HL 19: Transport: Topological Insulators 2 (jointly with TT, MA)

Time: Monday 15:00–16:30 Location: H 3005

HL 19.1 Mon 15:00 H 3005

Majorana end states in disordered topological superconducting wires — •Alessandro Romito, Piet Brouwer, Mathias Duckheim, and Felix von Oppen — Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universit at Berlin, 14195 Berlin, Germany

Zeeman fields can drive semiconductor quantum wires with strong spin-orbit coupling and in proximity to s-wave superconductors into a topological phase. Such topological phases are characterized by the presence of Majorana Fermions which obey non-abelian statistics, and provide a possible platform for a topological quantum computer. So far Majorana Fermions have never been observed in experiments. However, semiconducting wires with strong spin-orbit coupling offer a promising path towards this goal. A key question, both for theory and experiment, is whether the topological phase is robust against the unavoidable presence of disorder.

Here, after brefly introducing the proposals for the realization and control of Majorana Fermions in quantum wires, I will mainly address their robustness against disorder showing that Majorana fermions persist in disordered wires up to a critical disorder strength which, remarkably, depends sensitively and non-monotonously on the Zeeman field applied to the wire. In finite length disordered wires the Majorana states combine into fermionic excitation at finite energy with large sample-to sample fluctuations. I will discuss the probability distribution of such low energy level and the consequences for the speed at which such topological quantum bits can be operated.

HL 19.2 Mon 15:15 H 3005

Competition between d-wave and topological p-wave superconductivity in the doped Kitaev-Heisenberg model — •Timo Hyart[1], Anthony Wright[1], Giniyat Khaliullin[2], and Bernd Rosenow[1] — [1]Institut für Theoretische Physik, Universität Leipzig, D-04103, Leipzig, Germany — [2]Max-Planck-Institut für Festkörperforschung, D-70569 Stuttgart, Germany

The competition between Kitaev and Heisenberg interactions away from half filling is studied for the hole-doped Kitaev-Heisenberg t-J_K-J_H model on a honeycomb lattice. While the isotropic Heisenberg coupling supports a time-reversal violating d-wave singlet state, we find that the Kitaev interaction favors a time-reversal invariant p-wave superconducting phase, which obeys the rotational symmetries of the microscopic model, and is robust for $J_H < J_K/2$. Within the p-wave superconducting phase, a critical chemical potential $\mu_c \approx t$ separates a topologically trivial phase for $|\mu| < \mu_c$ from a topologically non-trivial Z_2 time-reversal invariant spin-triplet phase for $|\mu| > \mu_c$.

HL 19.3 Mon 15:30 H 3005

s + p - wave proximity-induced superconductivity in impure topological insulators — •Grigory Tkachov, Pauli Virtanen, Florian Foohs, Patrik Recher, and Ewelina Hankiewicz — Universität Würzburg, Germany

In contacts with conventional s-wave superconductors (Ss), topological insulators (TIs) are expected to show both s- and p-wave superconducting correlations due to the spin-momentum locking on the surface. We analyze how the impurity scattering, extended defects (e.g. interfaces) and an external magnetic field influence such mixed proximity-induced superconductivity in topological insulators. As an example, we calculate a surface magnetosupercurrent through an S/TI/S Josephson junction.

HL 19.4 Mon 15:45 H 3005

Topologically protected zero-energy surface states of noncentrosymmetric superconductors — •Philip M. R. Brydon[1], Andreas P. Schnyder[2], and Carsten Timm[1] — [1]Technische Universität Dresden, Dresden, Germany — [2]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

It has recently been pointed out that nodal noncentrosymmetric superconductors are topologically non-trivial, with the nodal rings possessing a non-zero topological charge [1]. In these systems a bulk-boundary correspondence can be developed, which guarantees the existence of a flat band of singly degenerate zero-energy states within the projection of the nodal lines onto the surface Brillouin zone. Using the quasiclassical method [2,3], we present results for the surface bound state spectra, and provide a condition for the existence of the zero-energy states in terms of the sign of the gaps, which is complementary to the topological condition. The zero-energy surface states are shown to leave distinct signatures in the tunneling conductance.

[1] A. P. Schnyder and S. Ryu, Phys. Rev. B 84, 060504(R) (2011).
[2] P. M. R. Brydon, A. P. Schnyder, and C. Timm, Phys. Rev. B 84, 020501(R) (2011).
[3] A. P. Schnyder, P. M. R. Brydon, and C. Timm, arXiv:1111.1207 (unpublished).

HL 19.5 Mon 16:00 H 3005

Quantum phase transitions in the Kane-Mele-Hubbard model — Martin Hohenadler[1], Zi Yang Meng[2], •Thomas C. Lang[3], Stefan Wessel[3], Alejandro Muramatsu[4], and Fakher F. Assaad[1] — [1]Universität Würzburg, Würzburg, Germany — [2]Louisiana State University, Baton Rouge, USA — [3]RWTH Aachen, Aachen, Germany — [4]Universität Stuttgart, Stuttgart, Germany

We study the two-dimensional Kane-Mele-Hubbard model at half filling by means of quantum Monte Carlo simulations. We present a refined phase boundary for the quantum spin liquid. The topological insulator at finite Hubbard interaction strength is adiabatically connected to the groundstate of the Kane-Mele model. In the presence of spin-orbit coupling, magnetic order at large Hubbard U is restricted to the transverse direction. The transition from the topological band insulator to the antiferromagnetic Mott insulator is in the universality class of the three-dimensional XY model. The numerical data suggest that the spin liquid to topological insulator and spin liquid to Mott insulator transitions are both continuous.

HL 19.6 Mon 16:15 H 3005

Majorana fermions in strongly interacting helical liquids — •Eran Sela, Achim Rosch, and Alexander Altland — Koeln university, Germany

Majorana fermions were proposed to occur at edges and interfaces of gapped one-dimensional systems where phases with different topological character meet due to an interplay of spin-orbit coupling, proximity-induced superconductivity and external magnetic fields. Here we investigate the effect of strong particle interactions and show that a helical liquid offers a mechanism that protects the very existence of Majorana edge states: whereas moderate interactions close the proximity gap that supports the edge states, in helical liquids the gap reopens due to two-particle processes. However, gapless fermionic excitations occur at spatial proximity to the Majorana states at interfaces and may jeopardize their long-term Majorana coherence.