TT 75: Low Dimensional Systems

Time: Thursday 15:00–17:45 Location: H 3007

TT 75.1 Thu 15:00 H 3007

First-order electronic phase transition in α-(BEDT-TTF)$_2$I$_3$ revealed by temperature-dependent generalized ellipsometry — •Achyut Tiwari, Bruno Gompf, Dieter Schweitzer, and Martin Dressel — Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

The nature of correlation-driven metal-insulator transitions remains a longstanding puzzle in solid-state physics. While some theories suggest a second-order character, various experimental observations in these materials indicate first-order phase transitions. Despite considerable progress over the last decades in understanding the underlying driving mechanisms of metal-insulator transitions, in particular the phase coexistence remains poorly understood on a microscopic scale. Here, we employ Mueller matrix spectroscopic and temperature-dependent ellipsometry to determine the anisotropic dielectric functions of the two-dimensional charge-transfer salt α-(BEDT-TTF)$_2$I$_3$ across its charge-order metal-insulator transition. Our results offer valuable insights into temperature-dependent changes of the dielectric functions along the different crystallographic axes. Furthermore, we apply an effective-medium approximation to quantify the correlation between the metal-to-insulator transition and the volume fraction of the metallic phase embedded within the insulating phase. Through this comprehensive approach, generalized ellipsometry unravels the nature of the correlation-driven metal-insulator transition.

TT 75.2 Thu 15:15 H 3007

Quantum spin dynamics across field-induced phase transitions in the spin-chain compound Cu$_2$(OH)$_3$Br — •Anneke Reinold[1], Kirill Amelin[2], Zhiying Zhao[3], Changqing Zhu[1], Patrick Pilch[1], Hans Engelkamp[4], Toomas Rõõm[2], Urmas Nagel[2], and Zhe Wang[1] — [1]TU Dortmund University, Germany — [2]National Institute of Chemical Physics and Biophysics, Tallinn, Estonia — [3]Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou, China — [4]Radboud University, Nijmegen, The Netherlands

In low-dimensional quantum magnets, exotic magnetic phenomena can emerge due to strong spin fluctuations. Here we investigate quantum spin dynamics of the spin-1/2 chain compound Cu$_2$(OH)$_3$Br by high-resolution terahertz spectroscopy as a function of temperature and in high magnetic fields. Below a Néel temperature of $T_N = 9.3\,K$, this compound exhibits a unique magnetic structure consisting of alternating ferromagnetically and antiferromagnetically aligned chains of Cu^{2+} spins. In this ordered phase we observe magnetic excitations, which are characteristic for this unique spin structure and consistent with previous results of inelastic neutron scattering experiments. Crossing a field-induced quantum phase transition, we reveal different characteristics of spin dynamics for the high-field phase.

TT 75.3 Thu 15:30 H 3007

Temperature-dependence of 2D electron transport in presence of different scattering mechanisms — •Philipp Heilmann[1] and Björn Trauzettel[1,2] — [1]Institute of Theoretical and Astrophysics, University of Würzburg, Germanny — [2]Würzburg-Dresden Cluster of Excellence ct.qmat, Germany

We examine 2D electron transport through a long narrow channel driven by an external electric field in presence of diffusive boundary scattering. At zero temperature, electron scattering leads to a transition from the ballistic to the diffusive regime with characteristic current density profiles. At finite temperature, the phase space for transport and particle scattering is enlarged. We study the influence of finite temperature on current densities and average current in this system. We are particularly interested in temperature-dependent scattering, for instance, electron-electron scattering, and its observable signatures.

