DS 1: Transport: Topological Insulators (jointly with DS, MA, HL, O)

Time: Monday 9:30–13:00 Location: HSZ 204

DS 1.1 Mon 9:30 HSZ 204

Magnetic excitations in the symmetry protected, topological Haldane phase of $SrNi_2V_2O_8$ — Vladimir Gnezdilov[1,2], Vladimir Kurnosov[2], •Peter Lemmens[1], A. K. Bera[3], A. T. M. N. Islam[3], and Bella Lake[3] — [1]TU-BS, Braunschweig — [2]ILTP Kharkov — [3]HZB Berlin

We report results of a single-crystal Raman scattering study of the coupled spin-1 Haldane chain compound $SrNi_2V_2O_8$. In addition to the one-and two-magnon excitations, broad gapless and temperature dependent continua are detected with light polarization parallel to the basal plane. This feature is discussed in terms of spinon-like excitations related to a symmetry protected topological state, of which the Haldane phase in 1D is a preeminent example.

Work supported by RTG-DFG 1952/1, Metrology for Complex Nanosystems and the Laboratory for Emerging Nanometrology, TU Braunschweig.

DS 1.2 Mon 9:45 HSZ 204

Low-temperature magnetotransport in Mn-doped Bi_2Se_3 topological insulators — V. Tkáč[1], V. Komanicky[2], R. Tarasenko[1], M. Vališka[1], V. Holý[1], G. Springholz[3], V. Sechovský[1], and •J. Honolka[4] — [1]Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, CZ — [2]Institute of Physics, P. J. Šafárik University, SK — [3]Institute of Semiconductor and Solid State Physics, Johannes Kepler University, AT — [4]Institute of Physics, Academy of Sciences of the Czech Republic, CZ

Magnetic impurities can break the time-reversal symmetry of 3D topological insulators (TI), thereby opening an energy gap Δ at the Dirac point of a topological surface state with large consequences for transport properties in the thin film limit. In magnetotransport a transition from weak antilocalisation to weak localisation is expected, strongly dependent on contributions from possible coexisting 2D quantum well and bulk states. We present a low-T magnetotransport study ($T = 0.3$ K - 300 K, $B_{\max} = 14$ T) of MBE-grown Bi_2Se_3 films of 20 nm - 500 nm thickness with varying Mn concentrations up to 8% and Curie temperatures $T_C = 5-7$ K [1,2]. The results are interpreted following mainly theory by Lu et al. [3] as a competition of quantum corrections to the conductivity σ (phase coherence length $l_\phi \propto T^{-1/2} \sim 50-150$nm for pure Bi_2Se_3) and 2D e-e interaction corrections both in the ferro- and paramagnetic phase.

[1] M. Valiska et al., Appl. Phys. Lett. 108, 262402 (2016).
[2] R. Tarasenko et al., Physica B 481, 262 (2016).
[3] H.-Z. Lu et al., Phys. Rev. Lett. 112, 146601 (2014).

DS 1.3 Mon 10:00 HSZ 204

Proximity-induced superconductivity and quantum interference in topological crystalline insulator SnTe devices — •Robin Klett[1], Joachim Schönle[2], Denis Dyck[1], Karsten Rott[1], Shekhar Chandra[3], Claudia Felser[3], Wolfgang Wernsdorfer[2], and Günter Reiss[1] — [1]CSMD, Bielefeld University, Germany — [2]CNRS, Institut Neél, France — [3]MPI for Chemical Physics of Solids, Germany

Topological states of matter host a variety of new physics that is promising for future technology. Among these phenomena, the emergence of metallic symmetry-protected topological surface states (TSS) are of major interest. The coupling of topological matter to a nearby superconductor is forsaken to host unconventional proximity-induced superconductivity. We demonstrate the fabrication of superconducting Quantum interference devices (SQUIDs) out of SnTe/Nb hybrid structures. Our findings show strong proximity-induced superconductivity in the surface of SnTe. Transport contributions of Majorana Bound States are predicted to enter with a shift in periodicity to DC SQUID experiments. The Analysis of the SQUID response suggest the absence of periodicity shifts, but show additional features expected for TSS carried supercurrents, such as unconventional Fraunhofer shapes.

