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Technische
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ECRFB26

Early Career Researchers on Flat Bands 2026

July 1-3 2026, JMU Würzburg

Program

WEDNESDAY, JULY 1

08.00-08.45	**Registration**	
08.45-09.00	**Opening Remarks**	**M. Crispino, F. Paoletti, and N. Witt** **JMU Würzburg**
	Session 1 – Moiré Materials (I)	**Chair: D. Călugăru**
09.00-09.50	*Probing correlated electronic states in graphene by thermodynamic measurements*	Fangyuan Yang TU Wien
09.50-10.10	*Observation and Control of Moiré-Tailored Topological Dirac States*	Romana Ganser JMU Würzburg
10.10-10.30	*Unifying description of competing chiral and nematic superconducting states in twisted bilayer graphene*	Luca Baldo Mesa Casa University of Uppsala
	Coffee Break	
	Session 2 – Correlations and Methods (I)	**Chair: F. Paoletti**
11.00-11.50	*From Superconductivity to Fractionalization in Flat Chern Bands*	Daniele Guerci MIT (REMOTE)
11.50-12.10	*Band structure picture for topology in strongly correlated systems with the ghost Gutzwiller ansatz*	Ivan Pasqua SISSA
12.10-12.30	*Incommensurate moiré stacking and pseudomagnetic field in turbostratic graphene*	Mona Mona Charles University Prague
12.30-13.45	**Lunch**	

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Complexity, Topology and Dynamics in Quantum Matter

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WEDNESDAY, JULY 1

	Session 3 – Topological Heterostructures	**Chair: M. Tanaka**
14.00-14.50	*Robust Orbital-Selective Flat Bands in Layered Transition-Metal Oxyhalides at Room Temperature*	Xiangyu Luo Princeton University (REMOTE)
14.50-15.10	*Switchable Chern number in van der Waals heterostructures*	Amarjyoti Choudhury University of Modena
15.10-15.30	*Engineering superconductivity on the surface of Weyl semimetals via van Hove singularities*	Mattia Trama University of Salerno
	Coffee Break	
	Session 4 – Emergent Phenomena in Flat Bands	**Chair: L. Klebl**
16.00-16.20	*Interaction-induced altermagnetism in flat bands*	Maksim Ulybyshev JMU Würzburg
16.20-16.40	*Surfaces reconstructions: an intrinsic landscape toward nearly-flat bands*	Mattia Iannetti University of L'Aquila
16.40-17.00	*Thermoelectric properties of nodal-line semimetals thin slabs*	Francesco Buccheri IFW Dresden
17.00-17.20	*Dispersion of Anyon Bloch Bands*	Kishore Iyer CNRS, Laboratoire MPQ, Paris
	Free time	
18.30-…	**Poster Session + Buffet**	

THURSDAY, JULY 2

	Session 5 – Moiré Materials (II)	**Chair: F. Yang**
09.00-09.50	*M-point moiré materials: emergent symmetries, strong correlations, and sign-problem-free Quantum Monte Carlo*	Dumitru Călugăru University of Oxford
09.50-10.10	*Hidden antiferromagnetism, persistent valley fluctuations, and U(6) crossovers in triangular lattice M-point moiré materials via determinantal QMC*	Konstantinos Vasiliou University of Oxford
10.10-10.30	*Extended s-wave superconductivity in M-point twisted bilayer $SnSe_2$*	Lennart Klebl JMU Würzburg
	Coffee Break	
	Session 6 – Quantum Geometry	**Chair: N. Witt**
11.00-11.50	*Inductance and capacitance in van der Waals materials*	Miuko Tanaka University of Tokyo
11.50-12.10	*Interplay of local and global quantum geometry in the stability of flat-band superfluids*	Matteo Dürrnagel JMU Würzburg and ETH Zürich
12.10-12.30	*Quantum geometry of a one-dimensional quasicrystal*	Quentin Marsal University of Uppsala
12.30-13.45	**Lunch**	
	Free time + Transportantion to the city center	
14.30-15.30	**Round Table – Meet the Invited Speakers**	
16.00-18.00	**City Tour**	
18.30-…	**Conference Dinner**	

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FRIDAY, JULY 3

	Session 7 – Kagome Materials	**Chair: M. Crispino**
09.00-09.50	*Pressure Tuning of Electronic Correlations and Flat Bands in $CsCr_3Sb_5$*	Maria Chatzieleftheriou Ecole Polytechnique
09.50-10.10	*Correlation effects in a breathing kagome lattice: insights from Fe_3Sn*	Shivalika Sharma KENTECH
10.10-10.30	*Emergence of the MISOH Effect in Ti-Based Kagome Metal*	Luciano J. D'Onofrio CNR-SPIN
10.30-10.50	*Experimental Realization of an Acoustic Kagome-Model Simulator*	Louis Müller JMU Würzburg
	Coffee Break	
	Session 8 – Correlations and Methods (II)	**Chair: M. Chatzieleftheriou**
11.20-11.40	*Comprehensive fluctuating field theory study of magnetic instabilities in the Hubbard model*	Erik Linnér SISSA
11.40-12.00	*Universal relation between residual resistivity and A coefficient in correlated metals*	Anna Efimova University of Geneva
12.00-12.20	*Second-order self-energy of the 2D Hubbard model: high-precision low-frequency asymptotics*	Oleksandr Sulyma University of Cologne
12.20-12.40	**Final Remarks**	
12.40-14.00	**Lunch**	
	Departure	

Abstracts

Session 1 – MOIRÉ MATERIALS (I)

Invited Talk

Probing correlated electronic states in graphene by thermodynamic measurements

Fangyuan Yang

TU Wien

Moiré van der Waals (vdW) materials have become an active playground for investigating strongly correlated electrons due to the realization of narrow electronic bands. In this talk, I will first discuss how to realize narrow electronic bands in graphene moiré heterostructures by engineering artificial stacking orders. Rich phase diagrams with various magnetic, topological, and superconducting states have been observed. Next, I will present a method for measuring thermodynamic quantities in vdW heterostructures that relies on electrostatic sensing. In magic-angle twisted bilayer graphene, we directly probe the chemical potential change in the flat band. Magnetization and entropy are further determined by using Maxwell relations. Our experiment reveals an isospin-Pomeranchuk effect in which an isospin-polarized state is stabilized as the temperature increases.

Observation and Control of Moiré-Tailored Topological Dirac States

Romana Ganser

JMU Würzburg

Moiré heterostructures offer a versatile platform for engineering electronic band structures by precise control over long-range superlattice potentials. These give rise to flat bands in the folded moiré band structure, quenching kinetic energy and thus increasing electron-correlation effects [1]. Moreover, moiré mini-bands can host emergent Dirac states, which may be accompanied by a so-called relativistic Mott transition [2]. Direct momentum-resolved evidence of these flat Dirac states, however, is challenging and has so far remained elusive. Here, we present angle-resolved photoemission spectroscopy (ARPES) measurements on a highly tunable, one-dimensional (1D) epitaxial moiré heterostructure [3]. We show that the electronic structure is strongly altered by the moiré superlattice hosting replica bands and sizable hybridization gaps. From our experimental data, we can trace back to the local, spatially-varying interlayer coupling, shaping the moiré potential. The latter leads to a 1D confinement of the electrons and, interestingly, also gives rise to Dirac nodal lines, which are robustly protected by the superlattice symmetry.

