TT 59: TR: Topological Insulators 2 (jointly with HL and MA)

Time: Friday 10:30–13:00 Location: HSZ 03

TT 59.1 Fri 10:30 HSZ 03

New Family of Materials for Three-Dimensional Topological Insulators in the Antiperovskite Structure — •Yan Sun[1], Xing-Qiu Chen[1], Dianzhong Li[1], Yiyi Li[1], and Seiji Yunoki[2] — [1]Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China — [2]Computational Condensed Matter Physics Laboratory, RIKEN ASI, Saitama 351-0198, Japan

Up to now, all known topological insulators found experimentally and theoretically are related to two families with distinct crystal structures, i.e., one being a cubic non-centrosymmetric zinc-blende HgTe type and the other being a hexagonal centrosymmetric Bi_2Se_3 type. Here, we propose a new family of materials for topological insulators in the antiperovskite structure. Through first-principles calculations, we show evidences that under a proper uniaxial strain, cubic ternary centrosymmetric antiperovskite compounds (M_3N)Bi (M = Ca, Sr, and Ba) are three-dimensional (3D) topological insulators. We also discuss other related materials of the same antiperovskite structure which are good candidates for 3D topological insulators. This proposed family of materials is chemically inert and the lattice structure is well matched to important semiconductors, which provides a rich platform to easily integrate with electronic devices. This work was supported by the "Hundred Talents Project" of Chinese Academy of Sciences and by startup funding of the Institute of Metal Research, CAS in China.

TT 59.2 Fri 10:45 HSZ 03

Transport signatures of Majorana bound states in disordered superconducting nanowires — •Jan Dahlhaus, Michael Wimmer, Fabian Hassler, Anton Akhmerov, and Carlo Beenakker — Instituut-Lorentz, Universiteit Leiden, The Netherlands

Superconducting wires without time-reversal and spin-rotation symmetries can be driven into a topological phase that supports Majorana bound states. We show that the phase transition is signaled by a quantized thermal conductance and electrical shot noise power, irrespective of disorder. In a ring geometry, it is signaled by a period doubling of the magnetoconductance oscillations. Furthermore the influence on the Andreev reflection process at the Fermi level is addressed.

TT 59.3 Fri 11:00 HSZ 03

Majorana bound states without vortices in topological superconductors with electrostatic defects — •Michael Wimmer[1], Anton Akhmerov[1], Maryia Medvedyeva[1], Jakub Tworzydlo[2], and Carlo Beenakker[1] — [1]Universiteit Leiden, The Netherlands — [2]University of Warsaw, Poland

Vortices in two-dimensional superconductors with broken time-reversal and spin-rotation symmetry can bind states at zero excitation energy. These socalled Majorana bound states transform a thermal insulator into a thermal metal and may be used to encode topologically protected qubits. We identify an alternative mechanism for the formation of Majorana bound states, akin to the way in which Shockley states are formed on metal surfaces: An atomic-scale electrostatic line defect can have a pair of Majorana bound states at the end points. The Shockley mechanism explains the appearance of a thermal metal in vortex-free lattice models of chiral p-wave superconductors and (unlike the vortex mechanism) is also operative in the topologically trivial phase.

TT 59.4 Fri 11:15 HSZ 03

Zoology of topological phases and Chern number transfer in an exactly solvable spin model — Graham Kells[1,2], •Janik Kailasvuori[3], Joost Slingerland[1,4], and Jiri Vala[1,4] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Department of Mathematical Physics, National University of Ireland, Maynooth, Ireland — [3]Max-Planck-Institut für Physik komplexer Systeme, Germany — [4]Dublin Institute for Advanced Studies, School of Theoretical Physics, Dublin, Ireland

Exactly solvable models in spin lattices are an important playground for the study of topological phases. A primary tool for identifying these phases is the Chern invariant. For spin lattice models mapping to spinless p-wave fermions as well as for related models of topological insulators the Chern numbers for the ground states have mainly been restricted to $\nu = 0, \pm 1$, although general symmetry arguments would allow for more. With the rich phase zoology of spin-triplet p-wave fermions in mind we look at the square-octagon (4-8) variant of Kitaev's honeycomb lattice model. It allows for a mapping to spinful paired fermions and indeed, the phase diagram of the model turns out to be of unprecedented richness, possessing distinct Abelian and non-Abelian phases with total Chern number $\nu = 0, \pm 1, \pm 2, \pm 3$ and ± 4. Furthermore, we provide details on how the higher Chern numbers are reached by stepwise transfer of Chern numbers between the individual bands.

