MA 40: Weyl Semimetals

Time: Friday 9:30–10:45 Location: H48

MA 40.1 Fri 9:30 H48

Magneto-optical detection of topological contributions to the anomalous Hall effect — •Felix Schilberth[1,2], Nico Unglert[3], Lilian Prodan[1], Christine Kuntscher[4], Liviu Chioncel[3], and Sándor Bordács[2] — [1]Experimentalphysik V, Augsburg University, Augsburg, Germany — [2]Department of Physics, BME Budapest, Hungary — [3]Theoretische Physik III, Augsburg University, Augsburg, Germany — [4]Experimentalphysik II, Augsburg University, Augsburg, Germany

The anomalous Hall effect (AHE) is a profound manifestation of nontrivial band structure topology in magnetic materials. The ambiguous separation of its intrinsic and extrinsic contributions leads to a fundamental limitation in identifying topological states based on common magnetotransport experiments. Here we demonstrate, via a case study on the prominent topological kagome magnet Fe_3Sn_2, that the intrinsic contribution to AHE can be determined unambiguously from the broadband spectrum of the optical Hall effect, obtained by energy-resolved magneto-optical Kerr-effect (MOKE) measurements. Using MOKE spectroscopy complemented with material-specific theory, we identified the interband excitations responsible for the intrinsic AHE. We found that low-energy transitions, tracing "helical volumes" in momentum space reminiscent of the formerly predicted helical nodal lines, substantially contribute to the AHE, which is further increased by contributions from multiple higher-energy interband transitions. Our calculation also shows that local Coulomb interactions lead to important band reconstructions near the Fermi level.

MA 40.2 Fri 9:45 H48

Magnetic and transport properties of Mn_3Sn and Fe doped Mn_3Sn Weyl semimetal — •SUBHADIP JANA — Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institute (PGI-4), JARA-FIT, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

A large Anomalous Hall Effect (AHE) has been found in Mn_3Sn due to the non-vanishing Berry flux emerging from the Weyl points. This compound draws enormous interest due to the complicated magnetic structure and its correlation with the transport properties. We observed AHE from 420 K (T_N = 420 K) down to 5 K for $Mn_{3.17}Sn$. From single-crystal neutron diffraction, we conclude that the magnetic structure is commensurate with magnetic moments in the hexagonal basal plane between 420 K (T_N) < T < 5 K. An additional incommensurate phase appears below 250 K. The presence of AHE in the whole temperature range is consistent with the commensurate magnetic structure. Fe doping influences the nearest-neighbor exchange energy, thereby changing the magnetic and transport properties. The Néel temperature was found to be 405 K for $Mn_{3.02}Fe_{0.08}Sn$, slightly lower than the parent compound. The commensurate magnetic structure has been observed between 210 K < T < 405 K from neutron powder diffraction. An incommensurate magnetic phase was observed below 210 K. The electro-transport study of Fe-doped sample shows vanishing AHE below 207 K. Therefore, we conclude that Fe doping significantly influences the magnetic structure in the commensurate region and that AHE completely vanishes in the incommensurate region.

MA 40.3 Fri 10:00 H48

Anomalous transport properties of the topological (Weyl) semimetal: Hexagonal - $(Mn_{1-\alpha}Fe_\alpha)_3Ge$ — •Venus Rai[1], Shibabrata Nandi[1], Anne Stunault[2], Wolfgang Schmidt[3], Subhadip Jana[1], Jian-Rui Soh[4], Jörg Persson[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institute (PGI-4), JARA-FIT, Forschungszentrum Jülich, Germany — [2]Institut Laue-Langevin, 71 avenue des Martyrs, CS20156, Grenoble, France — [3]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science at ILL, 71 Avenue des Martyrs, Grenoble, France — [4]Institute of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland

Weyl semimetal (WS) - Mn_3Ge displays a large anomalous Hall effect (AHE), which originates from the non-zero Berry curvature. The location and separation of the Weyl nodes can be tuned using a suitable dopant. So, we have studied the evolution of transport properties of single-crystal $(Mn_{1-\alpha}Fe_\alpha)_3Ge$. We observed that the strength of AHE and chiral anomaly weakens drastically with an increase in Fe doping and vanishes beyond $\alpha = 0.22$. Polarized and unpolarized neutron diffraction of $\alpha = 0.22$ showed that the magnetic structure of the compound remains the same as that of the parent compound, only in the temperature regime where AHE and the chiral anomaly are observed. These observations suggest the location of Weyl points and separation between a pair of Weyl points change significantly with Fe doping. Therefore, suitable dopants can be used to tune the transport properties of the WS.

MA 40.4 Fri 10:15 H48

Prediction of a new type-I Weyl semimetal in a full-Heusler compound — •Davide Grassano and Nicola Marzari — Theory and Simulations of Materials (THEOS) and National Center for Computational Design and Discovery of Novel Materials (MARVEL), Ecole Polytechnique Federale de Lausanne, CH-1015 Lausanne, Switzerland

Weyl semimetals are a class of topological semimetals with linear band crossings close to the Fermi level with non-trivial chirality, the existence of which gives rise to several exotic physical properties[1,2]. In order for such crossings to exist, either time-reversal or inversion symmetry must be broken[3]. Here we identify a new inversion-breaking Weyl semimetal. This material shows several features that are comparatively more intriguing with respect to other known inversion-breaking Weyl semimetals. The distance between two neighboring nodes is large enough to observe a wide range of linear dispersion in the band and only one kind of nodes can be identified. Finally, the lack of other trivial points insures that the low-energy properties of the material can be directly related to the presence of the Weyl nodes.

[1] Murakami S., New Journal of Physics 9.9 (2007):356
[2] Armitage NP, Mele EJ, Vishwanath A. - Rev. Mod. Phys. 90.1 (2018):015001
[3] Wan, Xiangang, et al. Phys. Rev. B 83.20 (2011): 205101

MA 40.5 Fri 10:30 H48

Multifold Hopf semimetals — •Ansgar Graf and Frédéric Piéchon — Université Paris-Saclay, CNRS, Laboratoire de Physique des Solides, 91405, Orsay, France

Three-dimensional (3D) topological semimetals exhibit linear energy band crossings that act as monopole sources of Berry curvature. Here, we introduce *multifold Hopf semimetals (MHSs)*, which feature linear N-fold crossing points each of which acts as a *Berry dipole*. We construct models with $N = 3, 4, 5$ bands and show that their physical properties are crucially affected by the Berry dipole: First, it makes the Landau level spectrum strongly dependent on the orientation of an external magnetic field. Second, it causes an anomalous Hall effect and weak field magnetoconductivities resembling the chiral anomaly, chiral magnetic and magnetochiral effects familiar from a pair of coupled Weyl nodes. Gapping out MHSs, we obtain multiband Hopf insulators (MHIs) with Hopf numbers up to $\mathcal{N}_{\rm Hopf} = 10$. MHSs and MHIs provide a fertile playground to explore delicate topology and exhibit analogies to 2D Dirac semimetals and Chern insulators.