Spin-orbit induced triplet correlations and magnetoelectrics in superconducting heterostructures

Irina Bobkova*[1], Alexander Bobkov[1], Alexander Zyuzin[2,3], and Mohammad Alidoust[4]

[1]Institute of Solid State Physics RAS (ISSP RAS) – Chernogolovka, Moscow District, 2 Academician Ossipyan str., 142432, Russia

[2]A.F. Ioffe Physical - Technical Institute – 194021, St. Petersburg, Russia

[3]Department of Physics, KTH-Royal Institute of Technology – Stockholm, SE-10691, Sweden

[4]K.N. Toosi University of Technology – Tehran, Iran

Abstract

The systems with full spin-momentum locking of the conducting states, such as the surface states of 3D topological insulator, are a platform for realization and investigation of interplay between superconductivity and the strongest spin-orbit coupling.
We study the effective superconducting order parameter and the condensate wave function, induced in surface states of 3D topological insulator (TI) by proximity to an s-wave superconductor (S) in the presence of an external magnetic field or an applied supercurrent. We perform a symmetry analysis of the induced superconductivity and find that all possible pairings, allowed by the Pauli principle, are present due to the full spin-momentum locking of the underlying conducting surface state of the TI. We unveil the connection between the odd-frequency pairing in S/3D TI heterostructures and magnetoelectrical effects. It is shown that in the presence of the magnetic field or the supercurrent the helical nature of the surface states manifests itself not only in the condensate wave function, as it was known previously [1-5], but also in the structure of the effective order parameter, which acquires an odd-frequency component.

Due to the full spin-momentum locking of the surface states of the TI the magnetoelectric effects are extremely strong there. We consider possible experimental manifestations of the magnetoelectrical effects in S/3D TI heterostructures and their potential applications. In particular, we discuss a proposal to use such heterostructures as electrically controllable sources of highly spin-polarized current for spintronics applications.

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*Speaker