TT 75.4 Thu 15:45 H 3007

Mean-field theory for the thermodynamics of quantum spin systems — •Andreas Honecker — Laboratoire de Physique Théorique et Modélisation, CNRS UMR 8089, CY Cergy Paris Université, France

Many quantum-spin compounds realize a complex –typically higher-dimensional– exchange geometry. This poses a challenge for the theoretical description of their thermodynamic properties. Mean-field theory suggests itself as a flexible tool in this context. However, accuracy of simple single-site mean-field theory turns out to be disappointing for certain antiferromagnetic compounds with a low saturation field that are of potential interest for adiabatic demagnetization refrigeration [1]. We therefore revisit the mean-field approximation for the thermodynamic properties of the spin-1/2 Heisenberg ferro- and antiferromagnets on prototypical lattices such as the square, triangular, and simple cubic ones and benchmark it against numerical results obtained by quantum Monte Carlo simulations and exact diagonalization. We also discuss perspectives for improving the accuracy of mean-field methods.

[1] M. Tiwari, *Mean-Field Theory for Quantum Spin Systems and the Magnetocaloric Effect*, Ph.D. thesis, CY Cergy Paris Université (2022)

TT 75.5 Thu 16:00 H 3007

Fractional spin excitations and conductance in the spiral staircase Heisenberg ladder — •Flavio Ronetti[1,2], Daniel Loss[2], and Jelena Klinovaja[2] — [1]Aix-Marseille Univ, Université de Toulon, CNRS, CPT, Marseille, France — [2]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

In this talk, we present some theoretical investigation of the spiral staircase Heienberg spin-1/2 ladder in the presence of antiferromagnetic long-range spin interactions and a uniform magnetic field. If the magnetizations of the two chains forming the ladder satisfy a certain resonance condition, involving interchain couplings as perturbations, the system is in a partially gapped magnetic phase hosting excitations characterized by fractional spins, whose values can be changed by the magnetic field. We obtain our results with the help of bosonization and numerical density matrix renormalization group methods.

TT 75.6 Thu 16:15 H 3007

All product eigenstates in Heisenberg models from a graphical construction — •Felix Gerken[1,2], Ingo Runkel[3], Christoph Schweigert[3], and Thore Posske[1,2] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — [3]Fachbereich Mathematik, Universität Hamburg, Germany

Recently, large degeneracy based on product eigenstates has been found in spin ladders, Kagome-like lattices, and motif magnetism, connected to spin liquids, anyonic phases, and quantum scars. In this talk, we present a unified description of these systems by a complete classification of product eigenstates of Heisenberg XXZ Hamiltonians with Dzyaloshinskii-Moriya interaction on general graphs in the form of Kirchhoff rules for spin supercurrent. The Kirchhoff rules imply a graphical construction procedure for a yet unknown class of potentially strongly, in some cases even extensively, degenerate spin models. The algebraic problem of determining the degeneracy is translated into a graph-theoretic problem. Thus, we find an intriguing connection between graph topology, degeneracy and entanglement. Further, there are hints that the degeneracy is linked to exotic condensates which could be studied in atomic gases and quantum spin lattices.

[1] F. Gerken, I. Runkel, C. Schweigert, T. Posske, arXiv:2310.13158 (2023)

15 min. break

TT 75.7 Thu 16:45 H 3007

Tuneable band topology and non-reciprocal response in 2D altermagnets — •Peng Rao[1], Alexander Mook[2], and Johannes Knolle[1,3,4] — [1]Department of Physics, Technische Universität München, Garching, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, Mainz, Germany — [3]Blackett Laboratory, Imperial College London, London, United Kingdom — [4]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany

Non-reciprocal response due to time-reversal-symmetry (TRS) breaking in condensed matter platforms is an active field of research with broad theoretical and experimental interests, due to its application in building electrical devices, i.e. quantum circulators. In this work, we study the optical response of a newly proposed class of TRS-breaking materials called 'altermagnets', where TRS is broken by collinear antiferromagnetic order. Unlike usual antiferromagnets, in an altermag-

netic metal (i.e. RuO_2) the spin-polarized Fermi surfaces are split by the order of the Fermi energy, exhibiting strong TRS breaking in its electronic properties. We first consider the altermagnet bandstructure and band topology using a 2D band Hamiltonian with spin-orbit coupling and magnetic field. We then investigate the non-reciprocal optical response by computing the optical conductivity tensor and anomalous Hall response. In particular, we estimate the Faraday angle using parameters that are quantitatively correct for RuO_2.

