TT 7: Topological Semimetals I

Time: Monday 9:30–13:00 Location: A 053

TT 7.1 Mon 9:30 A 053

ARPES analysis of the $Mo_xW_{1-x}Te_2$-System — •Erik Haubold[1], Dmitry Efremov[1], Matthias Gillig[1], Boy Roman Piening[1], Saicharan Aswartham[1], Alexander Fedorov[1], Yevhen Kushnirenko[1], Thirupathaiah Setti[1], Igor Morozov[1,3], Timur Kim[2], Christian Hess[1], Bernd Büchner[1], and Sergey Borisenko[1] — [1]IFW Dresden, 01069 Dresden, Germany — [2]Diamond Light Source, Didcot OX11 0DE, United Kingdom — [3]Moscow State University, Moscow 119991, Russia

WTe_2 and the corresponding sister compound $MoTe_2$ sparked a lot of interest and research as potential Weyl semimetals or in the field of Dirac and Weyl semimetals in general. Although the stoichiometric compounds as well as some intermediate doping levels have been analysed, no complete thorough investigation of the whole series has been carried out.

Recent transport data measured at IFW Dresden indicates a nonlinear behaviour of the electrical and magnetic properties when going from pure WTe_2 to $MoTe_2$. We have collected ARPES data for the whole series of materials and analysed their electronic structure to clarify whether the changes in the bandstructure can explain this.

Initial results show a significant shift of bands close to the Fermi energy resulting in a change of the size of the Fermi surfaces. We compare these results to transport data and calculations to check whether such shifts explain the nonlinearity.

TT 7.2 Mon 9:45 A 053

Effects of pressure on the Fermi surface of Cd_3As_2 — •Aleksandar Vasiljković[1], Filip Orbanić[2], Mario Novak[2], Malte Grosche[1], and Ivan Kokanović[1,2] — [1]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [2]Department of Physics, Faculty of Science, University of Zagreb, 10002 Zagreb, Croatia

Cd_3As_2 is a symmetry-protected three dimensional Dirac semimetal with high carrier mobility [1], motivating detailed investigations of the electronic structure and its evolution with applied pressures. Shubnikov-de Haas oscillations have previously been reported with frequencies of around 55T, corresponding to tiny Fermi surface pockets in a semimetallic band structure [2]. De Haas-van Alphen oscillations have also been observed with slightly smaller frequencies [2]. We have examined the Shubnikov-de Haas oscillations of the magnetoresistance in a high-quality crystal grown under different conditions over a wide range of temperature and pressure. In contrast to previous reports, we observe a significantly lower quantum oscillation frequency of 27T at ambient pressure in a direction perpendicular to c direction, which decreases significantly with increasing pressure. We also saw 35T frequency at ambient pressure in c direction. The observed SdH oscillations allow us to characterize the Fermi surface by extracting its relevant parameters.

[1] Z.Wang, et al., Physical Review B 88, 125427 (2013).
[2] A. Pariari et al., Physical Review B 91, 155139 (2015).

TT 7.3 Mon 10:00 A 053

Large Nernst power factor in polycrystalline Weyl semimetal NbP — •Satya N. Guin, Chenguang Fu, Sarah J. Watzman, Gudrun Auffermann, Nitesh Kumar, Vicky Suess, Walter Schnelle, Yan Sun, Chandra Shekhar, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

The energy crisis has sparked a large boost in thermoelectric research, the base of which is the longitudinal thermoelectric response, the Seebeck effect. Recently, there is a growing interest in the Nernst effect (NE), the transverse thermoelectric response produced by the orthogonal thermal gradient and magnetic field. The NE is an alternate and simpler approach to conventional thermoelectrics as there is no need for both n-type or p-type legs. In parallel, Dirac and Weyl semimetals created an enormous interest due to interesting transport properties, which are gaining attention recently for NE. To date, the investigations are primarily engrossed on single crystals. However, the synthesis of large single crystals is the expensive, lengthy, and difficult process, which is unsuitable for mass production and practical applications. In contrast, polycrystalline samples are the better choice because of its ease of production. We demonstrate that polycrystalline, SPS sintered Weyl semimetal NbP show a large Nernst thermopower value of 90 μVK^{-1} and power factor of 35×10^{-4} $Wm^{-1}K^{-2}$ at 9 T. Our finding indicates the potential of polycrystalline Weyl semimetals for thermoelectrics.

