MA 59: Topological Insulators II (jointly with DS, HL, O, TT)

Time: Friday 9:30–11:30 Location: HSZ 04

MA 59.1 Fri 9:30 HSZ 04

Laser induced DC photocurrents in a Topological Insulator thin film — •Nina Meyer[1], Thomas Schumann[1], Eva Schmoranzerová[2], Helena Reichlová[3], Gregor Mussler[4], Petr Nemec[2], Detlev Grützmacher[4], and Markus Münzenberg[1] — [1]Institute of Physics, Ernst-Moritz-Arndt University, Greifswald, Germany — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic — [3]Institute of Physics ASCR v.v.i., Prague, Czech Republic — [4]Inst. for Semiconductor Nanoelectronics, Peter Grünberg Institute-9, Forschungszentrum Jülich, Germany

Recent experiments indicate that the optical excitation of spin-polarized surface states of topological insulators (TI) can launch electron currents along the surface. The current's direction can be controlled by varying the polarization of the driving light. We investigated if the spin-polarized current can be optimized by changing the angle of incident and the position of the laser spot on the sample. The used TI (Bi, Sb)$_2$Te$_3$ thin films with a thickness of 20 nm were structured to Hall bar devices. We successfully generated a photocurrent by illuminating the TI thin films with laser light whose polarization changes periodically. Analyzing the contributions of the photocurrent we detected a spin-polarized current. We found that the spin-polarized current is near-constant for angles of incident between 35° and 65° and that the position of the laser spot on the sample affects the spin-polarized current more than the angle of incident.
We acknowledge funding through DFG priority program SPP "Topological Insulators" and DAAD PPP Czech Republic "FemtomagTopo".

MA 59.2 Fri 9:45 HSZ 04

Origin of Dirac cones in projected band-gaps: W(110) — •Gustav Bihlmayer[1], Andrei Varykhalov[2], Oliver Rader[2], and Stefan Blügel[1] — [1]Peter Grünberg Institut (PGI-1) & Institute for Advanced Simulation (IAS-1), Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Elektronenspeicherring BESSY II, Albert-Einstein-Str. 15, 12489 Berlin, Germany

Angle-resolved photoemission experiments show the existence of band-crossings with linear dispersion - often called Dirac-cones - in the projected band gaps of W(110) and Au-covered W(110). While previous studies focused on a Dirac-cone at the $\overline{\Gamma}$-point and the possible connection to the topology of the bulk band-structure [1], we analyze the band-crossings in the metallic regions of the band structure along the $\overline{\Gamma - N}$ line of the Brillouin zone where such a term is not well defined. Based on density functional theory calculations we elucidate the origin of these crossings and find three necessary ingredients for the evolution of such structures: (i) the crossing of two surface states of different symmetry (ii) the presence of spin-orbit coupling that leads to a Rashba-type splitting of these states and (iii) mirror symmetry that protects the crossing point of the bands [2]. We discuss the relation of this mirror symmetry to the properties of topological crystalline insulators, which show similar Dirac-cones in global band-gaps.
Financial support of the DFG (SPP 1666) is gratefully acknowledged.
[1] D. Thonig et al., Phys. Rev. B. **94**, 155132 (2016).
[2] A. Varykhalov et al., submitted (2016).

MA 59.3 Fri 10:00 HSZ 04

Chiral anomaly and negative longitudinal magnetoresistance in Weyl semimetals within a Boltzmann approach — •Annika Johansson[1,2], Julia Weiner[2], Jürgen Henk[2], and Ingrid Mertig[2,1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

In Weyl semimetals, the application of non-orthogonal electric and magnetic fields gives rise to the chiral anomaly. The breaking of the chiral symmetry results in nonconservation of chiral charge [1-3]. Phenomena related to the chiral anomaly are the anomalous Hall effect, the chiral magnetic effect, and the negative longitudinal magnetoresistance (NLMR).

We consider the chiral anomaly in Weyl semimetals for small magnetic fields [4]. Using a semiclassical Boltzmann approach, we investigate the increase of the longitudinal charge conductivity related to the chiral anomaly. The longitudinal magnetoresistance is calculated for model systems including anisotropic and energy dependent momentum relaxation times. The energy dependence of the scattering processes has a pronounced effect on the magnitude of the NLMR, whereas the influence of the relaxation time anisotropy is negligible.

[1] S. Adler, Phys. Rev. **177**, 2426 (1969)
[2] J. S. Bell and R. Jackiw, Nuovo Cimento A **60**, 47 (1969)
[3] H. B. Nielsen and M. Ninomiya, Phys. Lett. B **130**, 389 (1983)
[4] D. T. Son and B. Z. Spivak, Phys. Rev. B **88**, 104412 (2013)

MA 59.4 Fri 10:15 HSZ 04

Topological Weyl semimetals in the chiral antiferromagnetic materials Mn3Ge and Mn3Sn — •Hao Yang[1,2], Yan Sun[2], Yang Zhang[2,3], Wu-Jun Shi[2], Stuart S. P. Parkin[1], and Binghai Yan[2] — [1]Max Planck Institute of Microstructure Physics, 06120 Halle(Saale), Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [3]Leibniz Institute for Solid State and Materials Research, 01069 Dresden, Germany

It was recently found in experiment that Mn3Sn and Mn3Ge exhibit a strong anomalous Hall effect at room temperature, provoking us to explore their electronic structures for topological properties. By ab initio band structure calculations, we have observed the existence of multiple Weyl points in the bulk and corresponding Fermi arcs on the surface, predicting antiferromagnetic Weyl semimetals in the titled compounds [1]. Here the chiral antiferromagnetism in the Kagome-type lattice structure is essential to determine the positions and numbers of Weyl points. Our work further reveals a new guiding principle to search for magnetic Weyl semimetals among materials that exhibit a strong anomalous Hall effect. [1] H Yang, Y Sun, Y Zhang et.al., arXiv preprint arXiv:1608.03404 (2016)

