Intercontinental binodal Workshop

# *Flat bands and high-order Van Hove singularities*

PCS IBS, Daejeon, Korea

May 27 – June 7, 2024

*Scientific coordinators:*

Joseph Betouras (UK), Claudio Chamon (USA), Laura Classen (Germany)

Sergej Flach (Korea), Bohm-Jung Yang (Korea)

MAX PLANCK GESELLSCHAFT

ibs Institute for Basic Science

pcs Center for Theoretical Physics of Complex Systems

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Program is subject to change during the event.
This version was prepared on May 24, 2024.

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  In case of emergency: +82 10 2743 4200 (Ms. Gileun Lee)

- Wi-Fi
  – Eduroam: if available, please use the access provided through your institution
  – otherwise, please refer to the information in the seminar room.

- MEALS, TRAVEL
  – IBS cafeteria (1st floor):
      lunches on Mon - Fri. (except June 6 – meal box provided at PCS lounge)
      (please use attached meal coupon and follow the sign at the cafeteria)
  – PCS Lounge:
      dinners on Mon – Fri. (1st week, 5.45 pm),
      Mon – Thu. (2nd week, 5.30 pm)
  – Bus or train ticket to ICN: please visit registration room

- SOCIAL PROGRAM
  – Banquet (Wednesday, June 5)
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- ADDITIONAL INFORMATION – cf. large screen in the PCS Lounge (daily)

- FEEDBACK FORM
  Please scan the QR code
  with your phone camera
  to provide feedback on this workshop

# Program — Monday, May 27

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| 19:15 – 19:45 | Mark Greenaway, Loughborough University, UK<br>*Out-of-equilibrium magnetophonon resonance phenomena in graphene* |
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10:00 – 12:30 Discussions

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**Electron-Phonon and Electron-Phason Coupling in Twisted Bilayer Graphene** 15:30 – 16:00

Shahal Ilani, Weizmann Institute of Science, Israel

TBA

**Josephson diode effect and flat band superconductivity with quantum metric in moiré materials** 16:00 – 16:30

Kam Teun Law, HKUST, Hong Kong

Recently, it has been observed that superconducting and interaction-driven quantum anomalous Hall states can appear simultaneously in gate-defined Josephson junctions in twisted bilayer graphene [1]. The interaction-driven state serves as the weak link in the superconductor/correlated state/superconductor Josephson junction. In this talk, we will discuss how the interaction-driven valley polarization is essential for the Josephson diode effect observed in experiments [2]. Moreover, many of the superconducting properties of moiré superconductors with ultra-flat bands deviate greatly from conventional BCS theory predictions [3]. In the second half of the talk, I would like to present a Ginzburg-Landau theory derived from a microscopic flat band Hamiltonian, which incorporates the quantum metric effects of moiré flat band superconductors [4,5,6]. The theory explains how the length scale defined by quantum metric, which we call the quantum metric length, is critically important in determining the properties of moiré flat band superconductors.

[1] J Díez-Mérida, A Díez-Carlón, SY Yang, Y-M Xie, X-J Gao, J Senior, K Watanabe, T Taniguchi, X Lu, AP Higginbotham, KT Law, Dmitri K Efetov, Nature Communications 14: 2396 (2023).
[2] Jin-Xin Hu, Zi-Ting Sun, Ying-Ming Xie, K. T. Law, Physical Review Letters 130 , 266003 (2023).
[3] Haidong Tian, et al. Nature 614, 440 (2023).
[4] Shuai A Chen, KT Law, Phys. Rev. Lett. 132, 026002 (2024).
[5] Jin-Xin Hu, Shuai A Chen, KT Law, arXiv:2308.05686.
[6] Zhong CF Li, Yuxuan Deng, Shuai A Chen, Dmitri K Efetov, KT Law, arXiv:2404.09211.

**Generation, modulation, and enhancement of superconductivity by quantum geometry** 16:45 – 17:15

Youichi Yanase, Kyoto University, Japan

While the dispersion relation in the band structure is a fundamental property of electron systems in solids, the quantum geometry in the band structure is essential for various many-body states and unconventional responses in quantum materials. In particular, the real part of the quantum geometric tensor, namely the Fubini-Study quantum metric, has recently attracted attention, although the imaginary part is well known as the Berry curvature.

While the study of quantum geometry in superconductors was initiated by the studies of flat band systems [1], quantum geometry is essential in a broader class of superconductors. I will discuss the high-temperature superconductivity in monolayer FeSe [2], finite-momentum pairing states [3,4], and spin-triplet superconductivity by ferromagnetic fluctuation [5], all of which are triggered by quantum geometry.

[1] S. Peotta and P. Törmä, Nat. Commun. 6, 8944 (2015).
[2] T. Kitamura, T. Yamashita, J. Ishizuka, A. Daido, Y. Yanase, Phys. Rev. Research 4, 023232 (2022).
[3] T. Kitamura, A. Daido, Y. Yanase, Phys. Rev. B 106, 184507 (2022).
[4] T. Kitamura, S. Kanasugi, M. Chazono, Y. Yanase, Phys. Rev. B 107, 214513 (2023).
[5] T. Kitamura, A. Daido, Y. Yanase, Phys. Rev. Lett. 132, 036001 (2024).

**Moiré x Moiré: self-alignment, topology and quasi-crystals** 17:15 – 17:45

Eva Andrei, Rutgers University, USA

Using scanning-tunneling-microscopy and spectroscopy on heterostructures of twisted bilayer graphene on hexagonal Boron-Nitride, we show that the ensuing super-moiré structures display a rich landscape of moiré-crystals and quasicrystals. We reveal a phase-diagram comprised of commensurate moiré-crystals embedded in swaths of moiré quasicrystals. The 1:1 commensurate moiré crystal, which is expected to be a Chern insulator exhibiting orbital magnetism, should only exist at one point on this phase-diagram, implying that it ought to be practically undetectable. Surprisingly we find that commensurate moiré crystals exist over a wide range of parameters, providing evidence of an unexpected relaxation mechanism favoring self-alignment. The remainder of the phase-diagram is comprised of moiré quasicrystals with emergent rotational symmetries of the electronic wave function. These moiré quasicrystals provide a synthetic platform for creating and exploring such rarely found in nature structures.

**Pairing at a single Van Hove point** 18:15 – 18:45

Jörg Schmalian, Karlsruhe Institute of Technology, Germany

We show that an interacting electronic system with a single, ordinary or extended Van Hove point that crosses the Fermi energy is unstable against triplet superconductivity. For extended Van Hove points we find that the transition temperature is uniquely determined by the exponent that governs the divergence of the electronic density of states at the Fermi level. Enhancing this exponent should drastically increase Tc. The Cooper pair wave function of the triplet state is found to be highly non-local, with a non-monotonic momentum dependence and a steep slope near the nodes of the gap. These findings go beyond of what a logarithmic renormalization group treatment would yield. They demonstrate that the supermetal state, discussed in the context of extended Van Hove points, is ultimately unstable against superconductivity.