[1] Balents, L. et al. Superconductivity and strong correlations in moir´e flat bands. Nat. Phys. 16, 725-733 (2020).

[2] Ma, L. et al. Relativistic Mott transition in twisted WSe_2 tetralayers. Nat. Mater. 24, 1935–1941 (2025).

[3] Ganser, R., Masilamani, M. P. T. et. al. Observation and Control of Moir´e-Tailored Topological Dirac States. (2026). https://arxiv.org/pdf/2604.25598.

Unifying description of competing chiral and nematic superconducting states in twisted bilayer graphene

Lucas Baldo Mesa Casa

University of Uppsala

The pairing symmetry and microscopic mechanism of superconductivity in twisted bilayer graphene remain open questions, with both phonon-mediated and purely electronic scenarios proposed. Intriguingly, both types of models exhibit similar phenomenology, with nematic order dominating in the flat-band regime in agreement with experimental observations. Using atomistic modeling combined with flat-band projection, we demonstrate that this common behavior arises because both scenarios share the same low-energy description, namely inter-valley, intra-Chern pairing. Within this unified framework, the competition between nematic and chiral superconducting states is naturally understood: while nematic order is locally favored in momentum space, incompatible optimal orientations across the Brillouin zone generate frustration. This momentum-space frustration stabilizes a chiral superconducting state at large fillings or weak interactions, despite the energetic cost associated with unpaired flat bands in the extreme Chern-polarized limit. This provides a microscopic explanation for when and why nematicity is overcome by chiral superconductivity, reconciling apparent discrepancies in the literature. Our results establish that, while phonon-mediated and electron-driven mechanisms are often seen as competing, they naturally cooperate in twisted bilayer graphene.

Session 2 – CORRELATIONS AND METHODS (I)

Invited Talk

From Superconductivity to Fractionalization in Flat Chern Bands

Daniele Guerci

MIT

Strong interactions in quantum materials can cause electrons to organize collectively, giving rise to new states of matter with unusual properties. In this talk, I connect two of the most striking collective phenomena in quantum physics: electron pairing in superconductors and the emergence of fractionalized excitations in quantum Hall systems.

I show how interactions can bind electrons into pairs, but can also lead to the opposite effect, where collective quantum behavior produces excitations that carry only a fraction of the electron's charge, known as anyons. Using van der Waals heterostructures as concrete examples, I illustrate how these phenomena can coexist, opening new directions for designing quantum materials and quantum technologies.

Band structure picture for topology in strongly correlated systems with the ghost Gutzwiller ansatz

Ivan Pasqua

SISSA

Flat-band systems provide a natural setting in which electronic interactions, quantum geometry, and topology become deeply intertwined, calling for theoretical tools that preserve the intuition of band theory while capturing non-perturbative correlation effects. In this talk, I will present a ghost-Gutzwiller (gGut) approach that addresses this challenge by introducing auxiliary quasiparticle degrees of freedom, yielding an effective band-structure description of correlated systems which provides direct access to energy- and momentum-resolved topological features. Applied to the interacting Bernevig-Hughes-Zhang model, gGut reproduces established benchmarks for correlation-driven topological transitions, while offering an interpretable quasiparticle picture. Furthermore, gGut unveils previously inaccessible aspects, most notably the emergence of topologically nontrivial Hubbard bands hosting their own edge states, as well as possible ways to manipulate these through a finite magnetization, leading to spin-dependent Chern features [1]. I will conclude by outlining our latest results on how the framework can be extended to include nonlocal interactions beyond mean field, providing a variational route to unconventional superconductivity and pseudogap physics [2].

[1] IP, A. Tagliente, G. Bellomia, B. Monserrat, M. Fabrizio, and C. Mejuto-Zaera, arXiv:2507.10670 (to appear in PRB).
[2] IP, C. Mejuto-Zaera, and M. Fabrizio, in preparation.

Incommensurate Moiré stacking and Pseudomagnetic field in turbostratic graphene

Mona Mona

Charles University Prague

In this contribution, I will discuss ultra-low temperature scanning tunneling microscopy and spectroscopy investigating of diverse landscape of stacking twist angles with varying degrees of electronic coupling, characterized by distinct Moiré patterns in turbostratic multilayer graphene on metallic foil.
In several regions, overlapping incommensurate moir´e patterns consistent with locally chiral trilayer stacking, are also identified. The local density of states and electronic properties are found to be in remarkable correlation with the local twist angle. Such films also spontaneously form wrinkles during growth with varying degrees of strain. In certain strained regions, robust signatures of a strain-induced pseudo-magnetic field of varying strength are obtained, through the observation of pseudo-Landau levels.
These findings demonstrate that turbostratic graphene, typically considered electronically decoupled, hosts spatially resolved, coherent low-energy electronic states shaped by interlayer twist alignments, incommensurability and strain fields. This presents turbostratic multilayers as a naturally disordered, yet theoretically rich, setting for exploring Moiré-driven emergent physics.

Invited Talk

Robust Orbital-Selective Flat Bands in Layered Transition-Metal Oxyhalides at Room Temperature

Xiangyu Luo

Princeton University

The quest for robust and tunable flat electronic bands is a central theme in modern condensed matter physics. While traditional strategies rely on geometrical frustration or moiré engineering, they often suffer from significant limitations. This report explores a newly discovered materials-by-design platform: the layered transition-metal oxyhalide family (MOX2). Throughout this talk, I will highlight the direct ARPES observation of room-temperature flat bands in these materials, emphasizing their exceptional stability from bulk down to the few-layer limit. A key focus of the presentation will be unpacking the unique orbital-driven ”SSH-Lieb” mechanism that generates these bands. By demonstrating how the bandwidth and Fermi level can be systematically tuned via chemical and electronic control, this presentation aims to show why MOX2 represents a robust and versatile new pathway for exploring room-temperature flat-band physics.

Switchable Chern number in van der Waals heterostructures

Amarjyoti Choudhury

University of Modena and Reggio Emilia

Despite the huge expansion in the family of 2D materials, Chern insulators remain rare, with most monolayers being topologically trivial. However, stacking such trivial materials into van der Waals heterostructures offers vast opportunities for emergent topological phases. Here we show how to engineer topological heterostructures from trivial layers and control their Chern number via an external magnetic field. The key is combining ferromagnetic monolayers–whose valence band edge depends on magnetization direction–with trivial semiconductors having suit- able band alignment. This can induce a band inversion and a topological transition–for one magnetization orientation but not the other, enabling field-tunable topological order. The theoretical scenario is validated through accurate first-principles simulations by screening 2D databases for realistic materials platforms.

