HL 85: Topological insulators (TT, jointly with DS, HL, MA)

Time: Thursday 15:00–18:00 Location: H18

Topical Talk HL 85.1 Thu 15:00 H18

Correlation Effects in Quantum Spin Hall Insulators — •MARTIN HOHENADLER — Theoretische Physik I, Universität Würzburg, 97074 Würzburg, Germany

Time-reversal invariant insulating states with topological properties, including topological insulators, have been in the focus of research in recent years. On the theoretical side, electronic correlation effects are of particular interest, as they can both destroy and create topological phases. This talk gives an overview of research on two-dimensional, correlated topological insulators, with a focus on quantum Monte Carlo results for the Kane-Mele-Hubbard model.

HL 85.2 Thu 15:30 H18

All in-ultra-high-vacuum study of thin film topological insulators: Bi_2Te_3 — •KATHARINA HOEFER, DIANA RATA, CHRISTOPH BECKER, and LIU HAO TJENG — Max Planck Institute for Chemical Physics of Solids

Thin films of topological insulators offer the possibility for the experimental study of the expected spectacular phenomena occurring at the surface of or interface with these materials due to the increased surface to bulk ratio in comparison to bulk crystals. Bulk materials are always defective which leads to extra contributions in conductance.

High quality thin films of Bi_2Te_3 were grown on α-Al_2O_3(0001) and BaF_2(111) using Molecular Beam Epitaxy. A two-step growth procedure provides high quality epitaxial films despite the large lattice mismatch of 9% to Al_2O_3; the mismatch to BaF_2 is less than 1%.

To protect the surface integrity an all in-ultra-high-vacuum study is crucial. This means not only the preparation and characterization by RHEED, LEED, XPS and ARPES, but especially the transport measurements are performed in-ultra-high-vacuum. The results of this study and ongoing work will be presented.

HL 85.3 Thu 15:45 H18

Magnetotransport in MBE-grown topological insulator $(Bi_{1-x}Sb_x)_2Te_3$ thin films — •CHRISTIAN WEYRICH[1], TOBIAS MERZENICH[1], IGOR E. BATOV[1,2], GREGOR MUSSLER[1], JÖRN KAMPMEIER[1], YULIETH ARANGO[1], DETLEV GRÜTZMACHER[1], and THOMAS SCHÄPERS[1,3] — [1]Peter Grünberg Institute (PGI-9), Research Centre Jülich GmbH, 52425 Jülich, Germany — [2]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, 142432, Moscow Distr., Russia — [3]II. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany

We report on the magnetotransport study of topological insulator $(Bi_{1-x}Sb_x)_2Te_3$ thin films. The films were grown on a silicon on insulator (SOI) substrate with a Si(111)-layer on top by molecular beam epitaxy. In Bi_2Te_3 samples, we observed a positive magnetoresistance at low magnetic fields with a cusplike minimum at $B = 0$ (weak antilocalization) as well as positive magnetoresistance in the entire magnetic field range (up to 12 T). The weak antilocalization effect disappears when an in-plane field is applied, showing the anisotropy between the transport parallel and perpendicular to the quintuple-layers. The estimated phase coherent lengths up to 250 nm at low temperatures are comparable to those previously obtained for Bi_2Te_3. The magnetotransport measurements were also performed on MBE-grown films of Sb_2Te_3 (p-doped) as well as on the ternary compound $(Bi_{1-x}Sb_x)_2Te_3$ ($0<x<1$). A transition from n- to p-doping depending on x has been seen in the measurements.

HL 85.4 Thu 16:00 H18

Surface state contribution to thermoelectric transport in Bi_2Te_3 — •NICKI F. HINSCHE[1], FLORIAN RITTWEGER[1], PETER ZAHN[3] und INGRID MERTIG[1,2] — [1]Martin-Luther-Universität, Institut für Physik, Von-Seckendorff-Platz 1, DE-06120 Halle — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, DE-06120 Halle — [3]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 51 01 19, DE-01314 Dresden

Bulk Bi_2Te_3 and related heterostructures are well known as efficient thermoelectric materials [1,2]. Recent research revealed Bi_2Te_3 to be a strong topological insulator, i.e. its bulk is insulating, while its surface is metallic due to the presence of robust gapless surface states [3]. While the spin structure and the low-temperature electrical transport gained much attention, the physics of the thermoelectric transport is still under debate. To contribute on this, we studied the electronic structure of the Bi_2Te_3 surface with a fully relativistic screened Korringa-Kohn-Rostoker Green's function method. The thermoelectric transport properties were calculated within the relaxation time approximation of the Boltzmann theory. The influence of temperature and doping on the thermoelectric properties of the surface state were analysed in detail.

[1] T. M. Tritt *et al.*, MRS bulletin **31**, 188 (2006)
[2] N. F. Hinsche *et al.*, Phys. Rev. B **86**, 085323 (2012)
[3] H. Zhang *et al.*, Nature Phys. **5**, 438 (2009)

HL 85.5 Thu 16:15 H18

Quasi-ballistic transport of Dirac fermions in a Bi_2Se_3 nanowire — •JOSEPH DUFOULEUR — IFW-Dresden, Dresden, Germany

Quantum coherent transport of Dirac fermions in a mesoscopic nanowire of the 3D topological insulator Bi_2Se_3 is studied in the weak-disorder limit. At very low temperatures, many harmonics are evidenced in the Fourier transform of Aharonov-Bohm oscillations, revealing the long phase coherence length of surface states. Remarkably, from their exponential temperature dependence, we infer an unusual 1/T power law for the phase coherence length. This decoherence is typical for quasi-ballistic fermions weakly coupled to the dynamics of their environment.