**Superconductivity in graphene stacks** 18:45 – 19:15

Francisco Guinea, IMDEA Materials Institute, Spain / DICP

Superconductivity has been observed in a number of twisted and untwisted graphene multilayers. The dependence of the superconducting properties on the geometry of the graphene stack will be discussed. The possibility of novel phenomena due to non trivial order parameters will also be highlighted.

**Out-of-equilibrium magnetophonon resonance phenomena in graphene** 19:15 – 19:45

Mark Greenaway, Loughborough University, UK

Resonant magnetoresistance measurements on graphene FETs under “ohmic” low current conditions have been used to study a wealth of novel physics. At high currents (up to 100 A$m^{-1}$), electrons are driven far from equilibrium with the atomic lattice vibrations so that their kinetic energy can exceed the thermal energy of the phonons. Here, we report three non-equilibrium phenomena in monolayer graphene at high currents [1]: (i) a “Doppler-like” shift and splitting of the frequencies of the transverse acoustic (TA) phonons, emitted resonantly when the electrons undergo inter-Landau level (LL) transitions [2] and revealed by shifts of peaks in the differential resistance, $r_y$; (ii) an intra-LL Mach effect with the emission of TA phonons when the electrons approach supersonic speed ( $\sim$ 1.4 x $10^4$ $ms^{-1}$), revealed by a strong and broad magnetic field-independent peak in $r_y$ at I $\sim$ 1 mA and (iii) the onset of elastic inter-LL transitions and an associated resonance maximum in $r_y$ at a critical carrier drift velocity (see Fig 1b). The third phenomenon is analogous to a “superfluid” Landau velocity and the formation of magneto-excitons involving a quantum jump, *h/m*, in the electron LL circulation. All three quantum phenomena can be unified in a single resonance equation. They offer avenues for research on out-of-equilibrium phenomena in other two-dimensional systems.

[1] M.T. Greenaway et al., Nature Communications 12, 6392 (2021)
[2] P. Kumaravadivel et al., Nature Communications 10, 3334 (2019)

**Maximally localized Wannier functions, interaction models, and fractional quantum anomalous Hall effect in twisted bilayer MoTe2** 19:45 – 20:15

Yang Zhang, University of Tennessee, USA

We investigate the moiré band structures and the strong correlation effects in twisted bilayer MoTe2 for a wide range of twist angles, employing a combination of various techniques. Using large-scale first-principles calculations, we pinpoint realistic continuum modeling parameters, subsequently deriving the maximally localized Wannier functions for the top three moiré bands. Simplifying our model with reasonable assumptions, we obtain a minimal two-band model, encompassing Coulomb repulsion, correlated hopping, and spin exchange. Our minimal interaction models pave the way for further exploration of the rich many-body physics in twisted MoTe2. Furthermore, we explore the phase diagrams of the system through Hartree–Fock approximation and exact diagonalization (ED). Our two-band ED analysis underscores significant band-mixing effects in this system, which enlarge the optimal twist angle for fractional quantum anomalous Hall states.

**Moiré fractional phases of matter** 15:30 – 16:00

Nicolas Regnault, École Normale Supérieure de Paris, France

In the realm of condensed matter physics, the fractional quantum Hall effect stands as a singular experimental manifestation of topological order, characterized by the presence of anyons—quasiparticles that bear fractional charge and exhibit exchange statistics diverging from conventional fermions and bosons. This phenomenon, observed over four decades ago, was still missing the direct observation of similar topological orders arising purely from band structure—without the application of strong magnetic fields. In 2023 within the span of a few months, several pioneering experiments have illuminated this once theoretical domain. Studies on twisted homobilayer MoTe2 and pentalayer rhombohedral graphene placed on hBN have finally unveiled the existence of fractional Chern insulators (FCIs), the zero-magnetic field analog of fractional quantum Hall states. The journey to this point, preceded by over a decade of theoretical frameworks and predictions surrounding FCIs, yet the experimental revelations have proved to be richer and more surprising than expected. In this talk, we will present how the combination of ab-initio and quantum many-body calculations can help us capture the different features observed in experiments. We will discuss the potential future for this exciting booming field, including the possible observation of fractional topological insulators, a yet-never observed topological ordered phase preserving the time reversal symmetry.

**TBA** 16:00 – 16:30

Jeil Jung, University of Seoul, Korea

**Where the current flows in a Chern insulator** 16:45 – 17:15

Roderich Moessner, MPIPKS, Germany

It is an old question whether an original, and intuitively compelling, picture of the current flowing in a narrow channel along the sample edge is the physically correct one. Motivated by recent experiments *locally* imaging the quantized current flow in a Chern insulating (Bi, Sb)$_2$Te$_3$ heterostructure, we theoretically demonstrate the possibility of a broad `edge state' meandering away from the sample boundary deep into the sample bulk. Further, we show that varying experimental parameters permits continuously tuning between narrow edge states and meandering channels all the way to incompressible bulk transport. This accounts for various features observed in, and differing between, experiments. Overall, this underscores the robustness of topological condensed matter physics, but it also unveils a phenomenological richness hidden by topological censorship.

**Quantum geometry and its relation to linear response** 17:15 – 17:45

Raquel Queiroz, Columbia University, USA

We present the time-dependent Quantum Geometric Tensor (tQGT) as a comprehensive tool for capturing the geometric character of insulators observable within linear response. We show that tQGT describes the zero-point motion of bound electrons and acts as a generating function for generalized sum rules of electronic conductivity. Therefore, tQGT enables a systematic and basis-independent framework to compute the instantaneous response of insulators, including optical mass, orbital angular momentum, and the dielectric constant in low-energy effective theories. It allows for a consistent approximation across these quantities upon restricting the number of occupied and unoccupied states in an effective low-energy description of an infinite quantum system. We outline how lattice interference can generate quantum geometry in periodic systems. We examine spectral weight transfer from small frequencies to high frequencies by creating geometrically frustrated flat bands.

**TBA** 18:15 – 18:45

Ipsita Mandal, Shiv Nadar Institution of Eminence, India

TBA

**Parquet RG near high order Van Hove singularities** 18:45 – 19:15

Rahul Nandkishore, University of Colorado at Boulder, USA

I will discuss the analysis of Fermi surface instabilities close to Van Hove singularities (high order and otherwise) using parquet RG. Particular emphasis will be given to hexagonal lattice systems. I will also discuss possible applications to Kagome metals.

**Progress in fractional quantum anomalous hall effect** 19:15 – 19:45

Xiaodong Xu, University of Washington, USA

The interplay between spontaneous symmetry breaking and topology can result in exotic quantum states of matter. A celebrated example is the quantum anomalous Hall (QAH) effect, which exhibits an integer quantum Hall effect at zero magnetic field due to topologically nontrivial bands and intrinsic magnetism. In the presence of strong electron-electron interactions, fractional-QAH (FQAH) effect at zero magnetic field can emerge, which is a lattice analog of fractional quantum Hall effect without Landau level formation. In this talk, I will first review our experimental observation of FQAH and associated effects in twisted $MoTe_2$ bilayer, using combined magneto-optical and -transport measurements. I will then present an optical probe of putative zero-field composite Fermi liquid state. Lastly, I will discuss the latest progress in the zero-field Fractional Chern insulator.