Engineering superconductivity on the surface of Weyl semimetals via van Hove singularities

Mattia Trama

University of Salerno

Ten years after the experimental discovery of Weyl semimetals, theoretical and experimental work has pointed to the possibility of realizing surface-only superconductivity at relatively high temperatures in these materials. A consensus is developing that this unusual form of superconductivity is mediated by surface electronic states unique to Weyl semimetals, known as Fermi arcs. In this work, we show that the topological protection of these exotic states can be exploited to engineer high critical temperatures. Motivated by a real-material example ($PtBi_2$), we demonstrate that surface van Hove singularities can be induced by depositing a suitable additional layer on top of the Weyl surface. We also investigate the role of these singularities in raising the critical temperature, showing that it is significantly enhanced when the chemical potential lies in their vicinity. More generally, our results demonstrate how topological protection can be exploited to manipulate surface electronic states, thereby opening experimentally accessible routes toward engineering high-temperature two-dimensional superconductivity and other exotic phases.

Interaction-induced altermagnetism in flat bands

Maksim Ulybyshev

JMU Würzburg

In this talk, I consider a flat-band system formed by adatoms deposited on top of a two dimensional Dirac semimetal. Strong repulsive Hubbard interaction leads to spin localization in the vicinity of the adatoms. I show that sufficiently strong interaction not only localizes the spins, but also generates an effective dispersion in the flat bands through double hopping processes. By varying the spatial arrangement of the adatoms, one can tune the resulting band dispersion and simultaneously control the magnetic ordering of the localized spins. In particular, if the spatial arrangement of adatoms breaks the rotational symmetry, one can stabilize antiferromagnetic order accompanied by spin-split electronic bands, resulting in an interaction-induced altermagnetic state. I discuss how such systems can be designed and present one specific realization studied using unbiased Quantum Monte Carlo simulations. I analyze both single-particle spectral functions and magnon spectral functions. The latter reveal qualitative differences between conventional altermagnets and the interaction-driven altermagnet considered here, originating from the fact that the spin-split bands emerge from interaction-induced higher-order hopping processes between localized flat band states.

Surfaces reconstructions: an intrinsic landscape toward nearly-flat bands

Mattia Iannetti

University of L'Aquila and CNR-SPIN L'Aquila

Adatoms on semiconductor surfaces provide a versatile platform for exploring low-dimensional electronic phenomena, where reduced dimensionality, electronic correlations, and substrate effects interplay in a highly non-trivial way. In particular, the combination of large adatom spacing and surface-induced reconstruction can lead to a substantial suppression of the electronic bandwidth, naturally promoting the emergence of flat-band regimes. We investigate adatom-based surface systems, including group IV adatoms on Si(111) and related structures, such as the Si(111)-7x7 reconstruction, as potential realizations of flat-band physics. We show how the geometrical arrangement of adatoms, together with the hybridization with the substrate, can be exploited to control the band dispersion and drive the system toward regimes of enhanced electronic localization and correlations.

Thermoelectric properties of nodal-line semimetals thin slabs Dispersion of Anyon Bloch Bands

Francesco Buccheri

IFW Dresden

Topological nodal-line semimetals host weakly dispersive protected surface states. In thin slabs, they hybridize into two-dimensional ”drum” bands. We study the thermoelectric transport properties of such states, computing the Seebeck and Nernst responses. We show that the system can achieve large figures of merit in the surface-dominated regime, opening the possibility to realize thermoelectric devices based on this family of materials.

Dispersion of Anyon Bloch Bands

Kishore Iyer

CNRS, Laboratoire MPQ, Paris

Fractional Chern insulators (FCIs) are zero magnetic field analogs of fractional quantum Hall states. While the electrons forming an FCI are not subject to an external magnetic field, their anyonic excitations experience a magnetic field with finite-flux due to a many-body Berry phase. The lattice periodicity of the latter generically induces some dispersion for anyons, even when the underlying electronic bands are flat.
From Laughlin wavefunctions at filling 1/m, we analytically construct single-anyon Bloch states in an ideal band, providing a basis to efficiently compute the dispersion. The anyon spectrum exhibits an m-fold degeneracy in the reduced magnetic Brillouin zone (BZ), which originates from the topological degeneracy of the FCI. From our wavefunctions, we derive the m2-fold degeneracy seen in previous works, showing it to be a splicing of anyon momenta into the electronic BZ. Finally, we find that the anyon dispersion bandwidth is controlled by quantum geometry non-uniformity, growing linearly at weak modulation and saturating at strong modulation. Remarkably, higher harmonics of the quantum geometry alone strongly suppress the dispersion, which we attribute to emergent magnetic translation symmetries.. When combined with the first harmonic, a positive (negative) second harmonic drives the system toward a second- (first-) harmonic-dominated regime, thereby reducing (enhancing) the bandwidth. Our results offer an analytically controlled method for evaluating anyon spectra in ideal band FCI, shedding light on how non-uniform quantum geometry and emergent symmetries shape the dispersion of anyons.

Session 5 – MOIRÉ MATERIALS (II)

Invited Talk

M-point moiré materials: emergent symmetries, strong correlations, and sign-problem-free Quantum Monte Carlo

Dumitru Călugăru

University of Oxford

When two monolayer materials are stacked with a relative twist, an emergent moiré translation symmetry arises, giving rise to electronic structures and correlation effects that are qualitatively distinct from those of the individual layers. Moiré materials have therefore become highly tunable platforms for exploring strongly correlated quantum matter. To date, however, most studies have focused on monolayers with triangular lattices whose low-energy electronic states reside near the Gamma or K points of the Brillouin zone.

In this talk, I introduce a new class of moiré systems based on monolayers with triangular lattices but low-energy states at the M points of the Brillouin zone. These so-called M-point moiré materials host three time-reversal-preserving valleys related by threefold rotational symmetry. I propose twisted bilayers of exfoliable 1T-$SnSe_2$ and 1T-ZrS_2 as experimentally viable realizations. Using extensive ab initio calculations, I identify twist angles that yield isolated flat conduction bands, construct accurate continuum models, and analyze their topology, charge density profiles, and emergent symmetries.

A defining feature of M-point moiré Hamiltonians is the emergence of momentum-space non-symmorphic symmetries. In particular, a non-symmorphic in-plane mirror symmetry renders certain materials effectively quasi-one-dimensional within each valley, suggesting a natural route toward realizing Luttinger-liquid physics in a two-dimensional moiré platform. I further explore the strong-coupling limit of twisted $SnSe_2$, where analytical solutions can be obtained at integer electron fillings and include dimerized phases with finite residual entropy, valence-bond solids, and quantum paramagnets.

Finally, I show that the same non-symmorphic in-plane mirror symmetry guarantees the absence of a sign problem in Quantum Monte Carlo simulations at any filling, enabling an unbiased investigation of interaction effects. Over broad and experimentally realistic ranges of twist angle and interaction strength,

these systems exhibit a rich phase diagram featuring correlated insulators at integer fillings —whose nature and strength depend sensitively on the twist angle— as well as Wigner–Mott insulating phases at selected commensurate fillings.

