SKM-SYTI 1: Topological Insulators

Time: Wednesday 10:30–13:00 Location: TRE Ma

Invited Talk SKM-SYTI 1.1 Wed 10:30 TRE Ma
Topological insulators and topological superconductors — •Shoucheng Zhang — Stanford

Recently, a new class of topological states has been theoretically predicted and experimentally observed. The topological insulators have an insulating gap in the bulk, but have topologically protected edge or surface states due to the time reversal symmetry. Similarly, topological superconductors or superfluids have novel edge or surface states consisting of Majorana fermions. In this talk, I shall review the recent theoretical and experimental progress in the field, and focus on a number of outstanding issues, including the quantized anomalous Hall effect, quantized magneto-electric effect, the topological Mott insulators and the search for topological superconductors.

Invited Talk SKM-SYTI 1.2 Wed 11:00 TRE Ma
Dirac Fermions in HgTe Quantum Wells — •Laurens Molenkamp — Physikalisches Institut(EP3) der Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

HgTe quantum wells have a linear band dispersion at low energies and thus mimic the Dirac Hamiltonian. Changing the well width tunes the band gap (i.e., the Dirac mass) from positive, through zero, to negative. Wells with a negative Dirac mass are 2-dimensional topological insulators and exhibit the quantum spin Hall effect, where a pair of spin polarized helical edge channels develops when the bulk of the material is insulating. Our transport data provide very direct evidence for the existence of this third quantum Hall effect. Wells with a thickness of 6.3 nm are zero gap Dirac systems, similar to graphene. However, zero gap HgTe wells possess only a single Dirac valley, which avoids inter-valley scattering. This makes them especially suitable to study quantum interference effects under a Dirac Hamiltonian.

Invited Talk SKM-SYTI 1.3 Wed 11:30 TRE Ma
Interaction, disorder, and quantum criticality in Z_2 topological insulators — •Alexander Mirlin — Karlsruhe Institute of Technology, Germany

We study disorder and interaction effects in topological insulators with strong spin-orbit coupling. We find that the interplay of nontrivial topology, quantum interference, and Coulomb repulsion induces a novel critical state on the surface of a three-dimensional topological insulator. Remarkably, this interaction-induced criticality, characterized by a universal value of conductivity, emerges without any adjustable parameters. Further, we predict a direct quantum-spin-Hall transition in two dimensions that occurs via a similar critical state.

[1] P.M. Ostrovsky, I.V. Gornyi, A.D. Mirlin, Interaction-induced criticality in Z_2 topological insulators, Phys. Rev. Lett. 105, 036803 (2010)

[2] A. D. Mirlin, F. Evers, I. V. Gornyi, P. M. Ostrovsky, Anderson Transitions: Criticality, Symmetries, and Topologies, in "50 Years of Anderson Localization", ed. by E. Abrahams (World Scientific, 2010); reprinted in Int J Mod Phys B 24, 1577 (2010).

Invited Talk SKM-SYTI 1.4 Wed 12:00 TRE Ma
Disorder and Interactions in Topological Insulators — •Allan H. MacDonald — University of Texas, Austin TX, USA

Three-dimensional topological insulators have protected surface states that are described by massless Dirac equations. I will discuss some properties of these two-dimensional Dirac systems, emphasizing the importance of disorder and interactions. The magneto-optical properties of topological insulator thin films depend intricately on a competition between disorder and time-reversal symmetry breaking by either external magnetic fields or exchange coupling to external magnetic fields. Broken symmetry states, including notably nteraction-driven spontaneous phase coherence between top and bottom surfaces are likely to occur in the absence of a magnetic field. In addition a wide variety of unusual broken symmetry states are likely to be discovered in the presence of external magnetic fields as sample qualities improve.

Invited Talk SKM-SYTI 1.5 Wed 12:30 TRE Ma
Tunable multifunctional topological insulators in ternary Heusler and related compounds — •Claudia Felser[1], Stanislav Chadov[1], Lukas Müchler[1], Jürgen Kübler[2], Shou Cheng Zhang[3], Xiaoliang Qi[3], and Hai-Jun Zhang[3] — [1]University Mainz — [2]TU Darmstadt — [3]Stanford University

Recently the quantum spin Hall effect was theoretically predicted and experimentally realized in quantum wells based on the binary semiconductor HgTe. The quantum spin Hall state and topological insulators are new states of quantum matter interesting for both fundamental condensed-matter physics and material science. Many Heusler compounds with C1b structure are ternary semiconductors that are structurally and electronically related to the binary semiconductors. The diversity of Heusler materials opens wide possibilities for tuning the bandgap and setting the desired band inversion by choosing compounds with appropriate hybridization strength (by the lattice parameter) and magnitude of spinorbit coupling (by the atomic charge). Based on first-principle calculations we demonstrate that around 50 Heusler compounds show band inversion similar to that of HgTe. The topological state in these zero-gap semiconductors can be created by applying strain or by designing an appropriate quantumwell structure, similar to the case of HgTe. Many of these ternary zero-gap semiconductors (LnAuPb, LnPdBi, LnPtSb and LnPtBi) contain the rare-earth element Ln, which can realize additional properties ranging from superconductivity (for example LaPtBi) to magnetism (for example GdPtBi) and heavy fermion behaviour (for example YbPtBi).