TT 10: Topological Semimetals

Time: Monday 15:00–17:45 Location: H36

TT 10.1 Mon 15:00 H36

Uniaxial pressure tuning of the anomalous Hall effect in Mn_3Ge — •Gustavo Lombardi[1], Leonardo Oparacz Kutelak[2], Mario Moda Piva[1], Vinicius Estevo Silva Frehse[3], Guilherme Calligaris[2], Ricardo Donizeth dos Reis[2], and Michael Nicklas[1] — [1]Max Planck Institute for Chemical Physics of Solids, 01187, Dresden, Germany — [2]Brazilian Synchrotron Light Laboratory, 13083-100, Campinas, Brazil — [3]Center for Electronic Correlations and Magnetism, 86159, Augsburg, Germany

The hexagonal Heusler compound Mn_3Ge exhibits an antiferromagnetic structure in which the Mn spins are arranged in a 120° triangular configuration characteristic of a Kagome lattice in the *ab* plane. These Kagome layers are periodically stacked along the *c* axis. This structure gives rise to a large anomalous Hall effect (AHE) due to a non-vanishing Berry curvature. Uniaxial pressure provides an effective method for tuning the AHE in Mn_3Ge. Our results reveal that applying stress along the *a* direction, which induces a distortion in the *ab* plane, significantly modifies the Hall signal. In contrast, stress applied along the *c* axis has no visible effect on the Hall signal. These results, combined with previous hydrostatic pressure data [1], suggest that the strong variations in the AHE are due to changes in the magnetic order in the *ab* plane. We also find that the application of hydrostatic and uniaxial pressure leads to different modifications of the magnetic order, the former inducing an out-of-plane tilt of the Mn spins, while the latter induces rotations of the Mn spins within the *ab* plane.

[1] R. D. Dos Reis et al., Phys. Rev. Mater. **4**, 51401 (2020).

TT 10.2 Mon 15:15 H36

Terahertz-light induced dynamics in the magnetic Weyl semimetal Mn_3Sn — •Anneke Reinold[1], Sergey Kovalev[1], Tomohiro Uchimura[2], Shunsuke Fukami[2], and Zhe Wang[1] — [1]Department of Physic, TU Dortmund University, Germany — [2]Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University, Sendai, Japan

We present a time-resolved spectroscopic study of the strong terahertz (THz) field-driven dynamics in the chiral-structured non-collinear Kagome antiferromagnet Mn_3Sn, a material renowned for anomalous transport properties, topological effects, and promising spintronic applications [1]. The driven charge and spin nonequilibrium dynamics are probed by optical transmission and Faraday rotation with a subpicosecond time resolution for various experimental conditions. By varying THz and optical polarization, sample orientation, and sample temperature, we carry out a comprehensive investigation of the THz field-driven nonequilibrium dynamics, in order to figure out the contributions due to different mechanisms. Our findings provide insight into the THz field-driven spin dynamics in this Kagome antiferromagnet and demonstrate its potential for THz spintronic applications.

[1] J. Han, T. Uchimura et al., Nat. Phys. **20**, 1110 (2024).

TT 10.3 Mon 15:30 H36

Anomalous Hall and Nernst effect in the Weyl semimetal $Ta_{1+x}Ru_{1-x}Te_4$ — •Mahdi Behnami[1,2,3], Dmitri Efremov[1], Grigory Shipunov[1], Saicharan Aswartham[1], Vilmos Kocsis[1], Marina Putti[3,4], Bernd Büchner[1,2], Helena Reichlova[1,2,5], and Federico Caglieris[4] — [1]IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany — [2]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — [3]Department of Physics, University of Genoa, 16146 Genova, Italy — [4]CNR-SPIN, 16152 Genova, Italy — [5]Institute of Physics ASCR, v.v.i., Cukrovarnick a 10, 162 53, Praha 6, Czech Republic

The anomalous Nernst effect is a transverse thermoelectric phenomenon driven by a temperature gradient perpendicular to both the heat current and the magnetic order vector. This effect is particularly valuable for probing the topological nature of materials, as it exhibits greater sensitivity to the Berry curvature near the Fermi energy compared to the anomalous Hall effect. In this study, we report that the type-II Weyl semimetal $Ta_{1+x}Ru_{1-x}Te_4$ exhibits both anomalous Hall and Nernst effects. These phenomena can be attributed to the finite Berry curvature generated by the Weyl points in this material.