Hidden antiferromagnetism, persistent valley fluctuations, and U(6) crossovers in triangular lattice M-point moiré materials via determinantal quantum Monte Carlo

Konstantinos Vasiliou

University of Oxford

Moiré materials formed by twisting two-dimensional monolayers with low-energy states at the three M-points of the Brillouin zone provide a promising route to realizing multi-valley correlated electron physics. Continuum and ab initio studies indicate that their conduction bands are described by three-valley Hubbard models with valley-selective, quasi-one-dimensional hopping, while the on-site interaction is nearly U(6)-symmetric. Here we show that these systems admit sign-problem-free determinantal quantum Monte Carlo simulations at three electrons per moiré unit cell, corresponding to half filling of the six spin-valley flavors. We use this to study the emergence of Mottness across interaction strengths and U(6)-breaking anisotropies. For nearly isotropic interactions, relevant for platforms such as AA-stacked twisted $SnSe_2$, we find an extended intermediate-coupling regime where local moment formation coexists with itinerant electrons. This regime is naturally interpreted in terms of fluctuating U(6) local moments and is consistent with a slave-rotor picture in which the total charge rotor is coupled to neutral valley-fluctuation rotors. We further show that small anisotropies can strongly influence whether the system behaves as a metal or insulator, highlighting the sensitivity of the Mott crossover to deviations from the ideal U(6)-symmetric limit.

Extended s-wave superconductivity in M-point twisted bilayer $SnSe_2$

Lennart Klebl

JMU Würzburg

We investigate the emergence of electronic order and unconventional superconductivity in M-valley moiré materials at weak coupling. Starting from a first-principles Wannier model of AB-stacked twisted $SnSe_2$, we tackle the (gate-screened) long-ranged Coulomb interaction using unbiased functional renormalization group simulations that resolve the momentum structure and energy scales of the leading Fermi surface instabilities. We find that upon doping an antiferromagnetic stripe state at half-filling (ν=3 electrons per moiré unit cell) of the moiré flat bands, magnetic order gives way to unconventional superconductivity mediated by valley-selective spin fluctuations: electron doping stabilizes a spin-singlet, extended s-wave state that benefits from scattering between virtual particle and hole states that are detuned from the Fermi level, whereas hole doping favors spin-triplet, p-wave pairing. These findings establish M-point moir´e materials as a quantum simulation platform with phenomenological parallels to the class of iron pnictide superconductors, though they are set apart from each other by the strong intravalley character and reduced dimensionality unique to the M-twisted systems.

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Session 6 – QUANTUM GEOMETRY

Invited Talk

Inductance and capacitance in van der Waals materials

Miuko Tanaka

University of Tokyo

Atomically thin van der Waals materials, such as graphene, possess a unique ability to precisely control a wide range of parameters—such as stacking with dissimilar materials and gate-voltage tunability—making them one of the ideal model systems for research in condensed-matter physics. However, owing to their extremely small volume, available measurement techniques are limited, and previous studies have largely focused on electrical transport and visible-light optical measurements. In some systems, however, electrical resistance is not necessarily an information-rich physical quantity. For example, in superconductors the resistance becomes zero regardless of microscopic details, while in insulators the resistance is often too large to be measured reliably.

For superconductors, inductance, and for insulators, capacitance (dielectric permittivity), remain finite physical quantities that directly reflect intraband electronic responses. Nevertheless, these properties have either been difficult to measure in atomically thin materials or have not received sufficient attention to date.

In this talk, I present our recent studies on inductance and capacitance measurements in atomically thin materials and provide an overview of emerging measurement methodologies for nanomaterials. Specifically, for superconductors, we have developed an inductance measurement technique applicable to samples only a few atomic layers thick, and we report the first direct observation of an enhancement of superfluid stiffness arising from quantum-geometric effects in twisted bilayer graphene. For insulating systems, we introduce quantitative evaluations of magnetoelectric coupling based on the dielectric response of atomically thin multiferroic materials, as well as observations of magnetic dynamics in atomically thin magnets using high-frequency measurements.

Interplay of local and global quantum geometry in the stability of flat-band superfluids

Matteo Dürrnagel

JMU Würzburg and ETH Zürich

Quantum geometry strongly impacts physical properties in flat-band systems. We consider its role in bosonic condensation and superfluidity on flat bands, and show that the superfluid weight has an important contribution proportional to the condensate quantum metric at the condensation momentum. Based on this result, we uncover conditions under which flat-band superfluidity is unlikely. For instance, we find that stable flat-band superfluidity in a two-dimensional system requires at least three bands within Bogoliubov theory. Because the quantum geometry at the condensation momentum plays a disproportionately large role, a large integrated quantum metric is not sufficient for flat-band superfluidity, but how the quantum metric is distributed in the Brillouin zone is crucial.

Quantum geometry of a one-dimensional quasicrystal

Quentin Marsal

University of Uppsala

The atomic structure of quasicrystals, long-range ordered but not translational invariant, results in specific electronic properties, especially regarding the electron localization. Electrons in quasicrystals are more delocalized than in disordered materials, but less than in translational invariant crystals. This in turn influences correlated states such as superconductivity or magnetic orders. The quantum metric is a quantum geometric indicator probing the spreading of the Wannier orbitals composing an electronic band. It plays a prominent role in flat-band correlated systems as, in the absence of dispersion, wave function delocalization is the only remaining mechanism that can account for long-range coherence and correlations. I will present a work where we establish the quantum metric as an indispensable and natural tool to capture the deep relation between the structure of the quasicrystal, its energy spectrum and the localization of the electrons, and position quasicrystals as a potential platform for intriguing correlated states.

Session 7 – KAGOME MATERIALS

Invited Talk

Pressure Tuning of Electronic Correlations and Flat Bands in $CsCr_3Sb_5$

Maria Chatzieleftheriou

Ecole Polytechnique

$CsCr_3Sb_5$ is a recently discovered kagome superconductor that shows strong electronic correlations. At high temperatures, it exhibits non-Fermi-liquid behavior, while below about 54 K it develops intertwined charge- and spin-density-wave order. When pressure is applied, this ordered state is suppressed and superconductivity appears, giving rise to a phase diagram resembling that of high-Tc superconductors. This combination of features -especially the presence of a kagome flat band near the Fermi level and the possibility of altermagnetic order- has made the system particularly interesting. A key question is how pressure drives these changes in the electronic state. I will discuss a recent work on the material, where DFT+DMFT calculations were performed to track how the electronic structure evolves under pressure. A nontrivial interplay between two effects was found: a redistribution of spectral weight in the flat bands and a change in the strength of electronic correlations. The findings revealed that pressure enhances orbital hybridization, which effectively weakens correlations. This weakening appears to destabilize the density-wave order, and the results support the idea that superconductivity emerges as a direct consequence of suppressing that ordered phase.