DS 1.4 Mon 10:15 HSZ 204

Emergence of topological and topological crystalline phases in $TlBiS_2$ and $TlSbS_2$ — •Udo Schwingenschlögl, Qingyun Zhang, and Yingchun Cheng — King Abdullah University of Science and Technology (KAUST), Physical Science and Engineering Division (PSE), Thuwal 23955-6900, Saudi Arabia

Using first-principles calculations, we investigate the band structure evolution and topological phase transitions in $TlBiS_2$ and $TlSbS_2$ under hydrostatic pressure as well as uniaxial and biaxial strain. The phase transitions are identified by parity analysis and by calculating the surface states. Zero, one, and four Dirac cones are found for the (111) surfaces of both $TlBiS_2$ and $TlSbS_2$ when the pressure grows, which confirms trivial-nontrivial-trivial phase transitions. The Dirac cones at the $\bar{\mathrm{M}}$ points are anisotropic with large out-of-plane component. $TlBiS_2$ shows normal, topological, and topological crystalline insulator phases under hydrostatic pressure, thus being the first compound to exhibit a phase transition from a topological to a topological crystalline insulator. [1] Scientific Reports **5**, 8379 (2015)

DS 1.5 Mon 10:30 HSZ 204

Perfect filter for triplet superconductivity on the surface of a 3DTI — •Daniel Breunig[1], Pablo Burset[1], François Crépin[2], and Björn Trauzettel[1] — [1]Institute for Theoretical Physics and Astrophysics, Wuerzburg University, 97074 Wuerzburg, Germany — [2]Laboratoire de Physique Théorique de la Matière Condensée, UPMC, Sorbonne Universités, 75252 Paris, France

We study a NSN junction on the surface of a 3D topological insulator (TI), where N is a normal region and S is a s-wave proximity-induced superconducting region. Spin-orbit coupling in the TI breaks spin rotational symmetry and induces unconventional triplet superconductivity.

From the anomalous Green function, we identify the singlet and triplet pairing amplitudes and perform a symmetry classification on these quantities. Pauli exclusion principle demands the antisymmetry of the Green function under simultaneous exchange of its space, time and spin variables. The pairing amplitudes can thus be classified as ESE, OSO, ETO or OTE. Here, the first (last) letter specifies the time/frequency (parity) symmetry (Even or Odd) and the second one describes the spin (Singlet or Triplet). A special feature of our system is the emergence of the exotic odd-frequency pairing.

Interestingly, we find that for a bipolar junction, where the chemical potentials in the N leads only differ in their signs, the non-local singlet pairing amplitude is completely suppressed and only triplet pairing occurs. As a result, the non-local conductance across the junction can be dominated by purely spin triplet crossed Andreev reflections, while electron cotunneling is absent.

DS 1.6 Mon 10:45 HSZ 204

Ferromagnetic transition and fluctuation-induced Dzyaloshinskii-Morya interaction at the surface of three-dimensional topological insulators — •Flavio Nogueira[1], Ferhat Katmis[2], and Ilya Eremin[2] — [1]Institut für Theoretische Physik III, Ruhr-Universität Bochum — [2]Deparment of Physics and Francis Bitter Magnet Laboratory, Massachusetts Institute of Technology

A ferromagnetic insulator (FMI) proximate to the surface of a three-dimensional topological insulator (TI) generate a gap in the spectrum of surface Dirac fermions, provided an out-of-plane exchange exists. We study the ferromagnetic transition in TI-FMI structures and show that fluctuations from Dirac fermions induce a Dzyaloshinskii-Morya (DM) interaction in the effective free energy of the FMI. This DM interaction arises only if the chemical potential is nonzero. Thus, if the proximity effect gaps the Dirac fermions, this means that the Fermi level must be outside the gap in order for a DM term to be induced. We also show that the Curie temperature of the ferromagnetic state at the interface between the TI and FMI is necessarily higher than the bulk Curie temperature of the FMI. This result is corroborated by recent experiments in Bi_2Se_3-EuS bilayer structures. These results imply an interface critical behavior very different from the bulk FMI.

