## HL 98: Topological insulators (TT, jointly with DS, HL, MA, O)

Time: Friday 9:30–13:00 Location: H18

HL 98.1 Fri 9:30 H18

**Structure factor of a weakly interacting helical liquid** — •Suhas Gangadharaiah[1,2], Thomas L. Schmidt[2], and Daniel Loss[2] — [1]Indian Institute of Science Education and Research, Bhopal, India — [2]Department of Physics, University of Basel, CH-4056 Basel, Switzerland

We calculate the density structure factor $S(q,\omega)$ of a weakly interacting helical liquid in the presence of a magnetic field $B$. The latter opens a gap of width $2B$ in the single-particle spectrum $\epsilon_\pm(k)$, and leads to a strongly nonlinear spectrum near $k=0$. For chemical potentials $\mu > B$, the system then behaves as a nonlinear helical Luttinger liquid, and a mobile-impurity analysis reveals interaction-dependent power-law singularities in $S(q,\omega)$. For $\mu < B$, the low-energy excitations are gapped, and we determine $S(q,\omega)$ by using an analogy to exciton physics. We discuss the implications of the magnetic field induced non-linear spectrum on the Coulomb drag between the helical liquids.

HL 98.2 Fri 9:45 H18

**Strongly interacting Majorana modes in an array of Josephson junctions** — Fabian Hassler[1] and •Dirk Schuricht[2] — [1]Institute for Quantum Information, RWTH Aachen University — [2]Institute for Theory of Statistical Physics, RWTH Aachen University

An array of superconducting islands with semiconducting nanowires in the right regime provides a macroscopic implementation of Kitaev's toy model for Majorana wires. We show that a capacitive coupling between adjacent islands leads to an effective interaction between the Majorana modes. We demonstrate that even though strong repulsive interaction eventually drive the system into a Mott insulating state the competition between the (trivial) band-insulator and the (trivial) Mott insulator leads to an interjacent topological insulating state for arbitrary strong interactions.

HL 98.3 Fri 10:00 H18

**All-electrical measurement of crossed Andreev reflection in topological insulators** — •Rolf W. Reinthaler[1], Patrik Recher[2], and Ewelina M. Hankiewicz[1] — [1]Faculty of Physics and Astrophysics, University of Würzburg, Würzburg, Germany — [2]Institute for Mathematical Physics, Technical University Braunschweig, Braunschweig, Germany

Using a generalized wave matching method we solve the full scattering problem for quantum spin Hall insulator (QSHI) - superconductor (SC) - QSHI junctions. We find that for systems narrow enough so that the bulk states in the SC part couple both edges, the crossed Andreev reflection (CAR) is significant and the electron cotunneling (T) and CAR become spatially separated. We study the effectiveness of this separation as a function of the system geometry and the level of doping in the SC. Moreover, we show that the spatial separation of both effects allows for an all-electrical measurement of CAR and T separately in a 5-terminal setup or by using the spin selection of the quantum spin Hall effect in an H-bar structure [1].

We acknowledge financial support by the DFG grant HA 5893/3-1.

[1] R. W. Reinthaler, P. Recher, and E. M. Hankiewicz, arXiv:1209.5700 (2012)

HL 98.4 Fri 10:15 H18

**Zero-voltage conductance peak from weak antilocalization in a Majorana nanowire** — •Michael Wimmer[1], Dimitri Pikulin[1], Jan Dahlhaus[1], Henning Schomerus[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, The Netherlands — [2]Department of Physics, Lancaster University, United Kingdom

We show that weak antilocalization by disorder competes with resonant Andreev reflection from a Majorana zero-mode to produce a zero-voltage conductance peak of order $e^2/h$ in a superconducting nanowire. The phase conjugation needed for quantum interference to survive a disorder average is provided by particle-hole symmetry - in the absence of time-reversal symmetry and without requiring a topologically nontrivial phase. We identify methods to distinguish the Majorana resonance from the weak antilocalization effect.