TT 7.4 Mon 10:15 A 053

Surface and bulk superconductivity at ambient pressure in the Weyl semimetal TaP — •Maarten van Delft[1,2], Sergio Pezzini[1,2], Markus König[3], Andrew Mackenzie[3,4], Nigel Hussey[1,2], and Steffen Wiedmann[1,2] — [1]High Field Magnet Laboratory (HFML-EMFL), Radboud University, Nijmegen, NL — [2]Radboud University, Institute for Molecules and Materials, Nijmegen, NL — [3]Max Planck Institute for Chemical Physics of Solids, Dresden, GER — [4]Scottish Universities Physics Alliance (SUPA), University of St. Andrews, St. Andrews, UK

Since the discovery of topological Weyl semimetal states in the compounds TaAs, TaP, NbAs and NbP, a considerable effort has been made to investigate their novel electronic properties. Of particular interest to this field is the search for a superconducting state, as such a state may host Majorana fermions. This search has led to observations of superconductivity in TaP under extreme pressure and after ion bombardment, but has hitherto failed to find a bulk superconductor at ambient pressure. We report on the observation of a superconducting state in Tantalum Phosphide (TaP) without any additional treatment to the material or under any extreme conditions. A Tc varying between 1.7 and 5.3 K for different samples was observed, both for microscopic samples processed with focused ion beam (FIB) etching as well as for an as-grown crystal. Our data show that the superconductivity present in our untreated crystal is inhomogeneous yet exists in the bulk. For samples made with FIB, we observe additionally a two-dimensional superconducting film on the sample surface.

TT 7.5 Mon 10:30 A 053

Giant anomalous Nernst effect in Weyl semimetals TaP and TaAs — •Federico Caglieris[1], Christoph Wuttke[1], Steffen Sykora[1], Vicky Süss[2], Shekhar Chandra[2], Claudia Felser[2], Bernd Büchner[1,3,4], and Christian Hess[1,4] — [1]Leibniz-Institute for Solid State and Materials Research, 01069 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01069 Dresden, Germany — [3]Institut für Festkörperphysik, TU Dresden, 01069 Dresden, Germany — [4]Center for Transport and Devices, TU Dresden, 01069 Dresden, Germany

The discovery of Weyl fermions in transition metal monoarsenides/phosphides without inversion symmetry represents an exceptional breakthrough in modern condensed matter physics. However, exploring the inherent nature of these quasiparticles is experimentally challenging because most of the experimental probes rely on analyzing the Fermi arc topology or investigating the elusive chiral anomaly.

In this work we experimentally investigate the thermoelectric transport of the prototypical type-I Weyl semimetals TaP and TaAs. In particular we show that both the compounds possess a giant Nernst coefficient, which tends to saturate with increasing the magnetic field. This behavior resembles what is typically addressed as anomalous Nernst effect and it has recently been interpreted as a direct consequence of the finite Berry curvature originated from the Weyl points. Our results thus promote the Nernst coefficient as an ideal bulk probe for detecting and exploring the fingerprints of emergent Weyl physics.

TT 7.6 Mon 10:45 A 053

Giant anomalous Nernst effect in Weyl semimetals TaP and TaAs - Theory — •Steffen Sykora[1], Federico Caglieris[1], Christoph Wuttke[1], Bernd Büchner[1,2,3], and Christian Hess[1,3] — [1]IFW Dresden, 01069 Dresden, Germany — [2]Institute for Solid State Physics, TU Dresden, 01069 Dresden, Germany — [3]Center for Transport and Devices, TU Dresden, 01069 Dresden, Germany

In Weyl semimetals the Nernst coefficient is dominated by anomalous contributions to the electrical and thermal conductivity which originate from a specific property of the underlying system of conduction electrons, the Berry curvature. Motivated by recent experiments on the prototypical type-I Weyl semimetals TaP and TaAs we explain the measured anomalous field dependence of the Nernst coefficient in terms

of a minimal model of the energy dispersion near two separated Dirac nodes. On the basis of this result we argue that our observed field dependence of the Nernst effect can straightforwardly be explained by a characteristic change of the chemical potential under variation of the external magnetic field which is applied to obtain the Nernst effect.

