DS 22: Transport: Topological Insulators - 3D (Joint session of DS, HL, MA, O and TT, organized by TT)

Time: Tuesday 14:00–15:45 Location: H18

Invited Talk DS 22.1 Tue 14:00 H18

Coupled-wire constructions: New insights into the physics of interacting topological systems in two and three dimension (and beyond) — •Tobias Meng[1], Eran Sela[2], Titus Neupert[3], Martin Greiter[4], Ronny Thomale[4], Adolfo G. Grushin[5], Jens H. Bardarson[5], and Kirill Stengel[6] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University, Tel Aviv 69978, Israel — [3]Princeton Center for Theoretical Science, Princeton University, Princeton, New Jersey 08544, USA — [4]Institute for Theoretical Physics, University of Würzburg, 97074 Würzburg, Germany — [5]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany. — [6]Department of Physics & Astronomy, University of California, Riverside, California 92521, USA

Recently, it has been shown that coupled-wire constructions (CWCs) reproduce well-known fractional quantum Hall phases, and allow to derive new insights into, and setups for, interacting topological systems. I will review the basic concepts of 2D CWCs, discuss how they can teach us about spontaneous time-reversal symmetry breaking in topological insulators, and how they can be used to engineer chiral spin liquids in arrays of Mott-gapped quantum wires. I will show that 3D CWCs can for instance describe Weyl semimetals, and finally present new results on 4D fractional quantum Hall states built from coupled wires, whose 3D edges support a fractional chiral metal with a fractional chiral anomaly, thus generalizing the Weyl semimetal.

DS 22.2 Tue 14:30 H18

Revealing puddles of electrons and holes in compensated topological insulators — •Nick Borgwardt[1], Jonathan Lux[2], Zhiwei Wang[1,3], Ignacio Vergara[1], Malte Langenbach[1], Achim Rosch[2], Yoichi Ando[1,3], Paul van Loosdrecht[1], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Institut für theoretische Physik, Universität zu Köln — [3]Institute of Scientific and Industrial Research, Osaka University

Three-dimensional topological insulators harbour metallic surface states with exotic properties. In transport or optics, these properties are typically masked by defect-induced bulk carriers. Compensation of donors and acceptors reduces the carrier density, but the bulk resistivity remains disappointingly small. We show that measurements of the optical conductivity in $BiSbTeSe_2$ pinpoint the presence of electron-hole puddles in the bulk at low temperatures, which is essential for understanding DC bulk transport. The puddles arise from large fluctuations of the Coulomb potential of donors and acceptors, even in the case of full compensation. Surprisingly, the number of carriers appearing within puddles drops rapidly with increasing temperature and almost vanishes around 40 K. Monte Carlo simulations show that a highly non-linear screening effect arising from thermally activated carriers destroys the puddles at a temperature scale set by the Coulomb interaction between neighbouring dopants, explaining the experimental observation semi-quantitatively [1].

[1] N. Borgwardt et al., arXiv:1508.03212

DS 22.3 Tue 14:45 H18

Interaction Correction to the Magneto-Electric Polarizability of Z_2 Topological Insulators — •Karin Everschor-Sitte[1], Matthias Sitte[1], and Allan MacDonald[2] — [1]Institut für Physik - Johannes Gutenberg-Universität Mainz, Deutschland — [2]Department of Physics - University of Texas at Austin, USA

When time-reversal symmetry is weakly broken and interactions are neglected, the surface of a Z_2 topological insulator supports a half-quantized Hall conductivity $\sigma_S = e^2/(2h)$. A surface Hall conductivity in an insulator is equivalent to a bulk magneto-electric polarizability, *i.e.* to a magnetic field dependent charge polarization. By performing an explicit calculation for the case in which the surface is approximated by a two-dimensional massive Dirac model and time-reversal symmetry is broken by weak ferromagnetism in the bulk, we demonstrate that there is a non-universal interaction correction to σ_S. Our prediction can be tested by measuring the capacitance of magnetized thin films in which the anomalous quantum Hall effect is absent.

