MA 48: Topological Semimetals - Experiment (joint session TT/MA)

Time: Thursday 15:00–17:45 Location: H2

MA 48.1 Thu 15:00 H2

Electronic structure of Weyl semimetal TaAs under pressure — •Zuzana Medvecka, Marcel Naumann, Markus Schmidt, Vicky Süss und Michael Nicklas — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Weyl semimetals are topological materials with linear band dispersion around pair of nodes with fixed opposite chirality. The quasiparticles from such nodes are predicted to induce novel quantum mechanical phenomena, such as Fermi arcs. However, to observe them in transport experiments, the Weyl nodes have to be sufficiently close to the Fermi level. Tantalum arsenide is a Weyl semimetal with a well-studied electronic structure, where the Weyl nodes lie 6 meV from Fermi level [1].

Here, we study how hydrostatic pressure impacts the Fermi level and electronic structure of TaAs. Quantum oscillations in resistivity of single-crystal TaAs samples are investigated in a piston type pressure cell. Pressure dependence of the electronic structure in TaAs is then obtained from the evolution of quantum oscillation frequencies.

[1] F. Arnold, M. Naumann, S.-C. Wu, Y. Sun, M. Schmidt, H. Borrmann, C. Felser, B. Yan and E. Hassinger, PRL 117, 146401 (2016)

MA 48.2 Thu 15:15 H2

Absence of the chiral anomaly - the longitudinal magnetoresistance in TaAs-type Weyl metals — •Marcel Naumann[1,2], Frank Arnold[1], Maja Bachmann[1], Kimberley Modic[1], Vicky Süss[1], Marcus Schmidt[1], Philip Moll[1], Brad Ramshaw[3], and Elena Hassinger[1,2] — [1]MPI CPfS, Dresden, Germany — [2]Technische Universität München, Garching, Germany — [3]Cornell University, Ithaca, NY, USA

The discovery of materials with 3D linear band-crossing points close to the Fermi level, such as Dirac and Weyl semimetals, has offered the possibility to study relativistic fermions in solid state systems. One manifestation, the 'chiral anomaly', should appear as a reduction of the longitudinal magnetoresistance (LMR), as was quickly observed in TaAs [1]. Subsequent studies found that current inhomogeneities ('current jetting') often induce an apparent negative LMR in semimetals, and that the true LMR is still unknown [2,3].

In this study, we determine the intrinsic LMR in the TaAs family (TaAs, TaP, NbAs, NbP) of Weyl semimetals. We reduced current jetting effects by trying to achieve a homogeneous current injection and by increasing the aspect ratio of our samples. The results show an *absence* of the negative LMR in chiral materials and a *presence* of a negative LMR in non-chiral materials. This suggests a chirality independent effect, which we believe to be weak-localisation physics.

[1] Huang et at., PRX 5, 031023 (2015)
[2] Arnold et al., Nat. Com. 7, 11615 (2016)
[3] dos Reis et al., New J. Phys. 18, 085006 (2016)

MA 48.3 Thu 15:30 H2

Magneto-optical response of the Weyl semimetal TaP — •Sascha Polatkan[1], Milan Orlita[2], Artur Slobodeniuk[2], Mark O. Goerbig[3], Chandra Shekhar[4], Claudia Felser[4], Martin Dressel[1], and Artem V. Pronin[1] — [1]1. Physikalisches Institut, Universität Stuttgart, 70569 Stuttgart, Germany — [2]LNCMI, CNRS-UGA-UPS-INSA-EMFL, 38042 Grenoble, France — [3]LPS, Univ. Paris-Sud, Univ. Paris-Saclay, CNRS UMR 8502, 91405 Orsay, France — [4]MPI für Chemische Physik fester Stoffe, 01187 Dresden, Germany

Theory predicts that TaP, being structurally akin to TaAs, hosts two distinct Weyl-type band crossings. Optical (infrared) spectroscopy in magnetic fields offers crucial information about the band structure by means of analyzing the inter-Landau-level transitions. We investigated the magneto-optical response of TaP up to $B = 33$ T in the infrared regime ($5 - 200$ meV). The reflection spectra are rich of features, many of which show a $\sqrt{B}$-dependence, hinting at the massless nature of the involved (presumably Weyl) bands. Moreover, we observe a peculiar fan-shaped subset of the transitions. In this subset, the energies of some of the transitions increase, while the energies of other transitions decrease with field. We discuss how the topological nature of the involved bands might be connected to this peculiar behavior.