Correlation effects in a breathing kagome lattice: insights from Fe_3Sn

Shivalika Sharma

KENTECH - Korea Institute of Energy Technology

Kagome lattices provide a natural platform for flat-band physics, where electronic correlations can be significantly enhanced. In this work, we investigate the breathing kagome metal Fe_3Sn using a combination of density-functional theory and dynamical mean-field theory, focusing on the interplay between nearly-flat bands and local Coulomb interactions. We identify multiple kagome-derived bands in close proximity to the Fermi level, whose positions are strongly renormalized by electronic correlations. In particular, correlation effects shift these low-dispersion features toward the Fermi energy, enhancing their potential relevance for emergent phenomena. Beyond band structure, we analyze how correlations influence magnetic properties, including orbital polarization, magnetic anisotropy, and chiral exchange interactions. Our results reveal that the combined effect of kagome geometry, breathing anisotropy, and electronic correlations plays a central role in shaping both the low-energy electronic structure and magnetism in Fe_3Sn. These findings highlight Fe_3Sn as a promising platform for exploring correlation-enhanced flat-band physics in kagome systems.

Emergence of the MISOH Effect in Ti-Based Kagome Metal

Luciano Jacopo D'Onofrio

CNR-SPIN

The kagome lattice is a rich platform for hosting correlated quantum phenomena, including charge density waves, superconductivity, and loop current states. Directly detecting loop currents in kagome systems remains highly challenging due to their intricate spatial arrangements and weak magnetic signatures, leaving their existence heavily debated. In this work, we uncover signatures compatible with loop currents through spin handedness-selective signals that surpass conventional dichroic, spin, and spin-dichroic responses. We observe this phenomenon in the kagome metal $CsTi_3Bi_5$, identifying it as the Multipolar-Induced Spin-Optical Helicity (MISOH) effect. This anomalous spin-optical helical effect arises from the coupling of light's helicity with spin-orbital electron correlations. When illuminated, the material emits electrons with a precise spin polarization whose direction depends directly on the light's helicity. This response encodes deep information about the internal electronic organization, providing a highly sensitive probe for loop-current-related correlations and opening new experimental strategies to exploit the electronic phases of quantum materials.

Experimental Realization of an Acoustic Kagome-Model Simulator

Louis Müller

JMU Würzburg

Kagome lattices are well known to host van-Hove singularities, Dirac cones and flat bands. The latter arise from destructive interference of adjacent lattice sites at their common neighbors, leading to localization around the hollow sites. In realistic electronic Kagome systems, however, this flat band can become dispersive or even completely obstructed due to interlayer coupling, defects, and other perturbations. To isolate the intrinsic lattice properties, we employed a 3D-printed macroscopic Kagome lattice as a Hamiltonian model simulator and probed it using sound waves. This approach provides access not only to the excitation spectrum — giving an almost ideal 2D-kagome-like band dispersion — but particularly to the underlying wave functions, including both amplitude and phase. We experimentally investigate the sublattice character of distinct features in the band structure. This demonstrates that interference between the sublattice wave functions suppresses parts of the band structure, and particularly the flat band within the first Brillouin zone.

Comprehensive fluctuating field theory study of magnetic instabilities in the Hubbard model

Erik Linnér

SISSA

Through an interplay of geometry and electron correlation, a plethora of collective instabilities may stabilize within the Hubbard model. We present our recent developments on the fluctuating field theory, a recently developed method for the description of competing collective fluctuations in correlated electron systems. On the basis of a variational principle, the method allows to explicitly account for the leading collective modes in the spin, charge, and superconducting channels, and their interplay, through a set of fluctuating fields. We present our work on extending its applicability from half-filled systems to doped systems, and to more complex instabilities associated with, e.g., incommensurate ordering and topological features. In particular, with access to electronic and spectroscopic properties, we utilize the method to investigate the phase diagram of the doped Hubbard model, accounting for different magnetic instabilities. Unlike for N´eel ordering, which dominates near half-filling, we observe the emergence of phase structures of the fluctuating fields for collective instabilities with arbitrary ordering vector Q becoming important. It expresses the modulation of the ordering relative the underlying lattice geometry, with relevance in distinguishing between commensurate and incommensurate orderings. Thus, we observe the method to be an efficient and general tool to investigate the phase diagrams of correlated electronic systems broadly.

Universal relation between residual resistivity and A coefficient in correlated metals

Anna Efimova

University of Geneva

Understanding how electronic correlations and disorder jointly influence charge transport remains a central challenge in quantum materials. In this work, we disentangle these intertwined effects by independently tuning the degree of randomness (via chemical substitution) and the strength of electronic correlations (via physical pressure) in metallic phases proximate to a Mott–insulating state. Focusing on the low-temperature Fermi-liquid regime, where the resistivity follows $\rho(T) = \rho_0 + AT^2$, we systematically extract both the residual resistivity ρ_0 and the coefficient A, which scales with the square of the quasiparticle mass enhancement. Contrary to conventional expectations that ρ_0 is independent of correlation strength, our experiments reveal a robust linear scaling between ρ_0 and A at fixed disorder level. We interpret this finding through a phenomenological framework in which spatial fluctuations of the chemical potential enhance the residual scattering rate, leading to $\rho_0 \propto A\sigma_\mu^2$, where σ_μ^2 quantifies the variance of chemical-potential disorder. Crucially, when comparing our results with transport data from a wide range of correlated metals—organic Mott systems, oxides, heavy-fermion compounds, and moiré heterostructures—we find this linear relation to be universal across diverse material classes. This discovery establishes a new scaling law linking disorder and correlation effects in strongly interacting electron systems and provides a unified perspective on charge transport in correlated metals. Moreover, we determine the minimum lattice size required to sustain Fermi-liquid behavior across different correlation strengths.

Second-order self-energy of the 2D Hubbard model: high-precision low-frequency asymptotics

Oleksandr Sulyma

University of Cologne

We compute the self-energy of the two-dimensional Hubbard model on a general square lattice using second-order perturbation theory, allowing for anisotropyand next-nearest-neighbor hopping. In the zero-temperature limit, we resolve the low-frequency behavior with high numerical precision.
When a van Hove singularity lies at the Fermi surface, we find clear deviations from Fermi-liquid behavior for momenta on the Fermi surface. At the van Hove point, the imaginary part of the self-energy scales as $\mathrm{Im}\Sigma(\nu) \sim \nu \ln \nu$. Away from it, the scaling depends on Fermi surface geometry: $\mathrm{Im}\Sigma(\nu) \sim \nu$ for perfect nesting, and $\mathrm{Im}\Sigma(\nu) \sim \nu3/2$ otherwise.
These results provide a microscopic explanation for the non-Fermi-liquid scattering rates observed in Strontium ruthenate $Sr2RuO4$ when strain tunes the van Hove singularity to the Fermi level.

Complexity, Topology and Dynamics in Quantum Matter

Julius-Maximilians-UNIVERSITÄT WÜRZBURG

Technische Universität Dresden

Poster

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Abstracts

1

First-principles investigation of polar vortices in twisted oxide bilayers

Anita Lalem Bayraktar

TU Berlin

Twisted complex oxide membranes offer a promising route to realizing emergent polar textures and moiré-driven phenomena. In this project, we investigate with Prof. Priyamvada Jadaun the structural and electronic origins of polar vortices in twisted bilayers of $BaTiO_3$ and $SrTiO_3$ using first-principles density functional theory calculations (DFT).