TT 7.7 Mon 11:00 A 053

Transport studies on the type-II Weyl semimetal candidate WTe_2 — •Matthias Gillig[1,2], Federico Caglieris[1], Boy Roman Piening[1], Igor Morozov[1,4], Saicharan Aswartham[1], Joseph Dufouleur[1], Bernd Büchner[1,2,3], and Christian Hess[1,2,3] — [1]Leibniz-Institute for Solid State and Materials Research, IFW Dresden, 01069 Dresden, Germany — [2]Institute of Solid State Physics, TU Dresden, 01069 Dresden, Germany — [3]Center for Transport and Devices of Emergent Materials, TU Dresden, 01069 Dresden, Germany — [4]Moscow State University, 119991 Moscow, Russia

The semimetal WTe_2 has attracted attention due to its non-saturating extremely large magnetoresistance. Furthermore, it has been the first compound to be predicted as a type-II Weyl semimetal which supposedly gives rise to new topological characteristics.

We have performed a broad spectrum of transport studies on WTe_2 single crystals. The peculiar magnetoresistance was reproduced while the Hall effect behaves normally. Likewise, the thermoelectric transport coefficients show no anomalous behavior. The thermopower is negative at high temperatures, changes sign at 50 K and develops a peak at 25 K. The Nernst signal is linear in field but shows a strong increase below 50 K. The thermal conductivity increases upon cooling with a phononic peak at 21 K. All results can explicitly be described by a simple two-band model where electron- and hole-like carriers are compensated and exhibit large mobilities.

15 min. break.

TT 7.8 Mon 11:30 A 053

Spectacular electrical transport in type-II Weyl semimetals WP_2 and MoP_2 — •Nitesh Kumar[1], Yan Sun[1], Nan Xu[2], Kaustuv Manna[1], Vicky Suess[1], Inge Leermakers[3], Tobias Foerster[4], Horst Borrmann[1], Uli Zeitler[3], Ming Shi[2], Claudia Felser[1], and Chandra Shekhar[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Paul Scherrer Institute, Switzerland — [3]High Field Magnet Laboratory, Nijmegen, Netherlands — [4]Dresden High Magnetic Field Laboratory, Dresden, Germany

Semimetals are in general less conducting compared to metals due to smaller number of charge carriers. However, recent progress in the topological Dirac and Weyl semimetals show spectacular electronic properties such as large mobilities accompanied by extremely high magnetoresistance. In particular, two closely neighbouring Weyl points of the same chirality are protected from annihilation by structural distortions or defects. Here we present the electronic properties of type-II Weyl semimetals, WP_2 and MoP_2, with robust Weyl points by transport and angle resolved and first principles calculations. Single crystals of WP_2 display an extremely low residual low-temperature resistivity of 3 nΩ cm accompanied by an enormous and highly anisotropic magnetoresistance above 200 million % at 63 T and 2.5 K [1]. A large suppression of charge carrier backscattering in WP_2 from transport measurements suggests the involvement of the novel Weyl fermions expressed in this compound.

[1] N. Kumar *et al.*, *Nature Commun.* **8**, (2017) 1642.

TT 7.9 Mon 11:45 A 053

Large anomalous Nernst effect driven by Berry curvature in Mn_3Ge — •Christoph Wuttke[1], Federico Caglieris[1], Kaustuv Manna[2], Steffen Sykora[1], Chandra Shekhar[2], Claudia Felser[2], Bernd Büchner[1,3,4], and Christian Hess[1,4] — [1]Leibniz-Institute for Solid State and Materials Research, IFW-Dresden, 01069 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [3]Institut für Festkörperphysik, TU Dresden, 01069 Dresden, Germany — [4]Center for Transport and Devices, Technische Universität Dresden, 01069 Dresden, Germany

Introducing Berry phase and curvature as properties of the electronic structure has not only started the quest for finding Weyl semimetal candidates, it was also predicted that the occurance of Weyl points in the band structure can lead to peculiar transport behaviour. We report Nernst effect measurements on the chiral antiferromagnet Mn_3Ge. A large anomalous compound dominates the magnetic field dependence of the Nernst signal and does not scale with the magnetization. Our theoretical examination shows that the anomalous behaviour is strongly influenced by the finite Berry curvature. The results show a significant sensitivity of transverse thermoelectric transport to the existence of Weyl points close to the Fermi surface.

TT 7.10 Mon 12:00 A 053

Quantum interference effects in 3D-Dirac antiperovskites — •Hiroyuki Nakamura[1], Johannes Merz[1], Eslam Khalaf[1], Pavel Ostrovsky[1], Debakanta Samal[3], and Hidenori Takagi[1,2,4] — [1]Max Planck Institute for Solid State Research, Germany — [2]Department of Physics, University of Tokyo, Japan — [3]Institute of Physics, India — [4]Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Germany

Magnetotrasport study has been carried out using epitaxial thin films of Sr_3PbO and Sr_3SnO grown by MBE. All the films showed clear 3D localization but differed in the sign of quantum interference governing the localization effect, which was associated with the location of E_F with respect to Dirac nodes. Detailed analysis of the localization effects for Dirac electrons will be presented.

