIrO 3 (SIO).

A single UC SIO film has the same structure as that of a single layer Sr2IrO4 , a relativistic Mott insulator. As a result, single UC SIO films show an electronic structure similar to that of Sr2IrO4 with the Mott insulating state with (short) AF order as expected. However, metallic states can be realized via strain by growing SIO films on substrates with different lattice constants. The metallic 'Mott insulator' has spectral features much more pronounced than Sr2IrO4. The sharp features make it possible to do detailed polarization dependent experiments. The results of polarization dependent experiments[1] show that the ground state of 1 UC SIO may have a spin nematic bond order. This newly found states are different from a spin nematic state discovered in a recent report[2], suggesting that various quantum states may be realized by tuning external parameters.

References:

1. J. Y. Kim, in preparation

2. H. Kim et al., Nature 625, 264 (2024)

Nov 19 (Wed)

Sangkook Choi (KIAS)

Title: Quantum Zeno Monte Carlo for computing

Abstract: The recent development of logical quantum processors marks a pivotal transition from the noisy intermediate-scale quantum (NISQ) era to the fault-tolerant quantum computing (FTQC) era. These devices have the potential to address classically challenging problems with polynomial computational time using quantum properties. However, they remain susceptible to noise, necessitating noise resilient algorithms. We introduce Quantum Zeno Monte Carlo (QZMC), a classical-quantum hybrid algorithm that demonstrates resilience to device noise and Trotter errors while showing polynomial computational cost for a gapped system. QZMC computes static and dynamic properties without requiring initial state overlap or variational parameters, offering reduced quantum circuit depth.

[1] M. Han, H. Park, and S. Choi, Quantum Zeno Monte Carlo for computing observables, Npj Quantum Inf 11, 1 (2025).

Myung Joon Han (KAIST)

Title: Ab-initio screening of quantum frustrated materials with Kagome and triangular geometries

Abstract: A new high-throughput strategy is suggested for discovering frustrated magnets, combining first-principles density functional theory calculations, magnetic force theory, and spin Hamiltonian analysis. Our search is specifically directed toward insulating magnetic materials incorporating 3d transition metals. Focusing on Kagome or triangular lattices, we predict candidate materials that may host competing exchange interactions and new types of magnetic states. The suggested workflow not only reproduces the majority of known frustrated magnetic materials, but also predicts novel candidate compounds with targeted frustration profiles that have not yet been experimentally synthesized. Among these, we identify six promising materials: one triangular-lattice compound, and five Kagome-lattice compounds. For each candidate, we identify detailed magnetic properties and further propose their potential magnetic ground states, revealing that some of them may host entirely new magnetic phases driven by their distinct frustration characteristics.

Xi Dai (HKUST)

Title: Electromagnetic responses of Excitonic Insulators

Abstract: In this seminar, I will first introduce the main concepts of bilayer exciton insulator, a new type of charge neutral quantum liquid recently realized in 2D materials. Then I will mostly focus on the electromagnetic responses of bilayer excitonic insulators (EIs) and identify two distinct collective modes: (1) Two gapped plasmon modes couple to the layer symmetric gauge field. The transverse mode is nearly dispersionless in the long wavelength limit, while the longitudinal mode, accounting for total charge fluctuations, has a linear dispersion with velocity proportional to 2D electrical polarizability. (2) A gapless phase (Goldstone) mode and a gapped amplitude mode, associated with the fluctuations of EI

order parameter, couple to the layer antisymmetric gauge field. In the long wavelength and low frequency limit, the phase mode behaves like an acoustic phonon with speed inversely proportional to the square root of exciton compressibility. Significantly, its linear dispersion yields a cubic frequency dependence of the real admittance in microwave impedance microscopy (MIM), providing a method to detect the Goldstone mode directly.

Youngjoon Choi (POSTECH)

Title: Correlation, Topology, and Superconductivity in Rhombohedral Multilayer Graphene

Abstract: Rhombohedral-stacked multilayer graphene provides an exceptional platform for exploring correlated electron phenomena, owing to its flat bands near the Fermi energy and the ability to tune its properties with an external electric field. Its valley-dependent Berry phase further suggests the emergence of topological states when isospin symmetry is broken by electron correlations. In this talk, I will present recent discoveries of novel quantum phases in rhombohedral multilayer graphene, including superconductivity as well as integer and fractional quantum anomalous Hall effects. I will then discuss recent STM measurements that directly visualize intervalley coherent states, offering new insights into the possible origin of superconductivity. These findings open fresh avenues for investigating the interplay between correlation and topology in two-dimensional crystals, with potential implications for realizing topological superconductivity.