This project is carried out as a collaborative effort between Technische Universität Berlin and Berkeley Lab's Molecular Foundry, combining first-principles modeling with expertise in optical experiments. We focus on how twist angle, interfacial atomic reconstruction, and local symmetry breaking influence the formation and evolution of polar vortex patterns. In particular, we analyze relaxed atomic structures, Ti interfacial displacements, local polarization textures, and electronic properties across different moiré configurations.

The resulting first-principles data will provide a foundation for interpreting and guiding optical characterization experiments, including Raman spectroscopy and second-harmonic generation measurements. More broadly, this work contributes to the theoretical understanding of moiré engineering in complex oxides and its potential for controlling polar, structural, and electronic phases in low-dimensional materials.

Neural Quantum States for Correlated Phases in Trilayer Moiré Materials

Jonas Beck

JMU Würzburg

We present ongoing work on continuum neural quantum states (NQS) applied to three-layer transition-metal dichalcogenide (TMD) moiré systems. This work extends previous two-layer implementations to a more general trilayer framework, enabling systematic exploration of how multilayer stacking modifies effective interactions, flat-band structure, and emergent correlated phases. Trilayer moiré systems are particularly compelling because they naturally host bands with higher Chern numbers ($|C| > 1$). This provides an ideal platform to investigate how these bands stabilize fractional Chern insulators (FCIs) and how their topological character influences competing symmetry-broken or topologically ordered states.

3

Kekulé Order from Diffuse Nesting near Higher-Order Van Hove Points

Jonathan Bodky

JMU Würzburg

Translation symmetry–breaking orders are commonly assumed to be suppressed near higher-order Van Hove singularities (HOVHS) due to the absence of Fermi surface nesting. We show that the anisotropic band flattening inherent to HOVHS, together with Fermi surface broadening at elevated critical scales, can instead produce effective nesting at a wave vector largely independent of the detailed Fermi surface geometry. This mechanism drives the formation of a $\sqrt{3} \times \sqrt{3}$ Kekulé density wave. We demonstrate this effect using unbiased renormalization-group calculations for a model of the breathing kagome lattice. We term this mechanism diffuse nesting, which represents a fundamentally new route to Fermi surface instabilities beyond conventional nesting scenarios.

Room Temperature Scanning NV Magnetometer for Quantum Sensing

Frederik Leon Carstens

TU Dresden

Nitrogen-Vacancy (NV) center based sensors are widely used because they are versatile, precise, and suitable for exploring a broad range of systems. We have previously designed NV setups capable of operating in ultra high vacuum (UHV) and cryogenic environments, which, however, are only meaningful to use with samples that mandate such extreme measurement conditions. In order to expand our measurement capabilities to room temperature (RT) systems (such as exploration of nanomagnetism in RT-stable 2D materials, antiferromagnetic / ferromagnetic spin textures, stable molecular systems) as well as to enable rapid pre-screening of both samples and NV probes prior to transferring them into the UHV cryogenic setups, we are now setting up a room-temperature-scanning-NV magnetometer. This system integrates atomic force microscopy (AFM) with optical readout of single NV centers and will feature microwave delivery directly on the AFM tip to achieve highly localized and efficient spin control. This setup will also feature piezo-controlled permanent magnets, thus enabling quantitative magnetic-field mapping with nanometer-scale spatial resolution. Together with our UHV low-temperature scanning NV magnetometer and UHV confocal microscopes, it will form a unified platform for a complete workflow across ambient, cryogenic, and UHV environments.

5

Thermoelectric Transport in Two-Dimensional WTe_2 and $MoWTe_2$: Role of Alloying and Carrier Scattering

Rasmiya Shirin Chemban

University of Chemistry and Technology, Prague

Two-dimensional transition metal dichalcogenides have attracted significant attention due to their tunable electronic structure and potential for energy conversion applications. In this work, we investigate the thermoelectric transport properties of layered WTe_2 and Mo-alloyed WTe_2 ($MoWTe_2$) single crystals. Structural characterization using X-ray diffraction confirms the orthorhombic phase, while Raman spectroscopy reveals characteristic vibrational modes of the layered structure. Temperature-dependent electrical conductivity and Seebeck coefficient measurements were performed to understand charge transport behavior. The results show that alloying with Mo enhances the Seebeck response at low temperatures, which can be attributed to enhanced carrier scattering and possible energy filtering effects. However, the electrical conductivity is reduced compared to pristine WTe_2, leading to a lower power factor in the alloyed compound. These findings highlight the influence of compositional tuning on thermoelectric performance in layered materials and provide insights into optimizing transport properties in two-dimensional systems for energy harvesting applications.

6

Bridging Machine Learning and DFT for Surface Energy Prediction in $CsSnI_3$ Perovskites

Atefe Ebrahimi

SISSA

$CsSnI_3$ is a promising lead-free perovskite for optoelectronic applications, where surface structure and stability play a critical role in determining device performance. While density functional theory (DFT) has provided detailed insights into the surface energetics of $CsSnI_3$, its high computational cost limits large-scale exploration of surface configurations. In this work, we develop a machine-learned interatomic potential (MLIP) based on the LATTE framework to model the surface energetics of orthorhombic $CsSnI_3$.

Transport properties of multilayer Rhombohedral Graphene

Cyril Endignoux

CEA Paris-Saclay / Service de Physique de l'état condensé (SPEC)

Rhombohedral (ABCA-stacked) multilayer graphene represents a remarkable form of allotrope of carbon, where subtle differences in stacking order profoundly reshape the electronic landscape. Unlike Bernal (ABAB) graphene, the rhombohedral sequence produces extremely flat low-energy bands near charge neutrality,which strongly enhances electron–electron interactions and enables a variety of correlated quantum phases, including superconductivity and orbital magnetism [1, 2, 3]. When this rhombohedral system is aligned with hexagonal boron nitride (hBN), giving rise to a moiré superlattice potential, and inversion symmetry is broken that reshapes the flat bands into topologically nontrivial minibands with non-zero Berry curvature. This leads to the formation of valley-polarized Chern bands that can host the quantum anomalous Hall effect, as well as orbital ferromagnetism and superconductivity [4].

Building on these unique properties, our work focuses on exploring quantum coherence and electron interferometry in the anomalous Hall regime of rhombohedral graphene aligned with hBN, analogous to Mach–Zehnder interferometry previously realized in graphene p–n junctions under high magnetic fields [5]. We are currently in the stage of fabricating rhombohedral devices with split-gate geometries designed to control displacement fields and create adjacent regions with opposite Chern numbers. These structures will enable us to probe interference between valley-polarized chiral edge states at B = 0. Through this, we aim to understand how coherence evolves in correlated Chern insulators, paving the way for zero-field quantum interferometers and novel valley-coherent device architectures. We will discuss some preliminary results on rhombohedral graphene aligned with hBN.

[1] T. Han et al., "Correlated insulator and Chern insulators in pentalayer rhombohedral-stacked graphene," Nat. Nanotechnol 19,181–187 (2024).

