Seminar: Hard Condensed Matter Theory

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Room: Galilei room, 01-128 (Staudinger Weg 9)
Time: Tuesday, 07.07.2015, 14:15

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Transport in hybrid structures of topological insulators and in topological superconductors: In the Search of Majorana Fermions

Topological insulators (TIs) have a bulk energy gap that separates the highest occupied band from the lowest unoccupied band while gapless electronic states that are protected by time reversal symmetry live at the edge [1].

S-wave superconductor on the top of the surface states of 3D TI generates, due to the spin-momentum locking, mixed order parameter (s-wave and p-wave pairing mixture in the surface state). The central question is how to get information about this unconventional p-wave component. In the Josephson junction setup, namely superconductor(S)/surface state of topological insulator (TI)/superconductor (S), existence of these two superconducting channels leads to novel features in transport. In particular, we show that the topological Andreev bound state (ABS) (the state of hybridized two helical Majorana fermions)) occurs for the normal incidence where ABS is protected against backscattering [2]. This topological helical ABS is characterized by the novel effect, which we dubbed superconducting Klein tunneling (tunneling of the helical ABS with the transmission one through the normal regime independent of the barrier strength). We propose the experimental setups to observe the topological helical ABS [3].

Finally, we will discuss new systems like topological superconductors on the hexagonal lattices where chiral d+id topological superconductivity is expected, and the theoretical schemes how to measure edge conductance in these materials [4]. Is there a way to measure Majorana particle in these systems?

[1] G. Tkachov and E. M. Hankiewicz, topical review in *Phys. Status Solidi B* **250**, 215 (2013).
[2] G. Tkachov and E. M. Hankiewicz, *Phys. Rev. B* **88**, 075401 (2013).
[3] I. Sochnikov, L. Maier, C. A. Watson, J. R. Kirtley, C. Gould, G. Tkachov, E. M. Hankiewicz, C. Brüne, H. Buhmann, L. W. Molenkamp, and K. A. Moler, Phys. Rev. Lett. **114**, 066801 (2015).
[4] L. Elster, C. Platt, R. Thomale, W. Hanke, and E. M. Hankiewicz, arXiv:1408.3551, accepted to Nat. Comm. (2015).

All interested are cordially welcome!

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