**Kekule orders and Berry-frustrated exciton condensates in moire materials** 19:45 – 20:15

Siddharth Parameswaran, University of Oxford, UK

I will discuss how the topological structure of the flat bands in moiré graphene systems can stabilize a host of complex charge-ordered states with intervalley coherence that can be frutifully viewed as "Berry-frustrated" exciton condensates. Apart from identifying a host of potential new correlated insulating states in a range of moiré graphene multilayers, this theory also sheds new light on the emergence of the "Kekulé spiral" charge orders that theoretically proposed [1-3] in twisted bilayer and symmetric trilayer graphene and recently observed via scanning tunneling microscopy experiments [4,5].

[1] Y.H. Kwan, G. Wagner, T. Soejima, M.P. Zaletel, S.H. Simon, S.A. Parameswaran, and N. Bultinck, Phys. Rev. X 11, 041063 (2021).
[2] G. Wagner, Y.H. Kwan, S.H. Simon, N. Bultinck, and S.A. Parameswaran, Phys. Rev. Lett. 128, 156401 (2022).
[3] Z. Wang, Y.H. Kwan, G. Wagner, N. Bultinck, S.H. Simon, and S.A. Parameswaran, arXiv:2310.16094 (2023).
[4] K.P. Nuckolls et al, Nature 620, 525(2023).
[5] H. Kim et al, Nature 623, 942 (2023).

**Visualizing correlated electronic states in flat bands** 15:30 – 16:00

Ali Yazdani, Princeton University, USA

Both Landau levels in a magnetic field and flat bands in moire materials give rise to strong correlation among electrons. These interaction can stabilize a wide range of electronic states, mostly studies using transport measurements. Our work focuses on high-resolution scanning tunneling microscopy measurements to directly visualizing electronic states of the correlated states. I will describe a wide range of experiments probing various broken symmetry states and their melting into exotic superconductors and other correlated electronic states we have done in the past few years.

**Magic angle of moire magnetic materials** 16:00 – 16:30

Moon Jip Park, Hangyang University, Korea

Recent experiments with twisted bilayer materials have provided a versatile platform for realizing exotic phases of matter. Among many interesting physical features, the emergence of the flatband in magic-angle twisted bilayer graphene(MATBG) is known as the source of a strong correlation effect. In this talk, we show that magnetic materials can also harbor the flatband of magnons. In sharp contrast to the electronic flatband at the Fermi level, the relevant energy level of the magnon(bosonic) flatband is zero energy. Therefore, the magnon flatband demands a completely different recipe for its realization from the case of the twisted bilayer graphene. We discuss the realization of magnonic flatband in twisted bilayer magnetic materials.

**Correlated phases at a tunable van-Hove singularity in Bernal bilayer graphene** 16:45 – 17:15

Thomas Weitz, University of Göttingen, Germany

The exchange interaction can lead to correlated states in low dimensional systems such as the graphene family. Regions of large density of states are especially prone to correltaion effects, an example that will be discussed is the recently identified exchange driven quantum anomalous Hall (QAH) nu=2 state that exhibits quantized charge Hall conductance close to zero magnetic field as well as spin, valley and spin-valley anomalous quantum Hall effects and out-of-plane ferroelectricity in suspended bilayer graphene [1]. In the case that bilayers are encapsulated in h-BN, a large displacement field can be applied allowing the opening of a gap in the density of states with a concomitant van-Hove-singularity close to the band edges. We will discuss our recent measurements [2] in such device structures that indicate that close to the band edges novel states appear that are distinct from Stoner [3,4] and other single particle physics. For example, one identified state is consistent with a Chern insulating state at finite density in the valence band.

[1] F. R. Geisenhof, F. Winterer, A. M. Seiler, J. Lenz, T. Xu, F. Zhang and R. T. Weitz, "Quantum anomalous Hall octet driven by orbital magnetism in bilayer graphene", Nature 598, 53 (2021)

[2] A. M. Seiler, F. R. Geisenhof, F. Winterer, K. Watanabe, T. Taniguchi, T. Xu, F. Zhang and R. T. Weitz, "Quantum cascade of new correlated phases in trigonally warped bilayer graphene", Nature 608, (2022) 298

[3] H. Zhou, Y. Saito, L. Cohen, W. Huynh, C. L. Patterson, F. Yang, T. Taniguchi, K. Watanabe, A. F. Young, "Isospin magnetism and spin-triplet superconductivity in Bernal bilayer graphene", Science 375 (2022), 774

[4] S. C. de la Barrera, S. Aronson, Z. Zheng, K. Watanabe, T. Taniguchi, Q. Ma, P. Jarillo-Herrero, R. Ashoori, "Cascade of isospin phase transitions in Bernal bilayer graphene at zero magnetic field" Nature Physics 18, (2022) 771

**Cascades: The unconventional state of twisted bilayer graphene** 17:15 – 17:45

Elena Bascones, Spanish National Research Council, Spain

Among the variety of correlated states found in twisted bilayer graphene (TBG), a strong reorganization of the density of states, up to tenths of meV, including oscillations of the remote bands energies in Scanning Tunneling Microscope experiments and sawtooth peaks in the inverse compressibility were detected and named cascades. These cascades happen in a much larger energy, twist angle and temperature range than other correlated phenomena in TBG, pointing to a hierarchy of phenomena [1]. Many proposals to explain the cascades involved symmetry breaking. Using Dynamical Mean Field Theory (DMFT) calculations we showed [2] that the cascades emerge already in the normal state, in which no symmetry breaking order is present, due to the formation of local moments and heavy quasiparticles. Besides explaining the signatures in STM and compressibility measurements, we predicted a strong momentum differentiation in the incoherent spectral weight, associated to the fragile topology of TBG. After reviewing the phenomenology of the cascades and our first results, in the talk I will discuss more recent calculations in which we both address another set of experimental results and make new predictions for future measurements.

[1] Wong et al, Nature 582, 198 (2020), Zondiner et al, Nature 582, 203 (2020). Polski et al, arXiv:2205.05225

[2] A. Datta, M.J. Calderón, A. Camjayi, and E. Bascones, Nature Communications 14, 5036 (2023)

**Competing orders at higher-order Van Hove points** 18:15 – 18:45

Michael Scherer, Ruhr University Bochum, Germany

At high-order Van Hove points the dispersion is exceptionally flat and the density of states has a power-law divergence. In my talk, I will discuss our analysis of the competition between different ordering tendencies using unbiased renormalization group approaches, both a parquet RG as well as a functional RG with high momentum resolution. In the simple parquet RG, we find that for purely repulsive interactions, the two key competitors are ferromagnetism and chiral superconductivity. For a small attractive exchange interaction, we find a new type of spin Pomeranchuk order, in which the spin order parameter winds around the Fermi surface. The supermetal state, predicted for a single high-order Van Hove point, is an unstable fixed point in our case. Using the functional RG, we also study full band models and the effect of (non-local) Coulomb interactions as relevant for intercalated graphene and other materials. We explore the competing correlated states and the phase diagram for various models in the vicinity of the high-order Van Hove points.