[2] H. Zhou et al., “Superconductivity in rhombohedral trilayer graphene,” Nature 598, 429 (2021).

[3] H. Polshyn et al., “Electrical switching of magnetic order in an orbital Chern insulator,” Nature 588, 66 (2020).

[4] Choi et al., ”Superconductivity and quantized anomalous Hall effect in rhombohedral graphene”. Nature 639, 342–347 (2025).

[5] M. Jo, P. Brasseur et al.,”Quantum Hall valley splitters and a tunable Mach-Zehnder interferometer in graphene”Phys. Rev. Lett. 126, 146803 (2021)

Structural properties of helicene molecules studied by STM

Kaushal Gavankar

JMU Würzburg

Helicenes are polycyclic aromatic hydrocarbons with a helical geometry that makes them inherently chiral, existing as P (right-handed) and M (left-handed) enantiomers. Studying these molecules at the single-molecule level using high-resolution imaging techniques is key to understanding chirality-dependent effects such as the Chiral-Induced Spin Selectivity (CISS) effect. In this work, we use scanning tunneling microscopy (STM) and Q-Plus atomic force microscopy (AFM) to image individual helicene molecules adsorbed on clean metal substrates under ultra-high vacuum (UHV) conditions. STM provides information on the electronic landscape and local density of states, while Q-Plus AFM allows us to resolve the internal molecular structure with sub-molecular precision.

Together, these techniques enable us to determine how individual helicene molecules adsorb, orient, and arrange on the surface — structural details that form the essential foundation for understanding the role of molecular chirality in such effects at the single-molecule level.

High-quality $HgTe/Hg_{1-x}Cd_xTe$ heterostructures grown by molecular beam epitaxy using elemental sources

Simran Anil Koche

JMU Würzburg

$HgTe/Hg_{1-x}Cd_xTe$ heterostructures are the most prominent platforms for investigating quantum transport in topological electron systems. These structures are typically grown by molecular beam epitaxy (MBE) using intricate growth conditions, including a narrow window of low substrate temperature and high Hg flux. For certain protocols, the growth of HgTe and $Hg_{1-x}Cd_xTe$ layers is performed by switching between an elemental Te source and a compound CdTe source, respectively. The CdTe compound inherently offers a Cd/Te flux ratio of one, which under controlled Hg flux leads to a fixed Cd content of $x = 0.7$. Our alternative approach is to grow $HgTe/Hg_{1-x}Cd_xTe$ heterostructures on CdTe(001) substrate using Hg, Cd, and Te elemental sources, it enables the tuning of the $Hg_{1-x}Cd_xTe$ composition. We find that the Cd content increases linearly with the increase of Cd/Te flux and does not affect the growth rate of the layer. In this work, we present a systematic comparison of structural and magneto-transport properties of heterostructures grown using elemental sources and CdTe compound sources under the same growth conditions. We observe a strong increase of about 50% in electron mobility in $HgTe/Hg_{1-x}Cd_xTe$ quantum wells by decreasing the Cd content of barrier layers by just about 5%. These results are attribute to an improved in $Hg_{1-x}Cd_xTe$ layer and a consequently, reduced electron scattering, likely resulting from more favorable growth conditions when using a Cd source instead of a CdTe source operated at higher temperatures. Our results demonstrate that employing elemental sources provides both improved electronic quality and greater flexibility in designing HgTe-based heterostructures, with promising application for topological electronic transport studies and optoelectronic device applications.

Berry Curvature-Driven Topological Transport Phenomena in CoYCrAl quaternary Heusler alloy

Kulwinder Kumar

Delhi Technological University

The anomalous electronic transport arising from the interplay between the magnetism and band topology leads to the remarkable phenomena of the anomalous Hall and Nernst effect. In this study, we have computationally explored the electronic, magnetic, topological, and anomalous transport properties of the CoYCrAl quaternary Heusler alloys. The spin-polarized calculation confirmed the half-metallic nature of the alloy. A tight-binding approach based on Wannier functions, including spin-orbit coupling, is used to investigate the topological features, revealing the existence of multiple Weyl nodes with opposite chirality. The presence of the symmetry-protected Fermi arc and topological surface states confirmed the material's Weyl semi-metallic nature. Further, we evaluate the Berry curvature corresponding to the electronic bandstructure along [001] crystallographic direction, under the effect of spin-orbit coupling. The Berry curvature-driven anomalous Hall conductivity is found to be 548.49 Scm^{-1}, which corresponds to a linear band crossing. Furthermore, a strong anomalous Nernst signal with a magnitude of -3.44 $Am^{-1}K^{-1}$ is observed at room temperature. These anomalous transport outcomes with topological characteristics highlight the potential of the CoYCrAl alloy for spintronic and thermoelectric applications.

Flat-band in cylindrical moire lattices enabled by rolling origami

Fanzhou Lv

IFW Dresden

Twisted photonic lattices that form moiré superlattices have attracted significant attention owing to their unique properties, in which the localized optical modes can serve as efficient light sources. However, in conventional moiré lattices, the emission direction of confined modes is typically fixed, and achieving a broad range of emission angles remains a significant challenge. Here, we design and fabricate single-layer moiré photonic lattices into cylindrical geometries using a nanomembrane origami technique. This approach enables wide-angle localized-mode emission while maintaining stable single-mode operation and excellent spectral uniformity. The moiré supercells support localized flat-band modes under various effective twist angles, resulting in the observation of periodic localized-mode emission over a wide range of azimuthal angles. Our research provides an approach for developing moiré light sources on curved surfaces, offering significant potential in applications that demand spatial light control, including three-dimensional imaging, light detection and ranging, and topological state manipulation.

Development of an Ultra High Vacuum and Low Temperature Scanning NV Magnetometer

Sandip Maity

TU Dresden

The nanoscale spatial resolution and calibration-free quantifiable magnetic field measurement capabilities of nitrogen-vacancy (NV) centers have enabled us to investigate the properties of magnetic spin textures with high magnetic sensitivity through scanning probe microscopy across a wide range of temperatures and pressure. In the poster I will be presenting the development of a scanning probe magnetometer capable of imaging magnetic textures under ultra-high vacuum and low temperature. Moreover, we have integrated commercial NV tips with a home-built tip holder equipped with an AFM amplifier and microwave excitation on the tip (not on the sample). This compact and modular probe holder allows us to have a magnetic image of any sample region without restriction. To exploit the quantifying nature of NV magnetometry using Optically Detected Magnetic Resonance, a coherent microwave (MW) delivery to the probe is mandatory. I will also present different means of delivering MW to the NV probes through different designs of the tip holders in a practical and versatile manner and how effective they are in coherently manipulating the NV spin states.

Topology in three-dimensional kagome magnets

Alma Partos

Institute of Physics, Nicolaus Copernicus University

Certain members of the iron-stannide family, which includes Fe_3Sn, Fe_3Sn_2, and FeSn, have been shown to exhibit a rich variety of topological features – flat bands, Dirac crossings, and three-dimensional Weyl nodes – deriving from their layered kagome structures, which differ in the stacking of kagome layers relative to the interlayer stanene sheets, as well as the geometric structures of the kagome layers themselves. This poster presents preliminary findings from our study of Fe_3Sn_2, a topological ferromagnet, known to exhibit large anomalous Hall and Nernst effects, flat bands, and nodal lines. We perform a theoretical investigation of the connection between magnetic and topological properties, along with the possible effects of strong correlations on the electronic structure, by way of, in particular, density functional theory (DFT) calculations.