15 min. break

HL 85.6 Thu 16:45 H18

Quasi-ballistic transport of Dirac fermions in a Bi_2Se_3 nanowire — •JOSEPH DUFOULEUR[1], LOUIS VEYRAT[1], ANDREAS TEICHGRÄBER[1], STEPHAN NEUHAUS[1], CHRISTIAN NOWKA[1], SILKE HAMPEL[1], J ÉRÔME CAYSSOL[2,3], JOACHIM SCHUMANN[1], BARBARA EICHLER[1], OLIVER SCHMIDT[1], BERND BÜCHNER[1], and ROMAIN GIRAUD[1,4] — [1]Leibniz Institute for Solid State and Materials Research, IFW Dresden, 01171 Dresden, Germany — [2]LOMA, University Bordeaux 1, F-33045 Talence, France — [3]Max-Planck-Institut für Physik Komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [4]CNRS - Laboratoire de Photonique et de Nanostructures, Route de Nozay, 91460 Marcoussis, France

Quantum coherent transport of Dirac fermions in a mesoscopic nanowire of the 3D topological insulator Bi_2Se_3 is studied in the weak-disorder limit. At very low temperatures, many harmonics are evidenced in the Fourier transform of Aharonov-Bohm oscillations, revealing the long phase-coherence length of surface states. Remarkably, from their exponential temperature dependence, we infer an unusual $1/T$ power law for the phase coherence length $L_\varphi(T)$. This decoherence is typical for quasi-ballistic fermions weakly coupled to the dynamics of their environment.

HL 85.7 Thu 17:00 H18

Magnetotransport in disordered HgTe ribbons — •SVEN ESSERT and KLAUS RICHTER — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

HgTe quantum wells allow the realization of 2D topological insulator structures. They feature edge states which are protected from backscattering by time-reversal symmetry leading to dissipationless transport in the presence of non-magnetic disorder. We perform transport calculations using the four-band BHZ model to investigate the lifting of this protection by an external magnetic field. We find that the edge state transport is very robust to the application of a perpendicular magnetic field as long as the transport is still in the quasi-one dimensional regime, i.e. as long as the system is far from a topological phase transition to the topologically trivial insulating phase. However, by gating parts of the system to the metallic regime and thereby allowing for true 2d transport, the effect of the magnetic field can be drastically increased.

HL 85.8 Thu 17:15 H18

Probing the Band Topology of Mercury Telluride through Weak Localization and Antilocalization — •VIKTOR KRUECKL and KLAUS RICHTER — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg

We investigate the effect of weak localization (WL) and weak antilocalization (WAL) in the diffusive transport through HgTe/CdTe quantum wells. Our results reveal different transitions between WL and WAL depending on the Fermi energy as well as the band topology [1]. If spin-orbit interactions from bulk and structure inversion asymmetry can be neglected, the magnetoconductance of a system with inverted band ordering features a transition from WL to WAL and back. This is a signature of the Berry phase arising for inverted band ordering and not present in heterostructures with conventional ordering. In presence of strong spin-orbit interaction both band topologies exhibit WAL, which is distinctly energy dependent solely for quantum wells with inverted band ordering. This can be explained by an energy-dependent decomposition of the Hamiltonian into two blocks.

[1] V. Krueckl and K. Richter, Semicond. Sci. Technol. **27**, 124006 (2012)

HL 85.9 Thu 17:30 H18

Robustness of edge states in non-centrosymmetric superconductors — •Raquel Queiroz und Andreas P. Schnyder — Max Planck Institut für Festörperforschung, 70569 Stuttgart, Germany

Nodal superconductors without inversion symmetry have non-trivial topological properties, manifested by topologically protected flat-band edge states [1-3]. Since the bulk is not fully gapped, the edge states of nodal superconductors can in principle be susceptible to impurities, which break translational symmetries. Using recursive Green's function techniques we study the robustness of these edge states against both magnetic and non-magnetic disorder. We show that for weak and dilute non-magnetic impurities, a finite number of mid-gap edge states remains at zero-energy. We compute the zero bias conductance of a junction between a normal lead and a non-centrosymmetric superconductor as a function of disorder strength. It is found that the flat-band edge states give rise to a nearly quantized zero-bias conductance even in the presence of non-magnetic impurities.

[1] A. P. Schnyder and S. Ryu, Phys. Rev. B 84, 060504(R) (2011)
[2] P. M. R. Brydon, A. P. Schnyder, and C. Timm, Phys. Rev. B 84, 020501(R) (2011)
[3] A. P. Schnyder, P. M. R. Brydon, and C. Timm, Phys. Rev. B 85, 024522 (2012)

HL 85.10 Thu 17:45 H18

The Kondo cloud in helical edge states — •Thore Posske and Björn Trauzettel — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

The Kondo cloud is one of the last left unobserved phenomena of the Kondo effect. It stands for spatially extended spin-spin correlation between the electrons in the leads and the spin of the impurity in a Kondo system. Attempts to measure the Kondo cloud directly at the impurity usually perturb the system vastly and therefore modify the Kondo cloud. Helical edge states of topological insulators obey a unique coupling of the direction of motion and the spin degree of freedom. This, as we show, allows for the possibility to find signatures of the Kondo cloud far away from its origin by measuring current-current correlations.