Takahiro Morimoto (Univ. of Tokyo)

Title: Nonlinear optical effects of magnetic materials: photocurrent and inverse Faraday effect

Abstract: In recent years, nonlinear optical phenomena in magnetic materials have garnered significant attention due to their rich interplay between electronic and magnetic degrees of freedom. In this talk, I will present two nonlinear optical effects—photocurrent generation and the inverse Faraday effect (IFE)—with their optoelectronic and spintronic applications.

The first part of the talk, I will talk about the shift current of magnetic excitations. The shift current is a type of bulk photovoltaic effect arising from the geometric phase of Bloch wave functions, and has been studied mainly in noninteracting systems for above-bandgap excitations. I demonstrate that interacting electron systems offer novel photocurrent responses even below the electronic band gap. In particular, I will present a theoretical framework for the photocurrent generation from magnon excitations [1] and its recent experimental observation in multiferroic materials [2].

In the second part, I will talk about the IFE, where circularly polarized light induces a static magnetization in a material. We show that, in multiorbital tight-binding systems, the total magnetic moment induced by light can be decomposed into spin and orbitals contributions of several origins, including a contribution from the electric dipole moment of Wannier orbitals, which is absent in conventional lattice formulations [3]. Using an s-p tight-binding model as a minimal model, we evaluate each component of the magnetization on an equal footing. We find that the orbital magnetic moment contributions are dominant, where their intra- and intersite, as well as dipole-related terms are comparable in magnitude, indicating the central role of orbital degrees of freedom in the IFE.

[1] T. Morimoto, and N. Nagaosa, Phys. Rev. B 100, 235138 (2019).; T. Morimoto, S. Kitamura, S. Okumura, Phys. Rev. B 104, 075139 (2021).

[2] M. Ogino et al. Nat. Commun. 15, 4699 (2024).

[3] Kosuke Tazuke, Takahiro Morimoto, Sota Kitamura, arXiv:2504.16490

Jiangping Hu (Institute of Physics, Chinese Academy of Sciences)

Title: Loop Current States in Correlated Electron Systems

Abstract: In this talk, I will discuss new progress in understanding electronic loop current states in correlated electron systems. A brief review of this type of states will be given for cuprates and Kagome lattice superconductors. We will develop correlated electron models where the loop current states are ground states and discuss the physics behind it.

Reference:

[1] X. Feng, k Jiang, Z. Wang, J.P. Hu, Sci. Bull. 66 1384 (2021)

[2] X. Feng et al. PRB 104 165136 (2021)

[3] Y. Gu et al. PRB 105 10 L100502 (2022)

[4] J. Zhan, et al, arXiv:2405.09451

[5] J. Zhan, et al, arXiv:2506.01648

Mingu Kang (Seoul Nat. Univ.)

Title: Time-domain investigation of kagome lattice quantum materials leveraging X-ray free electron laser

Abstract: In kagome lattice materials, quantum interplay between charge, spin, orbital, and lattice degrees of freedom gives rise to a remarkably rich set of emergent phenomena, ranging from unconventional charge order and superconductivity to topological magnetism. While the exact nature of these exotic orders is often hard to comprehend in static experiments, time-resolved techniques can offer critical insights by disentangling coupled degrees of freedom on the time-axis. In this talk, I will present our recent time-domain investigations on kagome systems, leveraging time-, energy-, and momentum-resolving capability of X-ray free electron laser. Our results not only reveal fundamentally distinct free energy landscapes governing charge order transition in nonmagnetic and magnetic kagome systems, but also provide an evidence of metastable states in kagome metals with multiple competing order parameters.

Nov 20 (Thu)

Zi-Yang Meng (Univ. of Hong Kong)

Title: Recent developments in Entanglement Measurements in Quantum Many-Body Systems

Abstract: I will report the recent algorithmic and computational developments in extracting

entanglement information in quantum many-body systems. From entanglement entropy, to multipartite entanglement and quantum Fisher information, we can now understand the exotic nature of quantum states and phase transitions from entanglement perspective, and hopefully making connections with spectroscopic experiments in quantum materials.

Jinsoo Park (POSTECH)

Title: Many-body Green’s function approach for color-center spin qubits

Abstract: Color centers in wide band gap semiconductors are promising candidates for solid-state quantum technologies. Their defect levels are usually well localized in real space as well as in energy, within the band gap of the material, thus minimizing the interactions between the defect and the host and leading to relatively long coherence times. However, the electron-phonon interaction between the defect states and the atomic vibrations of the system may yield an undesired coupling between defects and the host, thus affecting the coherence times. We present calculations of the electronic Green’s function of the defect states in the presence of the host lattice vibrations, using first-principles many-body perturbation theory. We focus on the prototypical negatively charged nitrogen vacancy (NV−) center in diamond and show that even at 0 K, the single-particle energy levels fluctuate within an interval of about 400 meV, due to quantum vibronic coupling. We discuss the temperature dependence of the photoemission and inverse photoemission spectra of the NV− in diamond, advancing our understanding of color centers for quantum technologies.