DS 1.7 Mon 11:00 HSZ 204

A time-reversal symmetric topological magnetoelectric effect in 3D topological insulators — •Heinrich-Gregor Zirnstein and Bernd Rosenow — Institut für Theoretische Physik, Universität Leipzig, Germany

One of the hallmarks of time-reversal symmetric (TRS) topological insulators in 3D is the topological magnetoelectric effect (TME). So far, a time-reversal breaking variant of this effect has been discussed, in the sense that the induced electric charge changes sign when the direction of an externally applied magnetic field is reversed. Theoretically, this effect is described by the so-called axion term. Here, we discuss a time-reversal symmetric TME, where the electric charge depends only on the magnitude of the magnetic field but is independent of its sign. We obtain this non-perturbative result by a combination of analytic and numerical arguments, and suggest a mesoscopic setup to demonstrate it experimentally.

In particular, we show that threading a thin magnetic flux tube of one flux quantum through the material and applying a uniform electric field will induce a half-integer charge $\Delta Q = e/2\,\mathrm{sgn}\,\mathbf{E}_z$ on the surface of the topological insulator. The sign of the induced charge is independent of the direction of the magnetic field.

15 min. break.

DS 1.8 Mon 11:30 HSZ 204

Single-electron injection in the edge states of a 2D topological insulator — •Giacomo Dolcetto and Thomas Schmidt — Physics and Materials Science Research Unit, University of Luxembourg

The realization of single-electron sources in integer quantum Hall systems has paved the way for exploring electronic quantum optics experiments in solid-state devices. Recently, two-dimensional topological insulators have also been considered as an interesting playground for implementing electron quantum optics. Here, two electron waveguides emerge at the edge, one for spin-up and one for spin-down electrons. Scattering between the two channels is strongly suppressed and phase-coherent ballistic transport is predicted. In this talk I will characterize the injection of single Kramers pairs from a mesoscopic capacitor: a periodic voltage drive results in the emission of periodic trains of electron and hole Kramers pairs. Due to spin-momentum locking and to the geometry of the device, the injected state is in general a superposition of many different orthogonal states, thus representing an interesting playground not only to study the transport properties, but also to investigate and to measure the entanglement production.

DS 1.9 Mon 11:45 HSZ 204

Odd-frequency superconductivity at the Helical Edge of a 2D Topological Insulator — •Felix Keidel[1], Pablo Burset[1], François Crépin[2], and Björn Trauzettel[1] — [1]Institute for Theoretical Physics and Astrophysics, Würzburg University, 97074 Würzburg, Germany — [2]Laboratoire de Physique Théorique de la Matière Condensée, UPMC, Sorbonne Universités, 75252 Paris, France

By virtue of the basic laws of quantum mechanics, the Pauli principle demands the Cooper pairs in superconductors to be odd under exchange of the two constituent electrons. Consequently, even-parity singlets are formed in conventional s-wave superconductivity. Exotic unconventional pairing symmetries emerge once the classification is extended to frequency, additionally to orbital and spin degrees of freedom.

In our work, we study a helical edge of a two-dimensional topological insulator in proximity to an s-wave superconductor and ferromagnetic insulators. While helicity and the magnetic field induce triplet correlations in addition to the inherited singlet pairing, both even- and odd-parity contributions arise since translational invariance and inversion symmetry are broken. In such a hybrid junction, odd-frequency amplitudes thus occur naturally as all combinations of spin and parity symmetry appear. On the basis of a Green's function analysis, we find signatures of these unconventional pairing amplitudes in the local density of states and in the non-local conductance. Strikingly, our method allows to track the emergence of unconventional superconductivity and make a connection to transport and pairing properties of the system.

