HL 79: Transport: Topological insulators II (organized by TT)

Time: Wednesday 16:30–18:30 Location: HSZ 204

HL 79.1 Wed 16:30 HSZ 204

Rashba spin orbit coupling in the Kane-Mele-Hubbard model
— •Stephan Rachel — Institut für Theoretische Physik, TU Dresden

Spin-orbit (SO) coupling is the crucial ingredient for topological insulating phases. In particular, the generic emergence of SO coupling involves the Rashba term which fully breaks the SU(2) spin symmetry. As soon as interactions are taken into account, however, many theoretical studies have to content themselves with the analysis of a simplified U(1) conserving SO term without Rashba coupling. We intend to fill this gap by studying the Kane-Mele-Hubbard model in the presence of Rashba SO coupling. We apply the variational cluster approach to determine the interacting phase diagram by computing local density of states, magnetization, single particle spectral function, and edge states.

We find that the Rashba SO coupling drives new electronic phases such as a metallic regime and a "gapless topological insulator phase" which persist in the presence of interactions.

HL 79.2 Wed 16:45 HSZ 204

Conductivity of a generic helical liquid
— •Nikolaos Kainaris[1], Igor Gornyi[1,2,4], Sam Carr[3], and Alexander Mirlin[1,2,5] — [1]Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, Karlsruhe, Germany — [2]Institut für Nanotechnologie, Karlsruher Institut für Technologie, Karlsruhe, Germany — [3]School of physical sciences, University of Kent, Canterbury, UK — [4]A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia — [5]Petersburg Nuclear Physics Institute, St. Petersburg, Russia

We study the transport properties of a helical Luttinger liquid without S_z symmetry. We focus on the case of long edges of 2D topological insulators and calculate the conductivity in the presence of both interactions and disorder. In the regime where temperature is larger than the frequency of the external field we use a kinetic equation approach to calculate the AC and DC conductivity for weakly interacting fermions. The opposite regime of the AC conductivity is discussed via full bosonization that allows us to treat certain interactions exactly. We find the dependence of the conductivity on temperature, frequency and Fermi energy for different scattering mechanisms and discuss their relevance to transport.

HL 79.3 Wed 17:00 HSZ 204

Influence of a random Rashba spin-orbit coupling on the transport properties of helical liquids
— •Florian Geissler, Francois Crepin, and Björn Trauzettel — Theoretische Physik IV, Universität Würzburg, Germany

In a quantum spin Hall system, the edge states are one-dimensional and helical, i.e. their (pseudo) spin degree of freedom and their direction of motion are strongly coupled to each other. This coupling gives rise to protection against elastic backscattering off non-magnetic impurities. Here, we analyze inelastic (two-particle) backscattering in interacting helical liquids in presence of random Rashba spin-orbit coupling. To study this peculiar type of disorder, we bosonize the Hamiltonian and employ a combination of operator product expansion and renormalization group calculations. Thereby, we obtain a consistent set of flow equations for the renormalization of the Luttinger liquid parameters, the disorder strength, and the two-particle backscattering. Finally, we discuss the corrections to the conductance at finite temperature stemming from this type of disorder.

HL 79.4 Wed 17:15 HSZ 204

Generic Helical Liquids: the effect of rotation of the spin-quantization axis
— •Alexia Rod[1], Thomas L. Schmidt[2], and Stephan Rachel[1] — [1]Institut für Theoretische Physik, TU Dresden — [2]Department of Physics, University of Basel

The generic helical liquid is the most general model of a time-reversal invariant helical liquid without axial spin symmetry. This symmetry is usually broken in experimental realizations, and it has been shown that its absence changes the transport properties significantly [1]. For a translation invariant system, the breaking of axial spin symmetry manifests itself in a rotation of the spin quantization axis with momentum. Its manifestation in real space has, however, remained elusive. Here we consider topological insulator sheets and discs and investigate the non-trivial spin structure of the helical edge states. We further propose how to measure this spin structure and discuss potential applications.

[1] T.L. Schmidt, S. Rachel, F. von Oppen, L. Glazman, Phys. Rev. Lett. 108, (2012).