DS 22.4 Tue 15:00 H18

Electron-Phonon Interaction in Surface States of Topological Insulators from First Principles — •Rolf Heid[1], Irina Yu. Sklyadneva[2], and Eugine V. Chulkov[2] — [1]Institut für Festkörperphysik, Karlsruher Institut für Technologie — [2]Donostia International Physics Center (DICP), San Sebastian/Donostia, Spain

Transport through the metallic 2D surface states of 3D topological insulators with a Dirac-like dispersion is controlled by many-body interactions. In particular, a large electron-phonon interaction could be a limiting factor for applications at elevated temperatures [1]. Previous experimental investigations of the coupling constant remained inconclusive as they found large variations ranging from <0.1 to 3 [2].

Here we present a first principles investigation of the electron-phonon interaction in surface states of topological insulators within density-functional perturbation theory including spin-orbit interaction [3], using Bi_2Se_3, Bi_2Te_3, and Sb_2Te_2S as prominent examples. We discuss the various challenges faced by this approach, such as the rather deep penetration of the surface state and the small momentum range of both electronic and phonon states relevant for the coupling. We find that the coupling strength exhibits a significant dependence on the binding energy, following essentially the available electronic phase space. We further investigate the variation of the coupling with doping to mimic typical experimental conditions.

[1] D. Kim et al., PRL **109**, 166801 (2012)
[2] X. Zhu et al., arXiv: 1307.4559
[3] R. Heid et al., PRB **81**, 174527 (2010)

DS 22.5 Tue 15:15 H18

Detection of current-induced spin polarization in $BiSbTeSe_2$ toplogical insulator — •Fan Yang[1], Subhamoy Ghatak[1], Alexey Taskin[1], Yuichiro Ando[2], and Yoichi Ando[1] — [1]Institute of Physics II, University of Cologne, Germany — [2]Department of Electronic Science and Engineering, Kyoto University, Japan

Topological insulators (TIs) are a class of quantum matter which possess spin-momentum-locked Dirac Fermions on the surfaces. Due to the spin-momentum locking, spin polarization will be induced when a charge current flows through the surface of a TI. Such spin polarization can be detected by using a ferromagnetic tunneling contact as a detector. In this talk, we present our results measured in devices fabricated from $BiSbTeSe_2$ flakes. Spin signals were observed in both n-type and p-type $BiSbTeSe_2$ samples.

DS 22.6 Tue 15:30 H18

Transport measurements on epitaxial $Bi_{1-x}Sb_x$ thin films grown on Si(111) — •Julian Koch, Philipp Kröger, Herbert Pfnür, and Christoph Tegenkamp — Leibniz Universität Hannover, Inst. für Festkörperphysik, Appelstr. 2, 30167 Hannover

The alloy $Bi_{1-x}Sb_x$ can be tuned to be either topologically trivial or non-trivial by changing the relative concentrations of Bismuth and Antimony [1]. In this study we present surface transport measurements performed on non-trivial $Bi_{1-x}Sb_x$ films. Thin films grown by in-situ co-deposition on Si(111) substrates are used, in order to reduce bulk contributions and to provide the possibility of nanostructuring. The morphology was controlled by low energy electron diffraction. Temperature dependent transport measurements for temperatures from 12 to 300 K were performed for films of different stoichiometry ranging from $x = 0.14 - 0.22$ and thicknesses of 4, 8, 16 and 24 nm. We find strong evidence for metallic surface transport in addition to activated bulk transport, which is, to the best of our knowledge, the first observation of metallic surface transport in $Bi_{1-x}Sb_x$ films. In previous studies the transport findings were discussed solely in terms of impurity and bulk bands (see e.g. [2]). For films thinner than 6 nm the surface transport is strongly suppressed, in accordance with measurements on Bi_2Se_3 [3]. The temperature dependent transport behaviour of these films is similar to that of thicker films with substracted surface contribution as well as to films examined in previous studies, further supporting the observation of metallic surface transport in thicker films.

[1] H. Guo, K. Sugawara, A. Takayama, S. Souma, T. Sato, N. Satoh, A. Ohnishi, M. Kitaura, M. Sasaki, Q.-K. Xue, and T. Takahashi, PRB **83**, 201104(R)
[2] S. Cho, A. DiVenere, G. K. Wong, J. B. Ketterson, and J. R. Meyer,

PRB **59** 10691

[3] A. A. Taskin, S. Sasaki, K. Segawa, and Y. Ando, PRL **109**, 066803