**Marginal Fermi liquid behavior at the onset of $2k_F$ density wave order in two-dimensional metals with flat hot spots** 18:45 – 19:15

Walter Metzner, MPI FKF, Germany

We analyze quantum fluctuation effects at the onset of incommensurate $2k_F$ charge- or spin-density wave order in two-dimensional metals, for a system where the ordering wave vector Q connects a pair of hot spots on the Fermi surface with a vanishing Fermi surface curvature. We first compute the order parameter susceptibility and the fermion self-energy in random phase approximation (RPA). Logarithmic divergences are subsequently treated by a renormalization group analysis. The coupling between the order parameter fluctuations and the fermions vanishes logarithmically in the low-energy limit. As a consequence, the logarithmic divergences found in RPA do not sum up to anomalous power laws. Instead, only logarithmic corrections to Fermi liquid behavior are obtained. In particular, the quasiparticle weight and the Fermi velocity vanish logarithmically at the hot spots.

L. Debbeler and W. Metzner, Phys. Rev. B 107, 165152 (2023). L. Debbeler and W. Metzner, arXiv:2403.00007.

**Flat band phenomena approaching the vHs in $Sr_3Ru_2O_7$** 19:15 – 19:45

Andreas Rost, University of St Andrews, UK

TBD

**Ab Initio Modelling of Twisted Bilayers and Heterostructures of 2D Materials** 19:45 – 20:15

Nicholas Hine, University of Warwick, UK

2D Materials exhibit a wide range of novel physics, much of it driven by behaviour such as flat bands and van Hove singularities emerging when layered materials are combined as twisted multi-layer systems or heterostructures. However, the electronic and vibrational properties of 2D materials whose minimal models are large are challenging for conventional modelling approaches due to their unfavourable scaling with system size. Our work uses two complementary approaches to large scale simulation, firstly Linear-Scaling DFT, using the ONETEP code [1], and secondly construction of Machine-Learned Interatomic Potentials. We demonstrate MLIP surrogate models for 2D systems whose accuracy closely matches that of DFT, with efficient use of training data, constructed using equivariant neural networks such as MACE [2]. These can perform geometry and vibrational spectroscopy calculations in situations where ab initio evaluation of the Hessian is unfeasibly expensive. For electronic properties, MLIPs can be applied to geometry pre-relaxation of twisted and heterostructured systems, enabling LS-DFT calculations with accurate corrugation at the large system sizes required to minimize strain. Applications of spectral function unfolding for heterostructures involving TMDs, hBN and graphene and hBN will be discussed.

[1] www.onetep.org and J.C.A. Prentice et al, J. Chem. Phys. 152, 174111 (2020).
[2] I. Batatia et al., Advances in Neural Information Processing Systems 35, 11423 (2022).

**First Landau Level Physics in Second Moiré Band of 2.1∘ Twisted Bilayer MoTe2** 15:30 – 16:00

Gil Young Cho, POSTECH, Korea

The recent experimental discovery of the fractional quantum spin Hall effect in twisted bilayer MoTe2 at a twist angle of 2.1 degrees highlights the unique properties of its second moiré band. Inspired by this finding, we conduct a comprehensive theoretical investigation of the half-filled second moiré band at this angle, utilizing an effective continuum model. Our analysis reveals that the band not only exhibits characteristics akin to the first Landau level, but also that its projected Coulomb interaction strikingly mirrors the Haldane pseudopotentials of the first Landau level. They together strongly indicate the potential emergence of a non-Abelian fractional quantum anomalous Hall state at the half-filling under the Coulomb interactions. By performing exact diagonalization calculations, we validate this hypothesis and construct a global phase diagram around this non-Abelian fractional quantum anomalous Hall state. We also introduce a novel metric of 1LL-ness of a band, which quantitatively measures the alignment of the projected Coulomb interaction with the Haldane pseudopotentials in Landau levels. This metric is then compared with the global phase diagram including the non-Abelian fractional quantum anomalous Hall state, revealing its utility in predicting the parameter region of the 1LL-ness. Finally, we discuss the potential implications on experiments.

**Quasi-localization and Wannier Obstruction in Partially Flat Bands** 16:00 – 16:30

Jun-Won Rhim, Ajou University, Korea

The localized nature of a flat band is understood by the existence of a compact localized eigenstate. However, the localization properties of a partially flat band, ubiquitous in surface modes of topological semimetals, have been unknown. We show that the partially flat band is characterized by a non-normalizable compact localized state (NCLS). The partially flat band develops only in a momentum range, where normalizable Bloch wave functions can be obtained by the linear combination of the NCLSs. Outside this momentum region, a ghost flat band, unseen from the band structure, is introduced for the consistent counting argument with the full set of NCLSs. Then, we demonstrate that the Wannier function corresponding to the partially flat band exhibits an algebraic ($\sim 1/r1+\epsilon$ in 1D and $\sim 1/r3/2+\epsilon$ in 2D) decay behavior, where $\epsilon$ is a positive number. Namely, one can have the Wannier obstruction even in a topologically trivial band if it is partially flat. Finally, we develop a construction scheme of a tight-binding model of the topological semimetal by designing an NCLS.

**Magnetic Kagome lattice: topology and frustration** 16:45 – 17:15

Claudia Felser, MPI CPfS, Germany

Recently, there has been a surge of interest in topological quantum materials exhibiting nontrivial topological states, marking a dynamic frontier in condensed matter physics. Theoretical predictions and experimental observations have unveiled a spectrum of intriguing topological states, including topological insulators, Dirac and Weyl semimetals. Within the realm of topological quantum materials, those featuring a kagome lattice have recently garnered significant attention. This lattice not only gives rise to geometrically frustrated magnetism but also hosts a nontrivial topological electronic structure, showcasing Dirac points, van Hove singularities, and flat bands. The unique structure of the kagome lattice, coupled with multiple spin, charge, and orbit degrees of freedom, creates a fertile ground for exploring the interplay between frustrated magnetism, nontrivial topology, and correlation effects. This interplay results in a multitude of quantum states, offering a platform for investigating emergent electronic orders and their correlations. These materials can be broadly categorized into magnetic and non-magnetic Kagome materials. Magnetic Kagome materials, such as Mn3Sn , Co3Sn2S2 , REMn6Sn6 and FeGe etc. primarily involve 3d transition metal-based Kagome systems. The interplay between magnetism and the topological band structure significantly influences the electronic response, leading, for example, to the enhancement of the Berry curvature and the emergence of a large intrinsic anomalous Hall effect due to the presence of massive Dirac or Weyl fermions. Additionally, the frustrated structure of Kagome materials allows them to host topologically protected Skyrmion lattices or noncoplanar spin textures, resulting in a topological Hall effect arising from real-space Berry phases.

**High-Order Van Hove Singularity Generation and Pomeranchuck Instability in a Kagome Metal** 17:15 – 17:45

Haim Beidenkopf, Weizmann Institute of Science, Israel

The Kagome band structure hosts several features of interest that primarily include a flat band and a Dirac node with two saddle points flanking it. Even though both the saddle points induce logarithmically divergent van Hove singularities in the density of states, they differ in the way they mix the electronic orbitals from the three unit cell sites. This affects the type of instabilities they may induce. We investigate a Kagome metal using scanning tunneling spectroscopy. We identify a particular distortion on its Kagome surface termination that considerably flattens the M-type saddle point and turns it into a higher order van Hove singularity pinned to the Fermi energy. We capture the process of its generation both in ab initio calculation and with a minimal tight binding model. The strong interactions result in a d-wave Pomeranchuck instability. We visualize it both in real and in reciprocal space as a cascade of wavefunction distributions that spontaneously break the rotational symmetry imposed by the underlying distorted Kagome lattice without generating any additional Bragg peaks. The evolution of the wave function across the Fermi energy further suggests the spontaneously deformed Fermi surface gives rise to charge pumping. The type of Kagome distortion that generates the higher order van Hove singularity may be common to other Kagome materials.