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Superconductivity in altermagnetic band structures: mean-field and quantum Monte Carlo simulations

Helke Parussel

JMU Würzburg

We investigate how altermagnetism affects superconductivity (SC). In an altermagnetic band structure, the conventional s-wave Cooper instability gives way to a p-wave one. To explore this, we study the ground state of an altermagnetic attractive Hubbard model on the square lattice using mean-field (MF) theory and quantum Monte Carlo (QMC) simulations. Since a standard MF decoupling of the Hubbard term cannot account for p-wave pairing, we introduce a “UV-cutoff” term that enables p-wave superconductivity at the MF level. QMC simulations of the original Hubbard model show the suppression of s-wave pairing and the enhancement of p-wave correlations when switching on altermagnetic symmetries. However, the sign problem restricts our current calculations to temperatures above the superconducting transition ($\beta/t \leq 10$). We plan to overcome this limitation through future projector-QMC studies.

Towards accurate low energy models

Jonas Profe

Goethe University Frankfurt

Effective low-energy models are a central cornerstone for understanding emergent phenomena in quantum materials. These models, often containing only a small subset of the original degrees of freedom, capture the low temperature dynamics while being tractable to a variety of numerical and analytical techniques enabling quantitative results even in the strongly correlated limit. As such, a faithful method to derive such low-energy models is essential. In this talk, we will introduce an exact framework for deriving effective models and extract known approaches from it. We further introduce conditions under which an effective model is guaranteed to capture the effective dynamics of the material. Within this framework, we then discuss what material classes display relevant corrections beyond standard downfolding approaches and we explain the physical origin of these corrections.

On-surface Spin Characterization using Shallow NV Centers in Diamond

Ahmad Rahimi

TU Dresden

Molecular spins offer almost infinite flexibility in quantum design NV-centers provide non-invasive optical readout at a wide range of environments with unmatched sensitivity Characterizing and quantifying the coherent properties of molecular spins using NV-centers will demonstrate their potential as stable and precisely controllable elements for future quantum technologies.

Electronic correlations in Kagome Kondo lattice

Lorenzo Riguzzi

University of Bologna

Kagome lattices host a plethora of physical phenomena, encompassing topology, electronic correlations, superconductivity, and magnetism. Characterized by their triangular lattice and the presence of a flat-band close to the Fermi level, Kagome systems are the perfect example of interplay between geometrical frustration and electronic correlations, as proved for example by $CsCr_6Sb_6$. It is indeed a candidate for the realization of a Kondo lattice, with a Sommerfeld coefficient 100 times larger than the V-based parent compound. For this reason this material seems to be a perfect playground for the study of heavy-fermion physics and strong electronic correlations. However, the theoretical description of how $CsCr_6Sb_6$ reacts to changes in the physical parameters has not been investigated yet. Here, by implementing a density functional theory + slave-spin mean field analysis, we describe the behaviour of the compound under varying electronic interaction and doping.

Green's Function Zeros and Gap Formation Mechanisms in Correlated Antiferromagnets

Francesco Valerio Servilio

JMU Würzburg

We investigate the temperature-dependent behavior of zeros in the determinant of the single-particle Green's function (det G) for an antiferromagnetic system using a hybrid Hubbard-tJ model. Through numerical calculations on the real frequency axis with extrapolation to zero broadening (η), we distinguish true zeros from minima. In the paramagnetic phase, det G exhibits zeros within the gap, consistent with Mott physics. Upon cooling into the antiferromagnetic phase, these zeros split and migrate between the intragap region and the Hubbard bands. Notably, we identify an intermediate temperature regime where intragap zeros are still present.

Local Correlation Effects in the Flat-Band Regime of the Kagome Hubbard Model

Alon Strugatsky

Goethe University Frankfurt

Kagome materials display a rich interplay of topology, strong electronic correlations, and lattice dynamics. Recently, attention has focused on a class of Kagome metals whose nearly flat bands sit close to the Fermi level. Examples include FeGe, CsV_3Sb_5, $YbCr_6Ge_6$. Such systems are natural hosts for flat-band phenomena (for instance, flat-band ferromagnetism and unconventional superconsuctivity), but their large density of states makes perturbative diagrammatic approaches challenging. Here, we present a systematic study using dynamical mean-field theory (DMFT) and cluster DMFT on the Kagome Hubbard model, and map the phase diagram at various fillings.

Temperature-Driven Modification of Moiré-Tailored Dirac Nodal Lines

Jonathan Vorndran

JMU Würzburg

The one-dimensional moiré superstructure appearing on a monolayer-substrate heterosystem AgTe/Ag(111) gives rise to a long-range superlattice potential that significantly alters the underlying electronic structure [1,2]. This leads to emergent replica bands with sizable hybridization gaps and Dirac nodal lines, both of which are strongly governed by this potential. Interestingly, we find that the moiré potential itself depends on sample temperature [2], making this material system a flexible platform with temperature-tunable electronic states. Using angle-resolved and X-ray photoemission spectroscopy, we here explore the influence of temperature on the material and its electronic structure in detail.

[1] M. Uenzelmann et al., Phys. Rev. Lett., 124, 176401, 2020.

[2] R. Ganser, M. P. T. Masilamani, et. al. Observation and Control of Moiré-Tailored Topological Dirac States. (2026). https://arxiv.org/pdf/2604.25598.

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Electronic Structure and Dynamical Correlations in Antiferromagnetic $BiFeO_3$

Yihan Wu

EPFL

We study the electronic structure and dynamical correlations in antiferromagnetic $BiFeO_3$, a prototypical room-temperature multiferroic, using a variety of static and dynamical first-principles methods. Conventional static Hubbard corrections (DFT+U, DFT+U+V) incorrectly predict a deep-valence Fe 3d peak (around -7 eV) in antiferromagnetic $BiFeO_3$, in contradiction with hard-X-ray photoemission. We resolve this failure by using a recent generalization of DFT+U to include a frequency-dependent screening – DFT+U(ω) – or using a dynamical Hubbard functional (dynH). The screened Coulomb interaction U(ω), computed with spin-polarized RPA and projected onto maximally localized Fe 3d Wannier orbitals, is expressed as a sum-over-poles, yielding a self-energy that augments the Kohn–Sham Hamiltonian. This DFT+U(ω) approach predicts a fundamental band gap of 1.53 eV, consistent with experiments, and completely eliminates the unphysical deep-valence peak. The resulting simulated HAXPES spectrum reproduces the experimental lineshape with an accuracy comparable to state-of-the-art approaches. Our work highlights the critical nature of dynamical screening in complex oxides and of DFT+U(ω) as a predictive and computationally efficient approach to address the electronic structure of correlated materials.