DS 1.10 Mon 12:00 HSZ 204

Parity anomaly driven topological transitions in magnetic field — •Jan Böttcher, Christian Tutschku, and Ewelina M. Hankiewicz — Institut für Theoretische Physik und Astronomie, Uni Würzburg, 97074 Würzburg, Germany

Recent developments in solid state physics give a prospect to observe the parity anomaly in (2+1)D massive Dirac systems. We show, that the charge neutrality condition for a quantum anomalous Hall (QAH) state in orbital magnetic fields gets modified by an additional term originating from an intrinsic Chern-Simons term in the one loop Lagrangian. This can be utilized to experimentally differentiate the QAH from the quantum Hall (QH) state at charge neutrality [1]. As a result, an experimental signature of the QAH phase in magnetic fields is a long $\sigma_{xy} = e^2/h$ ($\sigma_{xy} = -e^2/h$) plateau in $Cr_x(Bi_{1-y}Sb_y)_{2-x}Te_3$ (HgMnTe quantum wells). Furthermore, we predict a new transition between the quantum spin Hall (QSH) and the QAH state in magnetic fields without magnetic impurities but driven by effective g-factors and particle-hole asymmetry.

[1] J. Böttcher, C. Tutschku, E. M. Hankiewicz, arXiv:1607.07768v1

DS 1.11 Mon 12:15 HSZ 204

Tunable edge states and their robustness towards disorder — •Maik Malki and Götz S. Uhrig — Lehrstuhl für Theoretische Physik 1, TU Dortmund, Germany

The interest in the properties of edge states in Chern insulators and in $\mathbb{Z}_2$ topological insulator has increased rapidly in recent years. We present calculations on how to influence the transport properties of chiral and helical edge states by modifications of the edges in the Haldane and in the Kane-Mele model. The Fermi velocity of the chiral edge states becomes direction-dependent as does the spin-dependent Fermi velocity of the helical edge states. Moreover, it is possible to tune the Fermi velocity by orders of magnitude. Additionally, we explicitly investigate the robustness of edge states against local disorder. The edge states can be reconstructed in the Brillouin zone in presence of disorder. The influence of the width and of the length of the system is studied as well as the dependence on the strength of the disorder.

DS 1.12 Mon 12:30 HSZ 204

Instability of interaction-driven topological insulators against disorder — Jing Wang[1,2], Carmine Ortix[1,3], Jeroen van den Brink[1], and •Dmitri Efremov[1] — [1]IFW Dresden, Germany — [2]University of Science and Technology of China, Hefei, China — [3]Utrecht University, Netherlands

We analyze the effect of disorder on the weak-coupling instabilities of quadratic band crossing point (QBCP) in two-dimensional Fermi systems, which, in the clean limit, display interaction-driven topological insulating phases. In the frame of the weak-coupling renormalization group procedure, which treats fermionic interactions and disorder on the same footing, we test all possible instabilities and identify the corresponding ordered phases in the presence of disorder for both single-valley and two-valley QBCP systems. We find that disorder generally has a strong influence on the stability of the interaction-driven topological insulating phases – it strongly suppresses the critical temperature at which the topologically non-trivial order sets in – and can even trigger a phase transition to different, topologically trivial, ordered phases.

DS 1.13 Mon 12:45 HSZ 204

Effect of disordered geometry on transport properties of three dimensional topological insulator nanowires — •Emmanouil Xypakis[1], Jun Won Rhim[1], Roni Ilan[2], and Jens H. Bardarson[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Department of Physics, University of California, Berkeley, California

Three dimensional topological insulator nanowires are materials which, while insulating in the bulk, have a metallic boundary described by a two dimensional Dirac Hamiltonian with antiperiodic boundary conditions. Transport properties of this system have been extensively studied in the limit where the surface manifold is conformally at (e.g., a cylinder) in the presence of a random disordered scalar potential. In this talk I will discuss how this picture is altered when a more realistic surface manifold is chosen, such as a cylinder with a randomly fluctuating radius.