**Fractional topological insulators in Moire materials** 18:15 – 18:45

Titus Neupert, University of Zurich, Switzerland

TBA

**Topological Heavy Fermion Theory for Twisted Bilayer Graphene** 18:45 – 19:15

Bodgan A. Bernevig, Princeton University, USA

TBA

**Unconventional charge correlations and lattice instabilities in kagome metals** 19:15 – 19:45

Stephen Wilson, UCSB, USA

Partially flat bands and higher order Van Hove singularities are predicted to generate a number of unusual electronic states and lattice instabilities in metals built from kagome networks. Two recent experimental examples of this have been reported in the AV3Sb5 and RV6sn6 classes of kagome metals, both of which have a series of saddle points near their Fermi levels. In this talk, I will discuss the nature of charge correlations that form in these compounds and how they map to models of intertwined lattice and charge instabilities in these materials. I will focus mainly on the nature of short-range, diffuse correlations that appear once the primary charge instabilities in these materials are suppressed in these compounds and insights that can be gained from them.

**Topological superconductivity near van Hove fillings** 19:45 – 20:15

Andreas Schnyder, MPI FKF, Germany

Topological superconductors have become an important research topic, stimulated by their potential for quantum and superconducting applications. Since the topology only protects against perturbations smaller than the superconducting gap, it is of paramount importance to find topological superconductors with large gaps and high transition temperatures. One possible path to high-temperature topological superconductivity is to consider materials where the Fermi level lies close to van Hove singularities (VHSs), which enhance the density of states. Motivated by this, we theoretically analyze the conditions under which topological superconductivity emerges close to van Hove fillings on the square and kagome lattices. For the kagome lattice we investigate how the different sublattice textures of the m-type and p-type VHSs influence the propensity for topological superconductivity. For both lattices we find a variety of different topological superconducting states and discuss their properties, including Majorana edge and corner modes.

**Field-induced Lifshitz transitions: Probe of heavy fermion band structure** 15:30 – 16:00

Gertrud Zwicknagl, TU Braunschweig, Germany

The search for new types of exotic topological orders has recently rekindled the interest in Fermi surface reconstructions. Of particular interest are Electronic Topological (Lifshitz) transitions where the number of Fermi surface sheets changes abruptly under the influence of external parameters like chemical doping, pressure, or magnetic field. Lifshitz transitions are generally associated with the presence of critical points in the electronic band structure, i. e., maxima, minima, or saddle points whose presence follows directly from lattice periodicity. As their separation from the chemical potential is of the order of the bandwidth, the critical points hardly affect the low temperature behavior of "conventional" metals. In heavy-fermion materials, however, the widths of the quasi-particle bands are strongly reduced by electronic correlations and, consequently, magnetic fields can drive Lifshitz transitions. The characteristic anomalies in the equilibrium and transport properties provide a method to test the quasi-particle dispersion away from the Fermi surface. The values of the field at which the transitions occur reflects the microscopic mechanism leading to the formation of the heavy quasi-particles. Here we demonstrate that the magnetic field-dependent anomalies in the Seebeck coefficient provide detailed information not only on the critical points, i. e., their character and position relative to the chemical potential but also on the effective mass tensor, i. e.,the quasi-particle dispersion in the vicinity of the critical points. For lanthanide-based HFS, the theoretical analysis is based on Renormalized Band (RB) structure calculations assuming that the heavy quasi-particles result from a Kondo effect. For U-based HFS, on the other hand, we adopt the fully microscopic model which emphasizes the role of intra-atomic Hund's rule-type correlations for appearance of heavy quasi-particle masses. The calculations reproduce the observed positions of the anomalies surprisingly well.

**Quantum Geometry in Topological Bands: Chern Insulators from Landau Level Description and Beyond** 16:00 – 16:30

Bo Yang, Nanyang Technological University, Singapore

Intricate relationship between quantum geometry and topological phases of matters manifest itself both in the Landau levels of quantum Hall systems, and narrow Chern bands in 2D crystals. Recent experimental breakthroughs in twisted multilayer structures and moire lattices shows promises of a large variety of 2D platforms for realising both integer and correlated topological quantum fluids. In this talk, we explore two fundamental questions from comparing these two systems: a). what constitutes as "good qualities" of the Chern band for realising strongly correlated topological phases; b). what are the new behaviours unique to the lattice Chern bands beyond Landau level physics. We discuss the ideal flatband formalism in moire systems and how Landau level physics help understand many dynamical properties in the Chern bands. These include the absence of Anderson localization of the Chern bands in the presence of the superlattice potential, and how electron-electron interaction can impact the dynamics of integer Chern insulators via non-uniform quantum geometric tensor. We also discuss their experimental ramifications for the robustness of topological phases in 2D quantum materials.

**Unconventional discontinuous transitions in a 2D system with spin and valley degrees of freedom** 16:45 – 17:15

Andrey Chubukov, University of Minnesota Minneapolis, USA

We analyze the transition into the most favorable ordered state for a system of 2D fermions with spin and valley degrees of freedom. We show that for short-ranged interactions and a range of rotationally invariant dispersions, the ordering transition is highly unconventional: the associated susceptibility diverges (or almost diverges) at the transition, yet immediately below it the system jumps discontinuously into a fully polarized state. We analyze the dispersion of the longitudinal and transverse collective modes in different parameter regimes above and below the transition. Additionally, we consider ordering in a system with full SU(4) symmetry and show that there is a cascade of discontinuous transitions into a set of states, which includes a quarter-metal, a half-metal and a three-quarter metal. We compare our results with the data for biased bilayer and tri-layer graphene. With Z. Raines (UMN) and L. Glazman (Yale).

**Thermodynamic measurements across a uniaxial-pressure-tuned Lifshitz transition in $Sr_2RuO_4$** 17:15 – 17:45

Hilary Noad, MPI CPfS, Germany

$Sr_2RuO_4$ hosts a clean, two-dimensional Fermi liquid that is highly tunable with uniaxial pressure. Notably, a Van Hove singularity, which lies 14 meV above the Fermi level at ambient pressure, can be brought to the Fermi level by applying pressure along the <100> direction of the crystal. Compressed further, the Fermi surface undergoes a Lifshitz transition, and a magnetically ordered phase emerges at even higher compression. Together, these features make $Sr_2RuO_4$ an attractive system in which to study the physics of Lifshitz transitions, but the experimental conditions necessary to access the transition are incompatible with traditional thermodynamic measurements. With our ongoing development of thermodynamic probes compatible with uniaxial pressure tuning, it has become possible to study the low-temperature phase diagram of $Sr_2RuO_4$ across the Lifshitz transition in detail. I will discuss some of our recent results, including measurements of the stress-strain relation that reveal a strong coupling between the conduction electron system and the lattice at the Lifshitz transition, as well as measurements of the elastocaloric effect.