HL 98.5 Fri 10:30 H18

**Spectral properties of disordered multi-channel Majorana wires** — •Patrick Neven, Dmitry Bagrets, and Alexander Altland — Institut für Theoretische Physik, Universität zu Köln, Köln, Germany

Proximity coupled multi-channel spin-orbit quantum wires may support midgap Majorana states at the ends. We study the fate of these Majorana fermions in the presence of disorder in such wires. Inspired by the widely established theoretical methods of mesoscopic superconductivity, we develop a quasiclassical approach which is valid in the limit of strong spin-orbit coupling. A numerical solution of the Eilenberger equation reveals that disordered topological wires are prone to the formation of a zero-energy anomaly (class D impurity spectral peak) in the local density of states which shares the key features of a Majorana peak. We also find that the $\mathbb{Z}_2$ topological invariant distinguishing between the state with and without Majorana fermions (symmetry class B and D, resp.) is related to the Pfaffians of quasiclassical Green's functions.

HL 98.6 Fri 10:45 H18

**Topological invariants and interacting one-dimensional fermionic systems** — •Salvatore R. Manmana[1,2,3], Andrew M. Essin[3], Reinhard M. Noack[4], and Victor Gurarie[3] — [1]Institut für Theoretische Physik, Universität Göttingen, Germany — [2]JILA, University of Colorado and NIST, Boulder (CO), USA — [3]Department of Physics, University of Colorado at Boulder, USA — [4]Fachbereich Physik, Philipps-Universität Marburg, Germany

We study one-dimensional, interacting, gapped fermionic systems described by variants of the Peierls-Hubbard model, and we characterize their phases via a topological invariant constructed out of their Green‘s functions. We demonstrate that the existence of topologically protected, zero-energy states at the boundaries of these systems can be tied to the value of the topological invariant, just like when working with the conventional, non-interacting topological insulators. We use a combination of analytical methods and the numerical density matrix renormalization group method to calculate the values of the topological invariant throughout the phase diagrams of these systems, thus deducing when topologically protected boundary states are present. We are also able to study topological states in spin systems because, deep in the Mott insulating regime, these fermionic systems reduce to spin chains. In this way, we associate the zero-energy states at the end of an antiferromagnetic spin-1 Heisenberg chain with a topological invariant equal to 2.

HL 98.7 Fri 11:00 H18

**Fluctuation driven topological Hund insulator** — •Jan Carl Budich[1], Bjoern Trauzettel[2], and Giorgio Sangiovanni[2] — [1]Department of Physics, Stockholm University, Se-106 91 Stockholm, Sweden — [2]Institute for theoretical physics and astrophysics, 97074 Würzburg, Germany

We investigate in the framework of dynamical mean field theory a two-band Hubbard model based on the Bernevig-Hughes-Zhang Hamiltonian describing the quantum spin Hall (QSH) effect in HgTe quantum wells. In the presence of interaction, we find that a system with topologically trivial non-interacting parameters can be driven into a QSH phase at finite interaction strength by virtue of local dynamical fluctuations. For very strong interaction, the system reenters a trivial insulating phase by going through a Mott transition. We obtain the phase diagram of our model by direct calculation of the bulk topological invariant of the interacting system in terms of its single particle Green's function.

**15 min. break**

HL 98.8 Fri 11:30 H18

**Floquet Topological Quantum Phase Transitions in the Wen-Plaquette Model** — •Victor Manuel Bastidas Valencia, Clive Emary, Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Our aim in this talk is to describe the nonequilibrium behavior of the topological quantum phase transition in the Ac-driven Wen-plaquette model. We show that under the effect of a nonadiabatic driving the system exhibits a novel topological phase. We define generalized topological order parameters by considering cycle-averaged expectation values of string operators in a Floquet state.

HL 98.9 Fri 11:45 H18

**Fermion-parity anomaly of the critical supercurrent in the quantum spin-Hall effect** — •Jan Dahlhaus[1], Dmitry Pikulin[1], Timo Hyart[1], Henning Schomerus[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, Niederlande — [2]Department of Physics, Lancaster University, United Kingdom

The helical edge state of a quantum spin-Hall insulator can carry a supercurrent in equilibrium between two superconducting electrodes (separation $L$, coherence length $\xi$). We calculate the maximum (critical) current $I_c$ that can flow without dissipation along a single edge, going beyond the short-junction restriction $L \ll \xi$ of earlier work, and find a dependence on the fermion parity of the ground state when $L$ becomes larger than $\xi$. Fermion-parity conservation doubles the critical current in the low-temperature, long-junction limit, while for a short junction $I_c$ is the same with or without parity constraints. This provides a phase-insensitive, DC signature of the $4\pi$-periodic Josephson effect.

