Theory of hybrid collective excitations in topological superconductor/ferromagnetic insulator heterostructures

T. Karabassov[1,2], I.V. Bobkova[1*], A.M. Bobkov[1], A.S. Vasenko[2], and A.A. Golubov[1]

[1] Moscow Institute of Physics and Technology, Dolgoprudny, Russia
[2] National Research University Higher School of Economics, Moscow, Russia
*email: ivbobkova@mail.ru

Key words: proximity effect, collective modes

In this talk we address a still unexplored type of dynamical proximity effects in S/F heterostructures. As a basic system sustaining the strongest spin-orbit coupling (SOC), we consider a topological superconductor/ferromagnetic insulator (TS/FI) heterostructure. It is predicted that the magnons in the TS and the Nambu-Goldstone (NG) phase mode in the TS are coupled forming composite magnon-NG excitations. The coupling occurs via the interface exchange coupling between the conductivity electrons of the 2D TS superconducting surface state and the FI magnetization. The key ingredient providing the coupling is the spin-momentum locking of electrons in the helical surface state of the TS, which always maintains the same magnitude of singlet and triplet correlations, thus giving the superconducting OP the ability to respond to a magnon. Conversely, excitation of the NG mode in the TS leads to the appearance of an ac current, which is always accompanied by electron spin polarization (direct magnetoelectric effect). The current-induced spin polarization creates a torque, generating magnons in the FI.

The strength of magnon-NG coupling is anisotropic. It is maximal for excitations propagating along the equilibrium magnetization of the FI and vanishes for the perpendicular propagating direction. The reconstructed spectra and specific features in the decay rate of these composite excitations can be used for experimental study the NG mode and its interaction with the magnon. At the same time, the amplitude Higgs mode is not coupled to the magnon for the 2D helical state of the TS.

The financial support from the Grant of the Ministry of Science and Higher Education of the Russian Federation No. 075-15-2025-010 is acknowledged.