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Exotic Andreev bound states in topological superconductors

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Abstract:

Topological superconductor with time reversal symmetry is a hot topic now. Recently, topological superconducting state has been predicted in Cu doped Bi_2Se_3 ($Cu_xBi_2Se_3$)[1]. Point contact spectroscopy has shown a zero bias conductance peak (ZBCP) consistent with the presence of surface edge mode[2], i.e., surface Andreev bound states (SABSs)[2]. We have developed a theory of the tunneling spectroscopy for superconducting topological insulators (STIs), where the SABSs appear as helical Majorana fermions. We have found that the SABSs in the odd-parity STIs have a structural transition in the energy dispersions. The transition [3,4] results in a variety of Majorana fermions, by tuning the chemical potential and the effective mass of the energy band. We further derived an analytical formula of the conductance of the present junction [6] which is an extension of the conductance formula of unconventional superconductors [7]. The origin of this anomalous dispersion stemming from the residual surface density of states in topological insulator. Residual density of states plays an important role in Weyl semimetal where Fermi arc exists in the normal state. We have clarified a new type of crossed Andreev bound state in doped Weyl semimetal. Since Fermi arc which is the surface state of doped Weyl semimetal, does not have a Kramers partner, residual gapless states can remain in the superconducting state. We show that the Fermi arcs enable them to support an even more exotic surface state with crossed flat bands in the superconducting state. We clarify the topological origin of the crossed flat bands and the relevant symmetry that stabilizes the cross point. We also discuss their possible experimental verification by tunneling spectroscopy [8].

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