TT 75.8 Thu 17:00 H 3007

Thermal Hall transport in Semi-classical Magnets — •Ignacio Salgado-Linares[1,2], Alexander Mook[3], and Johannes Knolle[1,2] — [1]Physics Department, TUM School of Natural Sciences, Technical University of Munich, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — [3]Institute of Physics, Johannes Gutenberg University Mainz, 55128 Mainz, Germany

In recent years, the thermal Hall effect has emerged as a powerful tool for probing topological phenomena of magnetic systems. At low temperatures, the thermal Hall transport of long-range ordered magnets can be described in the framework of linear spin-wave theory (LSWT). However, how to treat regimes with increased thermal fluctuations or non-linearities beyond LSWT is an outstanding question. Therefore, within this project, we developed a novel numerical technique to extract the thermal Hall transport properties, which intrinsically includes non-linear effects. In particular, we use semi-classical spin dynamics simulations to compute topological thermal edge currents in the Kitaev honeycomb model on a cylinder geometry. The results are expected to shed new light on the topological thermal transport in Kitaev spin liquid candidate materials.

TT 75.9 Thu 17:15 H 3007

Characterizing the entanglement of mixed states in anyonic systems — •Nico Kirchner[1,2], Wonjune Choi[1,2], and Frank Pollmann[1,2] — [1]Technical University of Munich — [2]Munich Center for Quantum Science and Technology (MCQST)

Entanglement of mixed quantum states can be quantified using the so-called partial transpose and its corresponding entanglement measure, the logarithmic negativity. Recently, the notion of partial transpose has been extended to systems of anyons, which are exotic quasiparticles whose exchange statistics go beyond the bosonic and fermionic case. Studying the fundamental properties of this anyonic partial transpose for non-abelian anyons and the bipartition geometry, we find a rich multiplet structure in the eigenvalues of the partial transpose, the so-called negativity spectrum, and reveal the possiblity of defining both a charge- and an imbalance-resolved logarithmic negativity. Focusing on low-energy properties, we find that the anyonic partial transpose captures both the correct entanglement scaling for gapless systems, as predicted by conformal field theory, and the phase transition between a topologically trivial and a nontrivial phase.

TT 75.10 Thu 17:30 H 3007

Current-phase relation in Fibonacci Josephson junctions — •Ignacio Sardinero[1], Jorge Cayao[2], Keiji Yada[3], Yukio Tanaka[3], and Pablo Burset[1] — [1]Department of Theoretical Condensed Matter Physics, Condensed Matter Physics Center (IFIMAC) and Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, 28049 Madrid, Spain — [2]Department of Physics and Astronomy, Uppsala University, Box 516, S-751 20 Uppsala, Sweden — [3]Department of Applied Physics, Nagoya University, Nagoya 464-8603, Japan

Quasicrystals (QCs), lattices displaying long-range order without translational periodicity, have been shown to be topologically nontrivial. They feature energy gaps linked to topological invariants, harboring edge modes under specific conditions. The Fibonacci quasicrystal (FQC), a prototypical example of a one-dimensional QC, comprises an aperiodic sequence of two alternating parameters. We consider Josephson junctions where superconductors with a finite phase difference are subjected to chemical potentials arranged in a Fibonacci sequence. The FQC arrangement, which may be implemented using local gates, introduces gaps and edge modes above the superconducting energy gap. We show that these edge modes develop superconducting correlations, with an intriguing dependence on the superconducting phase difference. This effect gives rise to a finite Josephson current which can even dominate the contribution from common Andreev states. The interplay between FQCs and the Josephson effect opens up new avenues for exploring exotic phenomena with important consequences in topological superconductivity.