TT 7.11 Mon 12:15 A 053

Correlation meets topology: quasiparticles along the Dirac nodal loop in ZrSiS — Sergio Pezzini[1], Maarten van Delft[1], Leslie Schoop[2], Bettina Lotsch[2], Antony Carrington[3], Misha Katsnelson[4], Nigel Hussey[1], and •Steffen Wiedmann[1] — [1]High Field Magnet Laboratory (HFML-EMFL), Radboud University, Nijmegen 6525 ED, NL — [2]Max Planck Institute for Solid State Research, 70569 Stuttgart, GER — [3]H. H. Wills Physics Laboratory, University of Bristol, Bristol BS8 1TL, UK — [4]Radboud University, Institute for Molecules and Materials, Nijmegen 6525 AJ, NL

ZrSiS belongs to the recently discovered family of topological Dirac materials whose electronic structure hosts Dirac-like crossing points that form a closed loop at the Fermi level. While transport measurements have shown the presence of small electron and hole pockets via the observation of low-frequency Shubnikov-de Haas oscillations, experimental evidence for the enhanced correlation effects predicted to occur in this class of semi-metals has until now been lacking. We have performed a quantum oscillation study of the nodal-loop in high magnetic fields that reveals significant enhancement in the quasi-particle mass residing near the nodal loop. Above a threshold magnetic field ($B > 25$ T), magnetic breakdown occurs across gaps in the loop structure with orbits that enclose different windings around its vertices. The analysis of the amplitudes of these breakdown orbits reveals an anomalous temperature dependence demonstrating the emergence of novel, correlation-driven physics in ZrSiS associated with the Dirac-like quasiparticles [1].

[1] S. Pezzini et al., Nature Physics, doi:10.1038/nphys4306 (2017).

TT 7.12 Mon 12:30 A 053

Correlation-driven electron-hole instability in nodal-line semimetal ZrSiS — •Alexander Rudenko[1,2,3], Evgeny Stepanov[1,2], Alexander Lichtenstein[4], and Mikhail Katsnelson[1] — [1]Radboud University, Nijmegen, The Netherlands — [2]Ural Federal University, Ekaterinburg, Russia — [3]Wuhan University, Wuhan, China — [4]Hamburg University, Hamburg, Germany

ZrSiS is an emerging material, which belongs to the class of 3D materials that feature a nodal line in the electronic band structure [1]. Recent experimental observations reveal an unconventional mass enhancement of quasiparticles in ZrSiS [2], which suggests the importance of electron correlation effects in this material. Here, we study many-body effects in ZrSiS using a combination of first-principles calculations and model approaches, taking the correlation effects perturbatively. We show that at moderately low temperatures ZrSiS exhibit electron-hole instability, leading to the formation of a pseudogap in the electronic spectrum. The results can be understood in terms of Coulomb-interaction-assisted electron-hole pairing reminiscent to that of a conventional superconductor.

[1] L.M. Schoop et al. Nat. Commun. 7, 11696 (2016).
[2] S. Pezzini et al. Nat. Phys. doi:10.1038/nphys4306 (2017).

TT 7.13 Mon 12:45 A 053

Optical Conductivity Studies of the half-Heusler Compounds GdPtBi, LuPtBi, YPtBi and YbPtBi — •Felix Hütt[1], Micha B. Schilling[1], Martin Dressel[1], Claudia Felser[2], and Artem V. Pronin[1] — [1]1. Physikalisches Institut, Universität Stuttgart, 70569 Stuttgart, Germany — [2]Max Planck Institute for Chemical

Physics of Solids, 01187 Dresden, Germany

Many Heusler and half-Heusler compounds are known for their diverse and appealing physical properties. Some of the compounds are predicted to possess non-trivial topological electronic structure. Although the non-trivial topology has already been discussed by theory for a few years, experiments so far remain pretty much behind theory.

In this contribution, we report on experimental investigations of the optical response of four different half-Heusler compounds (GdPtBi, LuPtBi, YPtBi, YbPtBi) using Fourier-transform infrared spectroscopy. Reflectivity measurements were performed over a large frequency range, 10 to 3000 meV, at different temperatures down to 10 K. From the measured reflectivity, the optical conductivity and the dielectric function were extracted via the Kramers-Kronig relations. In the talk, we compare our results with theoretical predictions for optical manifestations of possible Dirac physics in these materials.