**Interactions across momentum space in $Sr_2RuO_4$** 18:15 – 18:45

Clifford Hicks, University of Birmingham, UK

Through application of uniaxial stress, a Lifshitz point that lies close to the Fermi level in unstressed $Sr_2RuO_4$ can be tuned to the Fermi level. Experimental data has provided information on how this tuning affects the electronic structure in the rest of k-space. Through angle-resolved photoemission data, it is seen that Fermi velocities far from the Lifshitz point are not strongly affected. Through Hall effect data, there is evidence that when $Sr_2RuO_4$ is tuned well beyond this Lifshitz transition, the rate of electron-electron scattering on one Fermi surface falls dramatically. Penetration depth data indicate that tuning to the Lifshitz transition magnifies the superconducting gap throughout the Brillouin zone. In this talk, these data will be discussed.

**Flat-band-mediated surface ferromagnetism in $PdCoO_2$** 18:45 – 19:15

Phil King, University of St. Andrews, UK

The ABO2 family of delafossite oxides host a rich array of materials properties, ranging from ultra-high conductivity to unconventional magnetism.[1,2] Here, I will discuss our microscopic-area angle-resolved photoemission (μ-ARPES) studies of the surface electronic structure of $PdCoO_2$, with a particular focus on the Pd-terminated surface. I will show how a self-doping at this polar surface[3,4] moves a flat band to the Fermi level. I will demonstrate how this, in turn, triggers a Stoner-like instability to surface ferromagnetism,[4,5] and will discuss our spectral signatures of a polaronic coupling of the resulting surface states.[6] I will further show how this can be substantially tuned by adsorption at the surface, providing a powerful model environment in which to study magnetism in the 2D limit and how this can be tuned. Key collaborators on this work include Gesa Siemann and Federico Mazzola (St Andrews), Veronika Sunko (St Andrews and Max-Planck Institute for Chemical Physics of Solids, Dresden), and Seunghyum Khim, Helge Rosner, and Andy Mackenzie (MPI-CPFS).

[1] Ok {\it et al.}, Phys. Rev. Lett. 111, 176405 (2013).
[2] Mackenzie, Rep. Prog. Phys. 80, 032501 (2017).
[3] Sunko {\it et al.}, Nature 549, 492 (2017).
[4] Mazzola {\it et al.}, PNAS 115, 12956 (2018).
[5] Mazzola {\it et al.}, npj Quantum Materials 7, 20 (2022).
[6] Siemann {\it et al.}, in preparation.

**Low energy electronic structure in strontium ruthenates: interplay of surface distortions with Van Hove singularities** 19:15 – 19:45

Peter Wahl, University of St. Andrews, UK

The phenomenology and radical changes seen in materials properties traversing a quantum phase transition has captivated condensed matter research over the past decades. Strong electronic correlations lead to novel ground states, including magnetic order, nematicity and unconventional superconductivity. In many cases these are driven or accompanied by Lifshitz transitions. I will present spectroscopic imaging of the electronic structure of strontium ruthenates performed at temperatures down to 100mK[1] and in vector-magnetic fields, and discuss the implications for the low energy electronic structure. Notably, for several of the strontium ruthenates the surface provides a platform to study the properties of the electronic structure under conditions not accessible in the bulk.[2,3] Comparison of the experimental data with continuum local density of states calculations enables us to identify microscopic models that explain some of the macroscopic properties of the materials.[4] I will further discuss how the electronic instabilities in the surface layer are affected by the subtle changes in the electronic structure.

[1] C.A. Marques et al., Atomic-scale imaging of emergent order at a magnetic-field-induced Lifshitz transition, Sci. Adv. 8, eabo7757 (2022).
[2] A. Kreisel et al., Quasiparticle Interference of the van-Hove singularity in Sr2RuO4, npj Quantum Materials 6, 100 (2021).
[3] C.A. Marques et al., Magnetic-Field Tunable Intertwined Checkerboard Charge Order and Nematicity in the Surface Layer of Sr2RuO4. Adv. Mat. 33, 2100593 (2021).
[4] M. Naritsuka et al., Compass-like manipulation of electronic nematicity in Sr3Ru2O7, Proc. Nat. Acad. Sci. 120, e2308972120 (2023).

**Impact of high order of van Hove singularities on the competition of charge and spin degrees of freedom** 19:45 – 20:15

Dmitri Efremov, IFW Dresden, Germany

In addition to the usual Van Hove singularities, there are higher-order Van Hove singularities (HOVHS) with DOS divergence according to the power law. They affect different types of ordering in quantum materials. We find that the spin wave density and charge density of the phase formation can be enhanced by the presence of a singularity depending on the strength of certain interactions, with the critical temperature increasing by orders of magnitude. We discuss the application of our findings to various experimental systems such as $Sr_3Ru_2O_7$.

**Flatbands: construction and effects of perturbations** 11:30 – 12:30

Alexei Andreanov, IBS PCS

Flatbands are dispersionless single particle bands.
The quenched kinetic energy (due to the absence of dispersion), makes them promising hosts for unconventional and exotic phases of matter in presence of perturbations, like disorder or interactions.
I am going to discuss how flatbands can be constructed in various tight-binding settings and how their properties change in presence of disorder or interactions.
I will discuss in particular, the emergence of non-perturbative metal-insulator transitions and ergodicity breaking: many-body localisation and many-body flatband localisation (with connections to percolation transitions), as well as weak ergodicity breaking.

**Exploring Moiré 2D Materials and Topological Quasicrystals** 15:00 – 16:00

Mikito Koshino, Osaka University, Japan

When distinct 2D materials with varying periodicities are overlaid, a moiré interference pattern emerging from lattice mismatches leads to exceptional electronic properties. This phenomenon is prominently observed in twisted bilayer graphene (TBG), where an moiré pattern gives rise to intriguing flat bands and associated correlated phenomena. In this tutorial talk, I will present a theoretical perspective on moiré materials and the emergent behaviors. I start with an introduction to the fundamental long-range continuum model, a essential tool to describe the electronic characteristics of representative moiré systems, including TBG, graphene/hBN superlattices, twisted topological insulators.
The latter segment of the talk focuses on recent theoretical works on moiré systems beyond TBG.
Particularly, emphasis is placed on trilayer systems,where interference among multiple moiré patterns results in quasiperiodic nature. A fascinating example is the twist-angle-dependent electronic spectrum, which exhibits fractal minigaps akin to the Hofstadter butterfly. These minigaps possess distinct topological numbers, which can be expressed as second Chern numbers through a formal connection with the quantum Hall effect in four-dimensional space.

**Quasicrystalline resonant states and nonlinear Landau fan diagram in van der Waals superlattices** 11:30 – 12:30

Pilkyung Moon, New York University Shanghai, China

When two atomic lattices are superimposed in an incommensurate configuration, the interlayer interaction generates an extra order along the in-plane direction in the form of a moiré interference pattern. In this talk we discuss two unique states of the electrons subjected to the potentials of such an extra order.

