Topological Superconductivity with Time-reversal Symmetry

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Topological phases in solids have attracted recent intensive interests. Among them, topological superconductors (TSCs) are of particular importance due to their potential applications to the quantum information in terms of the Majorana fermions. Therefore, theoretical design of TSCs in realistic setups is now a keen issue. In this talk, we give a presentation on (i) a possibility of TSC in bilayer Rashba system and (ii) proximity effect of metallic quantum nanowire on unconventional superconductor resulting degenerate Majorana bound states on its ends.

(i) Topological Superconductivity in Bilayer Rashba System [1]

We address the issue by theoretical study on the superconducting states and their topological features in the interacting two layers of Rashba systems, which might be available in interface systems of transition metal oxides and superlattices of heavy fermion compounds. We have obtained phase diagrams of superconductivity in the plane of two kinds of electron density-density interactions, i.e., intra-layer and inter-layer ones. It is revealed that the unconventional pairing states are induced by the Rashba spin-orbit interaction and the multi-layer effect. They provide TSC with time-reversal symmetry in some regions, which are expected to be realized in experimental systems.

(ii) Majorana bound states and non-local spin correlations in a quantum wire on a topological superconductor [2]

We theoretically study the proximity effect of the one-dimensional quantum wire of usual metal without the spin-orbit interaction on the substrate of unconventional superconductor. The Cooper pairs are induced into the wire, resulting effective one-dimensional superconducting system. We found degenerate zero energy Majorana bound states appear at both ends of the wire, unlike single Majorana state in spin-orbit coupled system with s-wave superconductor. These degenerate Majorana bound states constitute the spin 1/2 degrees of freedom at each end of the wire. These spins are non-locally correlated and can be controlled by electrical means.

References:

[1]S. Nakosai, Y. Tanaka and N. Nagaosa, Phys.Rev. Lett. 108 147003 (2012).

[2]S. Nakosai, Y. Jan C. Budich, Y. Tanaka, B. Trauzettel, and N. Nagaosa, arXiv:1211.2307