HL 79.5 Wed 17:30 HSZ 204

Hanbury Brown-Twiss and Aharonov-Casher effects in a quantum spin Hall Corbino ring
— •Anders Ström[1], Henrik Johannesson[2], and Patrik Recher[1] — [1]Institute for Mathematical Physics, TU Braunschweig, Germany — [2]Department of Physics, University of Gothenburg, Sweden

We study the entanglement production in a quantum spin Hall ring where electrons of different spins are emitted from a biased source and detected in two different grounded detectors. The fermionic Hanbury-Brown Twiss effect gives rise to entanglement in the system, measurable via the current-current correlations between the detectors. The production of entanglement is electrically controlled via the Aharonov-Casher phases arising from the Rashba coupling in the system.

HL 79.6 Wed 17:45 HSZ 204

Proximity induced perfectly conducting channel in 2D-metal topological insulator heterostructures
— •Sven Essert, Viktor Krueckl, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

Two-dimensional topological insulators have attracted much attention because of their peculiar edge-state transport features. We investigate how these properties carry over to heterostructures made of topological insulators and materials with extended states which are not topologically classifiable (metallic systems).

We find that the proximity of a topological insulator induces a perfectly conducting channel in the metal which is however not localized along the edge but spanning the whole extended state region. This resembles the perfectly conducting channels predicted in graphene nanoribbons and carbon nanotubes. However, the proximity induced channel is expected to be stable even with short-range disorder which should simplify its observation.

We propose experiments to detect this effect by conductance and shot-noise measurements and also show how the proximity of a topological insulator can be understood in terms of an effective boundary condition.

HL 79.7 Wed 18:00 HSZ 204

Majorana fermions on a hexagonally warped 3D topological insulator in proximity to a superconductor
— •Daniel Mendler, Panagiotis Kotetes, and Gerd Schön — Institut für theoretische Festkörperphysik, KIT, Karlsruhe

The recent discovery of topological insulators (TIs) opened new perspectives in the field of topological quantum computing (TQC), in terms of Majorana fermions (MFs). The latter are expected to appear in the vortex cores of artificial topological superconductors (TSCs), engineered from the surface states of a 3D-TI in proximity to a conventional SC. Nonetheless, if time-reversal symmetry is spontaneously broken on the TI surface, the hybrid system supports Majorana fermions without the requirement of vortices. The latter property can be advantageous for the experimental realization of TSCs and facilitate the implementation of TQC protocols. In this work, we investigate the above scenario for the hexagonally warped Dirac itinerant surface states of Bi2Te3, which demonstrate enhanced tendency towards the spontaneous formation of magnetism due to Fermi surface nesting. We perform a complete classification of the accessible spin density wave order parameters in the presence of a repulsive Hubbard-like interaction and retrieve the hierarchy of magnetic phase transitions which can occur in the particular system. For the dominant magnetic instability, we investigate the conditions which favor proximity induced SC on the magnetic TI surface. We explicitly demonstrate the emergence of MFs in this system and propose methods for their manipulation.

HL 79.8 Wed 18:15 HSZ 204

Unconventional s- and p-wave proximity effect in topological insulator/superconductor structures
— •Tkachov Grigory — University of Wuerzburg

Currently, much effort is being put into understanding unconventional superconductivity in topological insulators (TIs). This contribution addresses a microscopic theory of the proximity effect in three-dimensional TIs coupled to an *s*-wave superconductor. In agreement with earlier results [1] we demonstrate that the induced superconductivity is a mixture of singlet *s*-wave and triplet *p*-wave components [2]. Their interplay depends on several factors, such as the position of the Fermi level, excitation energy, and external magnetic fields, among others. We also discuss the role of disorder and applications of the theory to recent experiments on HgTe-based TIs [3,4].

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[1] T. D. Stanescu, J. D. Sau, R. M. Lutchyn, and S. Das Sarma, Phys. Rev. B **81**, 241310(R) (2010).
[2] G. Tkachov, Phys. Rev. B **87**, 245422 (2013).
[3] L. Maier, J. B. Oostinga, D. Knott, C. Brüne, P. Virtanen, G. Tkachov, E. M. Hankiewicz, C. Gould, H. Buhmann, and L. W. Molenkamp, Phys. Rev. Lett. 109, 186806 (2012).
[4] J. B. Oostinga, L. Maier, P. Schüffelgen, D. Knott, P. Leubner, C. Brüne, G. Tkachov, H. Buhmann, and L. W. Molenkamp, Phys. Rev. X **2**, 021007 (2013)