TT 44: Twisted Materials / Systems

Time: Wednesday 11:30–13:00 Location: H 3007

TT 44.1 Wed 11:30 H 3007

Large tunable kinetic inductance in a graphene based superconductor — Rounak Jha[1,2], Martin Endres[1], Kenji Watanabe[3], Takashi Taniguchi[4], Mitali Banerjee[2], Christian Schönenberger[1,5], and •Paritosh Karnatak[1] — [1]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [2]Laboratory of Quantum Physics (LQP), École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland — [3]Research Center for Functional Materials, National Institute for Material Science, 1-1 Namiki, Tsukuba 305-0044, Japan — [4]International Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan — [5]Swiss Nanoscience Institute, University of Basel, CH-4056 Basel, Switzerland

Graphene based twisted moiré heterostructures host a flat band at the magic angle where the kinetic energy of charge carriers is quenched and interaction effects dominate. This results in emergent phases such as correlated insulators and superconductors that are electrostatically tunable. In this work, we investigate superconductivity in magic angle twisted trilayer graphene (MATTG) by integrating it as a weak link in a SQUID (superconducting quantum interference device) loop of superconducting Molybdenum Rhenium. We study the current phase relation of MATTG in various configurations and show that superconducting MATTG has a large kinetic inductance up to 75 nH per square which is electrostatically tunable. This opens avenues for using MATTG as a tunable element in superconducting circuits.

TT 44.2 Wed 11:45 H 3007

Dynamical correlations and order in magic-angle twisted bilayer graphene — •Gautam Rai[1], Lorenzo Crippa[2], Dumitru Călugăru[3], Haoyu Hu[4], Luca de' Medici[5], Antoine Georges[6,7,8,9], B. Andrei Bernevig[3,4,10], Roser Valentí[11], Giorgio Sangiovanni[2], and Tim Wehling[1,12] — [1]U Hamburg — [2]U Würzburg — [3]Princeton U — [4]DIPC, Donostia-San Sebastian — [5]ESPCI, Paris — [6]Collège de France, Paris — [7]Flatiron Institute, New York — [8]École Polytechnique, Palaiseau Cedex — [9]Université de Genève — [10]IKERBASQUE, Bilbao — [11]Goethe U Frankfurt — [12]Hamburg CUI

In magic-angle twisted bilayer graphene, transport, thermodynamic and spectroscopic experiments pinpoint at a competition between distinct low-energy states with and without electronic order. We use Dynamical Mean Field Theory (DMFT) to study the emergence of electronic correlations and long-range order without strain. We explain the nature of emergent insulating and correlated metallic states by three central phenomena: (i) the formation of local spin and valley isospin moments around 100K, (ii) the ordering of these moments around 10K, and (iii) a cascadic redistribution of charge between localized and delocalized electronic states upon doping. Depending on the presence (absence) of order, we find insulating gaps (spectral weight depletion) at integer fillings, and a good (bad) metal at fractional fillings. Our findings provide a unified understanding of the most puzzling aspects of STS and transport experiments, including the isospin Pomeranchuk effect and doping-induced compressibility cascades.

TT 44.3 Wed 12:00 H 3007

Chiral Pseudo Spin Liquids in Tunable Moire Heterostructures — Clemens Kuhlenkamp[1,2,3], Wilhelm Kadow[1,2], Atac Imamoglu[3], and •Michael Knap[1,2] — [1]Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, D-80799 München, Germany — [3]Institute for Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland

We propose multi-layer moiré structures in strong external magnetic fields as a novel platform for realizing highly-tunable, frustrated Hubbard physics with topological order. Identifying a layer degree of freedom as a pseudo spin, allows us to retain SU(2) symmetry while controlling ring-exchange processes and concurrently quenching the kinetic energy by large external magnetic fields. This way, a broad class of interacting Hubbard-Hofstadter states and their transitions can be studied. Remarkably, in the limit of strong interactions the system becomes Mott insulating and we find exceptionally stable chiral pseudo spin liquid phases which are induced by the magnetic field. We discuss how layer pseudo-spin can be probed in near-term experiments. As the magnetic flux can be easily tuned in moiré systems, our approach provides a promising route towards the experimental realization and control of topologically ordered phases of matter.

TT 44.4 Wed 12:15 H 3007

Exploring unconventional transport in flat-band systems by quantum geometry — •Johannes Mitscherling[1], Dan S. Borgnia[1], and Joel E. Moore[1,2] — [1]Department of Physics, University of California, Berkeley, California 94720, USA — [2]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Characterization of the ground state and its excitations is fundamental to understanding the transport properties of any quantum material. Until recently, this mostly meant studying the dispersive features of the band structure and the topological features of the quantum state manifold. The featureless dispersion of flat-band materials challenges this approach since all transport quantities proportional to the quasiparticle velocity vanish. We show how quantum geometry, an emerging field of study with remarkable power to capture the parameter-local properties of the quantum states, can be used to analyze unconventional transport phenomena in flat-band systems. This talk will discuss the role of quantum geometric quantities other than the Berry curvature, such as the quantum metric. Given its broad applicability, quantum geometry is a promising tool for characterizing and understanding multiband systems with non-trivial quantum geometry even beyond flat-band systems.

TT 44.5 Wed 12:30 H 3007

Double resonance of twisted photon states and related transfer of orbital angular momentum to chiral model systems — Silvia Müllner[1], •Peter Lemmens[1], and Angela Möller[2] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]Dept. Chemistry, JGU Mainz, Germany

Twisted photon states that contain spin (helicity) and orbital angular momentum (chirality) are used to probe topological properties of chiral model systems. As the latter we recently identified chiral liquid crystals [1]. Their optical properties are dominated by a twistedness with a pitch length tailored both by temperature and composition. Using these two parameters as well as curved interfaces introduced by dispersed nanoparticles we establish resonances of pitch length with the geometry as well as with the OAM transfer.

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[1] S. Müllner, et al., Phys. Rev. Lett. 129 (2022) 207801.

TT 44.6 Wed 12:45 H 3007

Particle dynamics and ergodicity breaking in twisted-bilayer optical lattices — •Ganesh C. Paul — Technische Universität Braunschweig, Institut für Mathematische Physik, Mendelssohnstraße 3 , 38106 Braunschweig, Germany

Recent experiments have realized a twisted-bilayer-like optical potential for ultracold atoms, which in contrast to solid-state setups may allow for an arbitrary ratio between the inter- and intralayer couplings. For commen- surate moiré twistings, a large-enough interlayer coupling results in particle transport dominated by channel formation. For incommensurate twistings, the interlayer coupling acts as an effective disorder strength. Whereas for weak couplings the whole spectrum remains ergodic, at a critical value part of the eigenspectrum transitions into multifractal states. A similar transition may be observed as well as a function of an energy bias between the two layers. Our theoretical study reveals atoms in a twisted-bilayer system of square optical lattices as an interesting platform for the study of ergodicity breaking and multifractality.