We first show the emergence of quasicrystalline resonant states in dodecagonal and octagonal van der Waals quasicrystals as long as all dominant interlayer interactions occur between atomic orbitals having the same magnetic quantum number [1]. We present a theoretical model that can accurately calculate the electronic structures of such non-periodic systems without introducing any non-physical assumptions [2]. In addition, we discuss the geometry of van der Waals quasicrystals and show that the existence of the "precise center", which exhibits the highest rotational symmetry, is not guaranteed in these systems due to the difference in cardinality between the sets of integers and real numbers [3].

We then report conductance oscillations in graphene electrons exposed to moiré potentials that deviate from the linear Landau fan diagram [4]. And we explain that such anomalous behavior is due to the coexistence of multiple orbits resulting from the simultaneous occupation of multiple minibands and magnetic breakdown. We then propose a novel method to extract the spectral gaps without measuring the activation energy or carrying out tunneling spectroscopy, by using the density of states of the open orbits as a measure. This method is quite general, so it can be applied to any multiband system.

[1] J. A. Crosse and P. Moon†, Phys. Rev. B 103, 045408 (2021).
[2] P. Moon†, M. Koshino, Y.-W. Son, Phys. Rev. B 99, 165430 (2019).
[3] P. Moon, Phys. Rev. B 104, 115407 (2021).
[4] P. Moon†, Y. Kim, M. Koshino†, T. Taniguchi, K. Watanabe, J. H. Smet†, Nano Lett. 24, 3339 (2024).

**Interplay between stacking orders, interlayer interactions and nonlocal Coulomb interaction in twisted layered systems** 15:00 – 16:00

Young Woo Son, KIAS, Korea

Layered two-dimensional crystals have provided unprecedented platforms to study interesting physics intertwined with dimensional effects, anisotropic interlayer interactions, lattice geometries and Coulomb interactions. Typically, when one 2D crystal is overlaid on top of the others with rotational stacking faults, the systems display various distinct electronic and structural properties as functions of twist angles. In this talk, I will present theoretical and computational studies on nontrivial effects originated from interlayer interactions and nonlocal Coulomb interactions in twisted bi- and tri-layer graphene systems. Specifically, I will discuss critical effects of nonlocal Coulomb interactions in altering free energy landscape of twisted bilayer graphene and will present pivotal roles of long-ranged interlayer interactions in realizing nontrivial phase transitions in twisted trilayer graphene, respectively.

**Fine-tuning and detuning flat bands** 11:30 – 12:30

Carlo Danieli, ISC-CNR, Italy

Flat band networks are translationally invariant lattices which exhibit at least one dispersionless band in their Bloch spectrum, and host compact localized eigenstates with nonzero amplitudes restricted to a finite volume. These macroscopic degeneracies are typically sensitive to perturbations, which makes them natural candidates for emerging exotic and unconventional phases. One of the challenging part is to construct flat band networks, whose existence relies on symmetries and fine-tuning. In this talk we discuss recently proposed systematic schemes to fine-tune flat bands. We then discuss how the fine-tuning constructions can be further extended and adapted or exploited in presence of perturbations. We will in particular focus in the interacting case, where this strategy has lead to the discovery of compact breathers, nonlinear and quantum caging and many-body nonergodic quantum regimes.

**Quantum engineering for compactly localized states in disordered Lieb lattices** 15:00 – 16:00

Rudolf Roemer, University of Warwick, UK

Blending ordering within an uncorrelated disorder potential in families of 3D Lieb lattices preserves the macroscopic degeneracy of compact localized states and yields unconventional combinations of localized and delocalized phases -- as shown in Phys.Rev.B 106, 214204 (2022). We proceed to reintroduce translation invariance in the system by further ordering the disorder, and discuss the spectral structure and eigenstates features of the resulting perturbed lattices. We restore order in steps by first (i) rendering the disorder binary -- i.e. yielding a randomized checkerboard potential, then (ii) reordering the randomized checkerboard into an ordered one, and at last (iii) realigning all the checkerboard values yielding a constant potential shift, but only on a sub-lattice. Along this path, we test the influence of additional random impurities on the order restoration. We find that in each of these steps, sub-families of states are projected upon the location of the degenerate compact states, while the complementary ones are localized in the perturbed sites with energy determined by the strength of checkerboard. This strategy, herewith implemented in the 3D Lieb models, highlights order restoration as experimental pathway to engineer spectral and states features in disordered lattice structures in the pursuit of quantum storage and memory applications.

**Introduction to the Quantum Metric** 11:30 – 12:30

Tomoki Ozawa, Tohoku University, Japan

In this tutorial talk, I will give an introduction to the concept of quantum metric. Quantum metric assigns “distance” in a parameter space on which quantum states are defined. For example, according to the Bloch theorem, eigenstates of a particle moving in a periodic potential are labeled by a band index and a quasi-momentum. From the Bloch states one can then define the quantum metric, which introduces the measure of distance in (quasi-)momentum space. In recent years, there has been a significant progress in the understanding of physical manifestation/implication of the quantum metric. Effects of the quantum metric are often prominent in flat band systems. Starting from the definition and characterization of the quantum metric, I will review recent theoretical and experimental progress of the study of the quantum metric.

**Non-reciprocal quantum matter: quantum geometry and Kramers degeneracy** 14:00 – 15:00

Justin Song, Nanyang Technological University, Singapore

Non-reciprocity (differentiated forward and backward flows of electrons in quantum matter) are often effected by an applied magnetic field. I will describe a different, field-free, and “non-classical” paradigm that exploits the intricate winding of electronic wavefunctions in quantum materials (captured by topology and quantum geometry). I will highlight how quantum geometry enables to realize a range of non-reciprocal phenomena in both the linear regime (e.g., non-reciprocal collective modes such as plasmons) and nonlinear regime (e.g., nonlinearities that depend on the presence of Kramers degeneracy in PT antiferromagnets). If time permits, I will also discuss the regime when nonlinearities are pushed to an extreme limit. In such a regime, nonlinearities can enable self-sustained phases with properties markedly different from that in equilibrium. To that end, I will introduce an unusual type of out-of-equilibrium "layer electric phase" in layered matter such as centrosymmetric multilayer graphene. I will discuss how nonequilibrium photoexcitation can transform dielectric screening in multilayer graphene into anti-screening (polarization amplifies electric fields), overscreening (polarization inverts electric fields), as well as ferro-electric like polarizations that persist even without applied fields. Such phases can provide on demand means of controlling electric polarization in layered materials and are an example of how nonlinearities can be used for out-of-equilibrium dynamical quantum matter.

