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Normal and superconducting transport through a gated 3D topological insulator

Location: Hörsaal A (1.3.14)
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Topological insulators are a new recently discovered class of materials, characterized by the presence of an energy gap in the bulk electronic spectrum, coexisting with robust gapless states at the surface. The nature of the surface states depends on the dimensionality of the system. For 2D topological insulators, the "surface states" are 1D helical modes propagating ballistically at the edge of the system. For 3D topological insulators, the surface states consist of a gas of chiral, gapless Dirac fermions. Following their theoretical predictions, surface states in different topological insulators have been observed. Whereas in 2D the helical modes have been mainly studied by transport experiments, in 3D the use of transport to detect the surface states has proven to be difficult, owing to the presence of parasitic, large bulk conductivities. As a consequence, so far most experiments have relied on spectroscopic techniques (ARPES and STM). Here, we discuss our recent transport experiments on thin crystalline layers of Bi_2Se_3 – currently the best representative of 3D toplogical insulators- produced using techniques borrowed from the field of graphene electronics. The experiments rely on the measurement of magneto transport through devices equipped with a gate, which enable the observation of the fan diagram of Landau levels and the unambiguous identifications (and controlled filling) of surface Dirac electron and holes. At low-temperature and zero magnetic field, the use of superconducting electrodes allows the observation of supercurrent flowing through the system. The supercurrent is also found to be gate-tunable, indicating that at least a fraction of it is carried by Dirac fermions. Our results provide clear evidence that the Dirac surface states are robust and survive in the presence of considerable disorder, i.e. they provide indications as to the important role of topological protection.