TT 59.5 Fri 11:30 HSZ 03

Topological phase transitions in quantum spin Hall lattices — •Dario Bercioux[1,2], Nathan Goldman[3], and Daniel F. Urban[2] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universitat, D-79104 Freiburg, Germany — [3]Center for Nonlinear Phenomena and Complex Systems - Universitè Libre de Bruxelles (U.L.B.), Code Postal 231, Campus Plaine, B-1050 Brussels, Belgium

Physical phenomena driven by topological properties, such as the quantum Hall effect, have the appealing feature to be robust with respect to external perturbations. Lately, a new class of materials has emerged manifesting their topological properties at room temperature and without the need of external magnetic fields. These topological insulators are band insulators with large spin-orbit interactions and exhibit the quantum spin-Hall (QSH) effect. Here we investigate the transition between QSH and normal insulating phases under topological deformations of a two-dimensional lattice. We demonstrate that the QSH phase present in the honeycomb lattice looses its robustness as the occupancy of extra lattice sites is allowed [1]. Furthermore, we propose a method for verifying our predictions with fermionic cold atoms in optical lattices. In this context, the spin-orbit interaction is engineered via an appropriate synthetic gauge field [2].

[1] D. Bercioux, N. Goldman, and D.F. Urban, arXiv:1007.2056.
[2] N. Goldman *et al.*, arXiv:1011.3909 Phys. Rev. Lett. (2010) *in press*.

15 min. break

TT 59.6 Fri 12:00 HSZ 03

Bound states and persistent currents in topological insulator rings — •Patrik Recher and Paolo Michetti — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg

We analyze theoretically the bound state spectrum of an Aharonov Bohm (AB) ring in a two-dimensional topological insulator using the four-band model of HgTe-quantum wells as a concrete example. We calculate analytically the circular helical edge states and their spectrum as well as the bound states evolving out of the bulk spectrum as a function of the applied magnetic flux and dimension of the ring. We also analyze the spin-dependent persistent currents, which can be used to measure the spin of single electrons. We further take into account the Rashba spin-orbit interaction which mixes the spin states and derive its effect on the ring spectrum. The flux tunability of the ring states allows for coherent mixing of the edge- and the spin degrees of freedom of bound electrons which could be exploited for quantum information processing in topological insulator rings.

TT 59.7 Fri 12:15 HSZ 03

Dephasing of spin and charge interference in helical Luttinger liquids — •Pauli Virtanen and Patrik Recher — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

We consider a four-terminal Aharonov-Bohm interference setup formed out of two edges of a quantum spin Hall insulator, supporting helical Luttinger liquids (HLLs). We show that the temperature and bias dependence of the interference oscillations are linked to the amount of spin flips in tunneling between two HLLs which is a unique signature of a HLL. We predict that spin dephasing depends on the electron-electron (e-e) interaction but differently from the charge dephasing due to distinct dominant tunneling excitations. In contrast, in a spinful Luttinger liquid with SU(2) invariance, uncharged spin excitations can carry spin current without dephasing in spite of the presence of e-e interactions.

TT 59.8 Fri 12:30 HSZ 03

Helical modes in carbon nanotubes generated by strong electric fields — •Jelena Klinovaja, Manuel J. Schmidt, Bernd Braunecker, and Daniel Loss — Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland

Helical modes, conduction channels transporting opposite spins in opposite directions, naturally lead to spin filtering, but they have also potential application as Cooper pair splitters and, if in proximity with a superconductor, lead to Majorana bound states at the edges of the conductor. Helical modes have also attracted much attention recently in the context of topological insulators. Such physics may be achieved in CNTs [1]. This is a consequence of the interplay between spin-orbit interaction and strong electric fields. Starting from a tight-binding model we derive the effective low-energy Hamiltonian and the resulting spectrum. Helical modes are shown to exist in metallic armchair nanotubes in an all-electric setup. The helical regime can also be obtained in chiral metallic nanotubes by applying an additional magnetic field. In particular, it is possible to obtain helical modes at one of the two Dirac points only, while the other one remains gapped.

[1] Jelena Klinovaja, Manuel J. Schmidt, Bernd Braunecker, and Daniel Loss, arXiv:1011.3630

TT 59.9 Fri 12:45 HSZ 03

Chirality Induced Tilted-Hill Giant Nernst Signal — •Panagiotis Kotetes[1], Gerd Schön[1,3], Alexander Shnirman[2,3], and Georgios Varelogiannis[4] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany — [2]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany — [3]DFG-Center for Functional Nanostructures (CFN), D-76128 Karlsruhe, Germany — [4]Department of Physics, National Technical University of Athens, GR-15780 Athens, Greece

We reveal a novel source of giant Nernst response exhibiting strong non-linear temperature and magnetic field dependence including the mysterious tilted-hill temperature profile observed in a pleiad of materials [1]. The phenomenon can originate either from a topological insulator or from the formation of a chiral order parameter. Particular examples are the Quantum Anomalous Hall state and the chiral d-density wave, respectively. The occurence of this giant thermoelectric response is distinctly different from the usual quasiparticle and vortex Nernst mechanisms. Our picture provides a unified understanding of the anomalous thermoelectricity observed in materials as diverse as hole doped cuprates [1] and heavy-fermion compounds like URu2Si2 [2]. Moreover, fingerprints of this phenomenon could be observed on the surface of several 3D topological insulators.

[1] P. Kotetes and G. Varelogiannis, Phys. Rev. Lett. 104, 106404 (2010).
[2] P. Kotetes, A. Aperis, and G.Varelogiannis, arXiv:1002.2719.