TT 10.4 Mon 15:45 H36

Electronic transport and classification for topological nodal planes — •Moritz M Hirschmann[1,2], Kirill Alpin[1], Raymond Wiedmann[1], Niclas Heinsdorf[1,3], Wan Yee Yau[1,4], Andreas Leonhardt[1], Douglas H Fabini[5], Johannes Mitscherling[1,6,7], and Andreas P Schnyder[1] — [1]MPI FKF, Stuttgart, Germany — [2]RIKEN CEMS, Wako, Japan — [3]UBC, Vancouver, Canada — [4]MPI CBG, Dresden, Germany — [5]MIT, Cambridge, USA — [6]UC, Berkeley, USA — [7]MPI PKS, Dresden, Germany

Nodal planes are the two-dimensional generalization of nodal points/lines [1], and like them, they may carry a topological charge, for which we devise a symmetry-based classification. When a single or a pair of two nodal planes are topological, Fermi arcs connect the pockets of Weyl points and nodal planes on the surface. While this is similar to Weyl semimetals, their transport properties differ. We find that the large degeneracy of nodal planes is susceptible to a time-reversal breaking that contributes to the anomalous Hall effect. Further, perturbed nodal planes generically enhance the quantum metric contributing to the interband part of the optical conductivity. As an application, we study the hexagonal van der Waals material $CoNb_3S_6$, which exhibits such topological nodal planes. Recently, this compound has gained interest due to its All-in-All-out magnetic order that exhibits a nontrivial spin-space symmetry [2]. Here, the topological nodal planes dominate the anomalous Hall and Nernst effects.

[1] Nature 594, 374 (2021).
[2] arXiv:2403.01113 (2024).

TT 10.5 Mon 16:00 H36

Quantum geometry of topological nodal planes in Kondo systems — •Yannis Ulrich[1], Andreas Schnyder[1], and Laura Classen[1,2] — [1]Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Department of Physics, Technical University of Munich, D-85748 Garching, Germany

The geometric properties of the Hilbert space of Bloch states, such as the Berry curvature or quantum metric, play an important role in understanding topological semimetals. They are also fundamental for the understanding of various physical responses, including the (non-)linear Hall effect and (magneto-)optical conductivities. In this talk, I investigate the quantum geometry of two-dimensional topological band degeneracies, i.e., topological nodal planes, with a flat dispersion. Such nodal planes naturally arise in Kondo materials with screw rotation symmetries. Using a periodic Anderson model, I show how nodal planes in these Kondo materials can be tuned via pressure or temperature to be close to the Fermi level with a nearly flat dispersion. I show that such flat nodal planes exhibit a substantial quantum geometry, which in turn leads to nontrivial signatures in the (non-)linear Hall responses. Derivations of the Hall conductivities are presented in the manifestly gauge-invariant language of projectors, emphasizing their advantages in this type of calculation.

TT 10.6 Mon 16:15 H36

Finite-size topological phases from semimetals — •Adipta Pal[1,2] and Ashley M. Cook[1,2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute for the Chemical Physics of Solids, Dresden, Germany

Topological semimetals are some of the topological phases of matter most intensely-studied experimentally. The Weyl semimetal phase, in particular, has garnered tremendous, sustained interest given fascinating signatures such as the Fermi arc surface states and the chiral anomaly, as well as the minimal requirements to protect this three-dimensional topological phase. Here, we show that thin films of Weyl semimetals (which we call quasi-(3-1)-dimensional, or q(3-1)d) generically realize finite-size topological phases distinct from 3d and 2d topological phases of established classification schemes: response signatures of the 3d bulk topology co-exist with topologically-protected, quasi-(3-2)d Fermi arc states or chiral boundary modes due to a second, previously-unidentified bulk-boundary correspondence. We show these finite-size topological semimetal phases are realized by Hamiltonians capturing the Fermiology of few-layer Van der Waals material MoTe2 in experiment. Given the broad experimental interest in few-layer Van der Waals materials and topological semimetals, our work paves the way for extensive future theoretical and experimental characterization of finite-size topological phases.