* This work was funded by Singapore MOE Academic Research Fund Tier 2 Grant MOE-T2EP50222-0011 and Singapore MOE Academic Research Fund Tier 3 Grant MOE2018-T3-1-002

**Electrical Breakdown of Excitonic Insulators** 16:00 – 17:00

Xi Dai, HKUST, Hong Kong

In this paper, we propose a new electrical breakdown mechanism for exciton insulators in the BCS limit, which differs fundamentally from the Zener breakdown mechanism observed in traditional band insulators. Our new mechanism results from the instability of the many-body ground state for exciton condensation, caused by the strong competition between the polarization and condensation energies in the presence of an electric field. We refer to this mechanism as "many-body breakdown". To investigate this new mechanism, we propose a BCS-type trial wave function under finite electric fields and use it to study the many-body breakdown numerically. Our results reveal two different types of electric breakdown behavior. If the system size is larger than a critical value, the Zener tunnelling process is first turned on when an electrical field is applied, but the excitonic gap remains until the field strength reaches the critical value of the many-body breakdown, after which the excitonic gap disappears and the system becomes a highly conductive metallic state. However, if the system size is much smaller than the critical value, the intermediate tunnelling phase disappears since the many-body breakdown happens before the onset of Zener tunnelling. The sudden disappearance of the local gap leads to an "off-on" feature in the current-voltage ($I - V$) curve, providing a straightforward way to distinguish excitonic insulators from normal insulators.

# Posters

[1] **Moiré Fractals in Twistronics and Their Behavior Under Strain**
Deepanshu Aggarwal, Indian Institute of Technology Delhi, India

[2] **Flat Bands in Three-dimensional Lattice Models with Non-trivial Hopf Index**
Ivan Dutta, National Institute of Science Education and Research, India

[3] **Quantum Valley Hall Effect Without Berry Curvature**
Rasoul Ghadimi, Seoul National University, Korea

[4] **Quantum Geometric Bound for Saturated Ferromagnetism**
Junha Kang, Seoul National University, Korea

[5] **Quantum Geometry and Landau Levels of Quadratic Band Crossings**
Junseo Jung, Seoul National University, Korea

[6] **Measurement of the Complete Quantum Metric Tensor in Solids**
Sunje Kim, Seoul National University, Korea

[7] **Construction of Scanning Tunneling Microscope for Two-Dimensional van der Waals Devices**
Taeho Kim, IBS, Center for Van der Waals Quantum Solids, Korea

[8] **TBA**
Jaebeom Lee, Chungnam National University, Korea

[9] **Fermi Surface Spin Texture and Topological Superconductivity in Spin-Orbit Free Non-Collinear Antiferromagnets**
Seung Hun Lee, Seoul National University, Korea

[10] **Quantum Engineering for Compactly Localized States in Disordered Lieb Lattices**
Jie Liu, Central South University of Forestry and Technology, China

**[11] Emergent Superconductivity and Competing Charge Orders in Hole-Doped Square-Lattice t-J Model**
Xin Lu, Beihang University, China

**[12] Quantum Valley and Subvalley Hall Effect in Large-Angle Twisted Bilayer Graphene**
Chiranjit Mondal, Seoul National University, Korea

**[13] Density of States Singularities and Compact Localized States in Multifractal Networks**
Oleg Utesov, IBS PCS

**[14] Modified Bloch Theory of Topological Phases in Presence of Local/Global Deformations**
Sonu Verma, IBS PCS

**[15] Strain-Induced Pseudo-Landau Levels Beyond Graphene**
Junsong Sun, Beihang University, China

**[16] TBA**
Rudolf Roemer, University of Warwick, UK

# Participants (Daejeon node)

*Scientific Coordinators:*

| | |
|---|---|
| Sergej Flach | sergejflach@googlemail.com |
| Bohm-Jung Yang | bjyang@snu.ac.kr |

*Participants:*

| | |
|---|---|
| Deepanshu Aggarwal | daggarwal305@gmail.com |
| Alexei Andreanov | aalexei@ibs.re.kr |
| Chanbin Bark | qkrcksqls135@naver.com |
| Budhaditya Bhattacharjee | budhadityab@ibs.re.kr |
| Gil Young Cho | gilyoungcho@gmail.com |
| Hongchul Choi | chhchl@gmail.com |
| Xi Dai | daix@ust.hk |
| Carlo Danieli | peldicarotadaywalker@gmail.com |
| Barbara Dietz | barbara@ibs.re.kr |
| Ivan Dutta | ivan.dutta@niser.ac.in |
| Haru Ew | physics04221b@snu.ac.kr |
| Rasoul Ghadimi | ghadimi.rasoul@gmail.com |
| Jun Ha Kang | portmoody2@snu.ac.kr |
| Sang Jin Sin | sangjin.sin@gmail.com |
| Jeil Jung | jeil.jung@gmail.com |
| Junseo Jung | jungjunseo46@snu.ac.kr |
| Doh-Young Kim | princedy97@snu.ac.kr |

# Participants (cd.)

| | |
|---|---|
| Hanbyul Kim | khbof@hanyang.ac.kr |
| Jiwon Kim | rhkgkr159753@snu.ac.kr |
| Sunje Kim | sjhs0317@snu.ac.kr |
| Taeho Kim | kthppp@ibs.re.kr |
| Shingo Kobayashi | shingo.kobayashi@riken.jp |
| Mikito Koshino | mikito.koshino@gmail.com |
| Kam Tuen Law | phlaw@ust.hk |
| Jaebeom Lee | nanoleelab@cnu.ac.kr |
| Seokju Lee | lshlsj0828@snu.ac.kr |
| Seonjun Lee | rayleej@snu.ac.kr |
| Seung Hun Lee | sh2lee@snu.ac.kr |
| Hyeongmuk Lim | ihm5024@snu.ac.kr |
| Jie Liu | liujie940228@163.com |
| Xin Lu | hsinlu.tcmp@gmail.com |
| Chiranjit Mondal | nilcm90@gmail.com |
| Pilkyung Moon | pilkyung.moon@nyu.edu |
| Richard Moore | peaceb@ibs.re.kr |
| Myungchul Oh | myungchul@postech.ac.kr |
| Tomoki Ozawa | tomoki.ozawa.d8@tohoku.ac.jp |
| Moon Jip Park | moonjippark@gmail.com |
| Sunghun Park | sunghun.park@ibs.re.kr |
| Yuting Qian | qianyuting16@gmail.com |
| Rohit Kishan Ray | rkray@ibs.re.kr |

# Participants (cd.)

| | |
|---|---|
| Jun-Won Rhim | jwrhim@ajou.ac.kr |
| Rudolf Roemer | r.roemer@warwick.ac.uk |
| Jung-Wan Ryu | jungwanryu@gmail.com |
| Dongbin Shin | dshin@gist.ac.kr |
| Young Woo Son | hand@kias.re.kr |
| Justin Song | justinsong@ntu.edu.sg |
| Junsong Sun | sunjs@buaa.edu.cn |
| Oleg Utesov | utiosov@gmail.com |
| Sonu Verma | sonu.vermaiitk@gmail.com |
| Youichi Yanase | yanase@scphys.kyoto-u.ac.jp |
| Bo Yang | yang.bo@ntu.edu.sg |
| Cheol Hun Yeom | drhunny1@gmail.com |

pcs Center for Theoretical Physics of Complex Systems

ibs Institute for Basic Science

Center for Theoretical Physics of Complex Systems
Institute for Basic Science (IBS), Theory Bldg, 3. floor
Expo-ro 55, Yuseong-gu, Daejeon 34126
Tel: +82 42 878 8633 (29)
pcs@ibs.re.kr http://pcs.ibs.re.kr