MA 59.5 Fri 10:30 HSZ 04

Strong intrinsic spin Hall effect in the TaAs-family of Weyl semimetals — •Yan Sun[1], Yang Zhang[1,2], Claudia Felser[1], and Binghai Yan[1,3] — [1]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [2]Leibniz Institute for Solid State and Materials Research, 01069 Dresden, Germany — [3]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden,Germany

Since their birth topological insulators have been expected to be ideal spintronic materials due to the spin currents carried by the surface states with spin-momentum locking . However, the bulk doping problem still remains to be an obstacle that hinders such application. In this work, we predict that a newly discovered family of topological materials, the Weyl semimetals, exhibits large intrinsic spin Hall effects that can be utilized to generate and detect spin currents[1]. Our ab-initio calculations reveal large spin Hall conductivity that is comparable to that of 4d and 5d transition metals. The spin Hall effect originates intrinsically from the bulk band structure of Weyl semimetals that exhibits large Berry curvature and spin-orbit coupling, naturally avoiding the bulk carrier problem in the topological insulators. Our work not only paves a way to employ Weyl semimetals in spintronics, but also proposes a new guideline to search for spin Hall effect materials in various topological materials.

[1] Yan Sun, Yang Zhang, Claudia Felser, and Binghai Yan, Phy. Rew. Lett. 117, 146403 (2016)

MA 59.6 Fri 10:45 HSZ 04

Dzyaloshinskii-Moriya interaction in graphene nanoribbons on topological insulator substrates — •Farideh Hajiheidari[1], Wei Zhang[2], Yan Li[3], and Riccardo Mazzarello[1,4] — [1]Institute for Theoretical Solid State Physics, RWTH Aachen University, Aachen, Germany — [2]Center for Advancing Materials Performance from the Nanoscale, State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, China — [3]Institute IEK-6, Forschungszentrum Jülich, Germany — [4]JARA-FIT and JARA-HPC, RWTH Aachen University, Aachen, Germany

The three-dimensional topological insulators (TIs) realize an unconventional electronic phase originating from time-reversal symmetry and strong spin-orbit coupling. These class of material have conducting surface states in the bulk band gap. The surface states strongly affect the coupling between the magnetic impurities deposited on the surface. In this work, we present a first-principles investigation of zigzag graphene nanoribbons (GNRs) on the (111) surface of the topological insulator Sb2Te3. We consider unpassivated edges, which bind strongly to the substrate. In spite of the strong interaction between the edge atoms and the TI surface, the edge magnetism is preserved. However, the spins at the GNR edges are twisted due to the Dzyaloshinskii-Moriya interaction (DMI) which appears in magnetic systems that lack inversion symmetry and exhibit strong SOC. This results in a finite net magnetization due to the deviation from the perfect AFM coupling, and leads to a shift of the Dirac point of the surface state of the TI and can even open a small gap depending on its direction.

MA 59.7 Fri 11:00 HSZ 04

Is SmB$_6$ a failed superconductor — •Onur Erten — Max Planck Institute for the Physics of Complex Systems, Dresden

The classic theory of superfluids and superconductors is founded on London's idea of "wavefunction rigidity", in which gradients of the phase of the ground-state condensate carry the superflow. However, the study of neutral superfluids teaches that a stable superflow also requires the topological quantization of circulation: when this is absent, as in the case of He-3A, the superflow is unstable. Here, we generalize this idea to charged superfluids, introducing the concept of a failed superconductor in which a higher order parameter manifold topologically destablizes vortices, causing a rapid decay of supercurrents, giving rise to a novel diamagnetic insulator. We apply this idea to the case of SmB$_6$, arguing that the observation of a gapless diamagnetic Fermi surface within an insulating bulk can be understood as a failed odd-frequency superconductor. Our results enable us to understand the linear specific heat of SmB$_6$ in terms of a neutral Majorana Fermi surface and lead us to predict that in low fields, SmB$_6$ will develop a Meissner effect.

MA 59.8 Fri 11:15 HSZ 04

Instability of the topologically protected surface state inBi$_2$Se$_3$ upon deposition of gold — •Andrey Polyakov[1], Holger L. Meyerheim[1], Christian Tusche[2], Daryl E. Crozier[3], and Arthur Ernst[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany, Germany — [3]Department of Physics, Simon Fraser University Burnaby, BC Canada, V5A 1S6

We present an experimental and theoretical analysis of the stability of the Topological surface state (TSS) in Bi_2Se_3 upon sub-monolayer deposition of Au. Extended x-ray absorption fine structure experiments provide clear evidence that Au -when deposited on the (0001) surface kept at 160 K- substitutes Bi atoms within the first quintuple layer. This goes in parallel with the dramatic weakening of the spectral density of the TSS as observed by angular resolved photoemission. In accordance with first-principles calculations, Au in Bi substitutional sites within the first QL creates a d-type resonant state near E_F, which hybridizes with the TI bands and substantially modifies its surface electronic structure. According to the model of Black-Schaffer et al. [1] a bulk-surface interaction is a prerequisite for the gap opening, since the TSS is not protected by scattering processes involving bulk three-dimensional states. References: [1] A. M. Black-Schaffer and A. V. Balatsky, Phys. Rev. B 86, 115433 (2012). Acknowedgements: Work supported by SPP 1666. Work at the APS is supported by the U.S. DOE under Contract No. DE-AC02-06CH11357.