MA 14: Joint Symposium "Topological Insulators: Influence of Superconductivity, Magnetism and Extrinsic Spin-Orbit Interaction" (SYTI)

Time: Tuesday 9:30–12:00 Location: H 0105

Invited Talk MA 14.1 Tue 9:30 H 0105
Search for Majorana fermions in topological insulators — •Carlo Beenakker — Instituut-Lorentz, Leiden University, The Netherlands

Majorana fermions (particles which are their own antiparticle) may or may not exist in Nature as elementary building blocks, but in condensed matter they can be constructed out of electron and hole excitations. What is needed is a superconductor to hide the charge difference, and a topological (Berry) phase to eliminate the energy difference from zero-point motion. We discuss strategies to detect Majorana fermions at the edge of a 2D topological insulator and on the surface of a 3D topological insulator.

Invited Talk MA 14.2 Tue 10:00 H 0105
Cooper Pairs in Topological Insulator Bi_2Se_3 Thin Films Induced by Proximity Effect — •Jinfeng Jia — Key Laboratory of Artificial Structures and Quantum Control (Ministry of Education), Department of Physics, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, China

Three dimensional topological insulators (TIs), a new state of matter, have recently become a fertile farmland in which plenty of exotic quantum physical phenomena can grow. Among them, the interplay between topologically ordered states and symmetry-breaking states such as magnetism and superconductivity (SC) is particularly fascinating and has attracted extensive research activities. By introducing superconducting states into a TI via superconducting proximity effect, namely Cooper pairs tunneling into TI at TI/SC interface, the interplay between TI and SC can lead to the Majorana Fermion (MF) - quasiparticle that is its own antiparticle. MFs in solids obeys non-Abelian quantum statistics, are considered as the most promising candidate for fault-tolerant quantum computation. Here we report scanning tunneling microscopy observation of Cooper pairs formation on Bi_2Se_3 thin films grown on BCS type s-wave superconductor $NbSe_2$ by molecular beam epitaxy technique. Our data show that the Cooper pairs persist in the thickness regime from one quintuple layer (QL) up to seven QL of Bi_2Se_3 where topological order forms. This observation lays the groundwork for experimentally realizing MFs in condensed matter physics.

Invited Talk MA 14.3 Tue 10:30 H 0105
Gate tunable normal and superconducting transport through a 3D topological insulator — •Alberto Morpurgo — University of Geneva

We report on transport experiments though very thin Bi_2Se_3 layers, exfoliated from high quality single crystals and transferred onto a Si/SiO_2 substrate acting as a gate. Low-temperature magneto-resistance measurements exhibit clear Shubnikov de Haas oscillations, which can be tuned by applying a gate voltage. The plot of the resistance as a function of magnetic field and gate voltage exhibit a fan diagram of Landau levels originating from both electrons and holes at the surface closer to the gate electrode, whose quantitative analysis allows us to determine the Dirac character of the charge carriers. Shubnikov de Haas oscillation due to carriers on the surface far away from the gate are also observed as features in the fan diagram that do not depend on the gate voltage (which is screened by the first and by carriers in the bulk). Our analysis also shows that an impurity band is present inside the gap of the bulk bands of Bi_2Se_3, with a large density of states that coexist with the surface states. Finally, as the devices are fabricated with superconducting contacts, we succeeded in observing Andreev reflection and proximity induced supercurrent. The critical current is gate tunable and exhibits a bipolar behavior, with a minimum at the same gate voltage observe from extrapolating the fan diagram of Landau levels. This observation indicates that at least part of the supercurrent is carried by Dirac electrons and holes at the surface.

Invited Talk MA 14.4 Tue 11:00 H 0105
Weyl Metal States and Surface Fermi Arcs in Iridates — •Sergey Savrasov — University of California, Davis

We investigate[1] novel phases that emerge from the interplay of electron correlations and strong spin-orbit interactions. We focus on describing the topological semimetal, a three-dimensional phase of a magnetic solid, and argue that it may be realized in a class of pyrochlore iridates (such as Y2Ir2O7) based on calculations using the LDA + U method. This state is a three-dimensional analog of graphene with linearly dispersing excitations and provides a condensed-matter realization of Weyl fermions that obeys a two-component Dirac equation. It also exhibits remarkable topological properties manifested by surface states in the form of Fermi arcs, which are impossible to realize in purely two-dimensional band structures. For intermediate correlation strengths, we find this to be the ground state of the pyrochlore iridates, coexisting with noncollinear magnetic order. A narrow window of magnetic *axion* insulator may also be present. An applied magnetic field is found to induce a metallic ground state.

[1] Xiangang Wan, Ari M. Turner, Ashvin Vishwanath, Sergey Savrasov, Physical Review B 83, 205101 (2011)

Invited Talk MA 14.5 Tue 11:30 H 0105
Engineering a Room-Temperature Quantum Spin Hall State in Graphene via Adatom Deposition — •Marcel Franz — University of British Columbia

Using symmetry arguments, density functional theory, and tight-binding simulations, we predict that graphene endowed with certain heavy adatoms realizes a two-dimensional topological insulator phase with substantial band gap. For indium and thallium, our most promising adatom candidates, a modest coverage of 6% produces an estimated gap near 80K and 240K, respectively, which should be detectable in transport or spectroscopic measurements. Engineering such a robust topological phase in graphene could pave the way for a new generation of devices for spintronics, ultra-low-dissipation electronics and quantum information processing.