MA 48.4 Thu 15:45 H2

Dirac semimetal $PtBi_2$: polymorphism and challenges in crystal growth — •Grigory Shipunov, Boy Roman Piening, Saicharan Aswartham, and Bernd Büchner — IFW-Dresden, Dresden, Germany

$PtBi_2$ is showing rich polymorphism, with at least 3 different crystal structures corresponding to this composition are reported. At least two of this structures, pyrite-type cubic (space group $Pa\bar{3}$) and hexagonal (space group $P31m$), are showing linearly dispersive Dirac states and anomalous transport properties, such as extremly large linear magnetoresistance.

Here, we present our results on targeted crystal growth of cubic or hexagonal modification. Cubic and hexagonal modifications were grown via self-flux method, with growth parameteres such as Pt:Bi ratio and temperature profile chosen based on thermodynamical phase diagram data. High quality of the crystals is confirmed by powder and single crystal x-ray diffraction and scanning electron microscopy with energy dispersive x-ray spectroscopy techniques. Optimization of the growth parameters for the metastable trigonal polymorph is also discussed.

MA 48.5 Thu 16:00 H2

Chemical-pressure effect on the optical conductivity of topological nodal-line semimetals of ZrSiS type — •Markus Krottenmüller[1], Jihaan Ebad-Allah[1,2], Juan Fernandez Afonso[3], Zhiqiang Mao[4], Jan Kunes[3,5], and Christine Kuntscher[1] — [1]Experimentalphysik II, Universität Augsburg, 86159 Augsburg, Germany — [2]Department of Physics, Tanta University, 31527 Tanta, Egypt — [3]Institute of Solid State Physics, TU Wien, 1020 Vienna, Austria — [4]Department of Physics and Engineering Physics, Tulane University, New Orleans, LA 70118, USA — [5]Institute of Physics, The Czeck Academy of Sciences, 18221 Praha, Czech Republic

ZrSiS is a prototype nodal-line semimetal, whose electronic band structure contains a diamond-shaped nodal line. We studied the optical conductivity of ZrSiS and other members of the compound family ZrXY with X=Si, Ge and Y =S, Se, Te by reflectivity measurements over a broad frequeny range. The optical conductivity spectrum of ZrSiS has a distinct U-shape, ending at a sharp high-energy peak. Other ZrXY compounds have a very similar profile of the optical conductivity, except ZrSiTe. We will discuss our findings in terms of the theoretical optical conductivity obtained by density functional theory calculations.

MA 48.6 Thu 16:15 H2

ZrP_2 family of materials as topological semimetal candidates — Jörn Bannies[1,2], Elia Razzoli[2], Matteo Michiardi[1,2], •Ilya Elfimov[2], Andrea Damascelli[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Quantum Matter Institute, University of British Columbia, Vancouver, Canada

In recent years transition metal pnictides including dipnictides have attracted much research interest in the context of topological semimetals. These include type-I and type-II Weyl semimetals, triple-point fermions and weak topological insulators. Here we propose group IV dipnictides as potential nodal line semimetals, a class with only a few verified members to date.

We have successfully grown crystals of ZrP_2 and $ZrAs_2$ and, for the first time, investigated their transport properties. These materials are isostructural and crystallize in the non-symmorphic space group *Pnma*. For ZrP_2 an unsaturated magnetoresistance of $1.5{\cdot}10^4$ % at 2 K and 9 T with nearly quadratic field dependence is observed. This is accompanied by a resistivity plateau up to 20 K in high magnetic fields. Similar behavior in other topological semimetals suggests a topological origin. Indeed, ZrX_2 (X = P, As) compounds were recently identified as topological materials. Our DFT band structure calculations show a Dirac like band crossing close to the Fermi level as well as a nodal line in the k_x=0 plane. We discuss the role of non-symmorphic symmetry in stabilizing these features.

15 min. break.

MA 48.7 Thu 16:45 H2

Effect of inversion symmetry on the excitations in WP_2 —
•Dirk Wulferding[1,2], Peter Lemmens[1,2], Yurii Pashkevich[1,3], Tanya Shevtsova[3], Claudia Felser[4], and Chandra Shekhar[4] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]LENA, TU-BS, Braunschweig, Germany — [3]Galkin DonFTI, Kyiv, Ukraine — [4]MPI CPfS, Dresden, Germany

The two structural modifications of WP_2, one with and one without a center of inversion, allow to probe the effect of global symmetry on a Weyl semimetal. In our report we uncover phonon anomalies as well as electronic fluctuation of both phases using Raman scattering and compare their impact on anomalous charge transport [1,2,3].