HL 98.10 Fri 12:00 H18

**Topological kicked rotators** — •Jan Dahlhaus[1], Jonathan Edge[1], Jakub Tworzydlo[2], and Carlo Beenakker[1] — [1]Instituut-Lorentz, Universiteit Leiden, Niederlande — [2]Institute of Theoretical Physics, University of Warsaw, Poland

Topology is a nice mathematical concept that can have profound consequences on condensed matter systems. Maybe the most prominent examples are the quantum Hall effect, the quantum spin Hall effect and the 3D topological insulator. I will present a way to realize the ideas of band topology in a well-known and intensively-studied model - the quantum kicked rotator. This allows to study the Anderson localization properties of topological phase transitions numerically in a very efficient way, especially in higher dimensions. Furthermore it may open a way for experimental measurements of this transition behaviour with cold atomic gases in optical lattices.

HL 98.11 Fri 12:15 H18

**Theory of correlated topological insulators with broken axial spin symmetry** — •Stephan Rachel — TU Dresden, 01069 Dresden, Germany

The two-dimensional Hubbard model defined for topological band structures exhibiting a quantum spin Hall effect poses fundamental challenges in terms of phenomenological characterization and microscopic classification. We consider weak, moderate, and strong interactions and argue that the resulting phase diagrams depend on the microscopic details of the spin orbit interactions which give rise to the non-trivial topology. In particular, it turns out that there is a crucial difference between models with broken and with conserved axial spin symmetry. These results suggest that there is a general framework for correlated 2D topological insulators with broken axial spin symmetry.

[1] Rachel, LeHur, PRB 82, 075106 (2010)
[2] Schmidt, Rachel, von Oppen, Glazman, PRL 108, 156402 (2012)
[3] Cocks, Orth, Rachel *et al.*, PRL 108, 205303 (2012)
[4] Reuther, Thomale, Rachel, PRB 86, 155127 (2012)

HL 98.12 Fri 12:30 H18

**Interaction effects on almost flat surface bands in topological insulators** — •Matthias Sitte, Lars Fritz, and Achim Rosch — Universität zu Köln, Institut für Theoretische Physik, Zülpicher Str. 77, 50937 Köln, Deutschland

We investigate ferromagnetic instabilities of the two-dimensional helical Dirac fermions hosted on the surface of three-dimensional topological insulators. We concentrate on ways to increase the role of interactions by means of modifying the bulk properties which in turn changes the surface Dirac theory characteristics. We discuss both long-ranged Coulomb interactions controlled by the dimensionless coupling constant $\alpha = e^2/(\hbar\epsilon v_F^{\mathrm{surf}})$ as well as short-ranged Hubbard-like interactions of strength $U$ which can induce spontaneous surface ferromagnetism, thereby gapping the surface Dirac metal. In both cases, we find that a prerequisite for observing this effect is to reduce the Fermi velocity $v_F^{\mathrm{surf}}$, and we consider different mechanisms to achieve this. While for long-ranged Coulomb interactions we find that screening hinders ferromagnetism, for short-ranged interactions screening is not that vital and the instability can prevail.

HL 98.13 Fri 12:45 H18

**Local spin susceptibility and surface states in doped three-dimensional topological insulators with odd-parity superconducting pairing symmetry** — •Björn Zocher[1,2] and Bernd Rosenow[1] — [1]Institut für Theoretische Physik, Universität Leipzig, D-04103 Leipzig, Germany — [2]Max Planck Institut für Mathematik in den Naturwissenschaften, D-04103 Leipzig, Germany

We investigate characteristic features in the spin response of doped three-dimensional topological insulators with odd-parity unequal-spin superconducting pairing. To get insight into the nature of the superconducting pairing symmetry, we show that the odd-parity unequal-spin pairing can be mapped onto p-wave pairing and that these systems have gapless Majorana surface modes. The Majorana modes contribute to the local spin susceptibility, giving rise to a characteristic temperature behavior of the Knight shift and the spin-lattice relaxation time in magnetic resonance experiments. Because of their different decay lengths, the Majorana modes can be observed and clearly distinguished from the Dirac modes of the topological insulator by local probes which allow for a depth-controlled study of the electron spins on the nanometer length scale.