15 min. break

TT 10.7 Mon 16:45 H36

Phonon-mediated surface superconductivity in Weyl semimetals — •Kristian Maeland and Björn Trauzettel — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

Recent experiments show that Weyl semimetals can host surface superconductivity in the Fermi arcs, while remaining metallic in the bulk. We study a lattice model of a Weyl semimetal to see if phonons are a candidate pairing mechanism to explain this phenomenon. Specifically, we study the pairing mechanism in detail on the surface and in the bulk. Furthermore, we make predictions about the critical temperature and the momentum dependence of the gap function.

TT 10.8 Mon 17:00 H36

The Weyl-Mott point: Topological and non-Fermi liquid behavior from an isolated Green's function zero — •Rafael Alvaro Flores Calderon[1] and Chris Hooley[2] — [1]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Strasse 38, 01187 Dresden, Germany — [2]Centre for Fluid and Complex Systems, Coventry University, Coventry CV1 2TT, United Kingdom

We present a model in which a Hatsugai-Kohmoto interaction is added to a system of fermions with a Weyl point in their non-interacting dispersion relation, and analyze its behavior as a function of the chemical potential. We show that the model exhibits a Weyl-Mott point, a single isolated Green's function zero, and that this implies an emergent non-Fermi-liquid state at the border of the metallic regime and a gapped topological state for the insulating one. The Weyl-Mott point inherits the topological charge from the original Green's function pole, and is therefore naturally associated with a strongly correlated chiral anomaly.

TT 10.9 Mon 17:15 H36

Observation of quasiparticle lifetime oscillations in WSi_2 — •Ivan Volkau[1], Nico Huber[1], Leo Maximov[1], Andreas Bauer[1,3], Christian Pfleiderer[1,2,3], and Marc A. Wilde[1,3] — [1]Technical University of Munich (TUM) — [2]MCQST, Munich — [3]TUM Zentrum für Quantum Engineering

The observation of quasiparticle lifetime oscillation (QPLOs) in CoSi [1] raises the question whether they are a generic feature observable in many materials or if they require a specific band structure. Here, we report the observation of QPLOs in WSi_2, which has recently generated great interest due to its remarkable characteristics in its transport properties, such as axis-dependent conduction polarity [2] and extremely large magnetoresistance [3]. We present Shubnikov-de Haas (SdH) and de Haas-van Alphen measurements, performed at different orientation of magnetic field up to 18 T and temperatures down to 1.5 K. We analyze the oscillation frequencies, their angular dependence, and their temperature dependence. The detected combination frequencies in the SdH effect exhibit characteristics consistent with QPLOs theory providing another example where the influence of QPLOs is observed.

[1] Nature 621, 276 (2023).
[2] Chem. Mater. 35, 4228 (2023).
[3] Phys. Rev. B 102, 115158 (2020).

TT 10.10 Mon 17:30 H36

Anomalous photo-Nernst effect and impact of disorder in $HfTe_5$ films — Maanwinder Singh[1,2], Tobias Meng[3], and •Christoph Kastl[1,2] — [1]Walter-Schottky-Institute, Technical University of Munich, Germany — [2]Munich Center for Quantum Science and Technology — [3]Institute of Theoretical Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, Germany

We discuss optoelectronic transport in thin films of $HfTe_5$, which is a non-magnetic, weakly gapped semimetal at the border of a weak to strong topological insulator transition. We find that focused photoexcitation results in strong a transversal response at finite magnetic field, which we describe in terms of a Berry curvature driven anomalous photo-Nernst effect of three-dimensional massive Dirac fermions [1]. We further use Raman microscopy to reveal significant microscale disorder and strain in contacted films, which has important implications for the interpretation of transport experiments in $HfTe_5$ due to the sensitivity of its electronic structure to external strain [2].

[1] Singh et al., Adv. Phys. Res. 3, 2300099 (2024).
[2] Singh et al., ACS Nano 18, 18327 (2024).