Work supported by QUANOMET NL-4 and DFG LE967/16-1.

[1] Kumar et al., Nat. Commun. 8, 1642 (2017)
[2] Gooth el al., arXiv:1706.05925 (2017)
[3] Du et al., PRB 97, 245101 (2018)

MA 48.8 Thu 17:00 H2

Magnetotransport in microribbons of the magnetic Weyl semimetal $Co_3Sn_2S_2$ —
•Kevin Geishendorf[1], Richard Schlitz[2], Praveen Vir[3], Chandra Shekhar[3], Claudia Felser[3], Kornelius Nielsch[1], Sebastian T.B. Goennenwein[2], and Andy Thomas[1] — [1]Leibniz Institute for Solid State and Materials Research Dresden, Institute for Metallic Materials — [2]Institut für Festkörper- und Materialphysik — [3]Max Planck Institute for Chemical Physics of Solids, Dresden

Magnetic Weyl semimetals exhibit intriguing phenomena due to their non-trivial band structure. Recent experiments in bulk crystals have shown that shandite-type $Co_3Sn_2S_2$ is a magnetic Weyl semimetal [1,2]. To access the length scales relevant for electrical transport, it is mandatory to fabricate microstructures of this fascinating compound. We therefore have cut microribbons (typical size 0.3 x 3 x 50 μm^3) from $Co_3Sn_2S_2$ single crystals using a focused beam of Ga^{2+}-ions (FIB) and investigated the impact of the sample dimensions and possible surface doping on the magnetotransport properties. The large intrinsic anomalous Hall effect observed in the microribbons is quantitatively consistent with the one in bulk samples [1]. It is evident from our results that FIB cutting can be used for patterning single crystalline $Co_3Sn_2S_2$, enabling future transport experiments in complex microstructures of this compound.

[1] E. Liu et al., Nat. Phys. **14**, 1125-1131 (2018)
[2] Q. Wang et al., Nat. Commun. **9**, 3681 (2018)

MA 48.9 Thu 17:15 H2

Comparative analysis of the effects of pressure on Bi, NbP and Cd_3As_2 —
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Bismuth is a non-topological low carrier density semimetal, which has been investigated for a long time [1]. Cd_3As_2 is a symmetry-protected three dimensional Dirac semimetal with high carrier mobility [2]. Shubnikov-de Haas oscillations have previously been reported with frequencies of around 55 T, corresponding to tiny Fermi surface pockets in a semimetallic band structure [3]. NbP is a Weyl semimetal with large magnetoresistance and very high mobility[4]. We present a comparative analysis of the Shubnikov-de Haas oscillations of these three materials under pressure.

[1] L. Shubnikov, W. Y. de Haas, Comm. Phys. Lab. Univ. Leiden, 207a, 207c, 207d, 210a (1930)
[2] Z.Wang, et al., Phys. Rev. B 88, 125427 (2013)
[3] A. Pariari et al., Phys. Rev. B 91, 155139 (2015)
[4] C. Shekhar et al, Nat. Phys. 11, 724 (2015)

MA 48.10 Thu 17:30 H2

Spin-orbital texture in $MoTe_2$ and its response to the phase transition —
•Andrew Patton Weber[1,2,3], Philipp Rüssmann[4], Nan Xu[2,3], Stefan Muff[2,3], Mauro Fanciulli[2,3], Arnaud Magrez[2], Philippe Bugnon[2], Helmuth Berger[2], Nicholas C. Plumb[3], Ming Shi[3], Stefan Blügel[4], Phivos Mavropoulos[4], and J. Hugo Dil[2,3] — [1]Donostia International Physics Center, 20018 Donostia, Gipuzkoa, Spain — [2]Institute of Physics, École Polytechnique Fédérale de Lausanne, CH-1015, Lausanne, Switzerland — [3]Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen, Switzerland — [4]Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

The basis of exotic electromagnetic phenomena in $MoTe_2$ lies not only in the electronic band structure, but also in the crystal-momentum-dependence of spin-orbit-entangled wave functions. Here we discuss the challenges involved in obtaining this information directly from experiments and report the angular distribution of photoelectron spin-polarization and intensity dichroism in $MoTe_2$. A novel spin-orbital texture is uncovered in the bulk Fermi surface that is consistent with first-principles calculations. The spin-texture is three-dimensional and is not completely suppressed above the centrosymmetry-breaking transition temperature of the bulk crystal. The results indicate that a new form of polar instability exists near the surface when the bulk is largely in a centrosymmetric phase.