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Presentation Title

Majorana Fermions and Topological Superconductors

Abstract

The Majorana fermions have originally proposed by Majorana in 1937 as an elementary particle. Majorana fermions have distinct feature, where Majorana particle is its own antiparticle. Recently, the search for Majorana fermions in electroninc systems becomes a hot topic. There is a dream that fault tolerant topological quantum computation becomes possible based on Majorana Fermions.

There are several candidates of the superconducting systems hosting Majorana Fermion as edge states. Nowadays, superconductor with topological edge states is called topological superconductor. The edge state is a certain kind of Andreev bound state and is protected by the energy gap of the bulk Hamiltonian. Recently, we have clarified novel quantum properties of Majorana fermions in various systems including topological insulator hetero structures [1-4]. In this presentation, we would like to talk i)Helical edge modes and resulting spin current in non-centrosymmetric (NCS) superconductors[1], and ii)chiral Majorana Fermion in Rashba superconductor [4].

(I) Topological spin current in non-centrosymmetric superconductor

In non-centrosymmetric superconductor (NCS), since the parity is broken, spin-triplet *p*-wave and spin-singlet *s*-wave pairing can mix each other. We have clarified that in NCS superconductor with *s*+*p*-wave pairing, topologically nontrivial class analogous to the quantum spin Hall system is realized, when the amplitude of the *p*-wave pair potential is larger than that of *s*-wave one. The resulting helical edge modes as Andreev bound states carries spontaneous topologically protected spin current. We have found that the incident angle dependent spin polarized current flows through the

interface due to the presence of the helical

(II) Evolution of Edge states and Critical Phenomena in Rashba Superconductor

We study Andreev bound states (ABS) and resulting charge transport of Rashba superconductor (RSC) where two-dimensional semiconductor (2DSM) heterostructures is sandwiched by spin-singlet *s*-wave superconductor and ferromagnet insulator. ABS becomes a chiral Majorana edge mode similar to that in spinless chiral *p*-wave pairing in topological phase (TP). We clarify that two types of quantum criticality about the topological change of ABS near a quantum critical point (QCP), whether ABS exists at QCP or not. In the former type, ABS has a energy gap and does not cross at zero energy in non-topological phase (NTP). These complex properties can be detected by tunneling conductance between normal metal / RSC junctions.

[1] Y. Tanaka, T. Yokoyama and N. Nagaosa, Phys. Rev. Lett. 103, 107002 (2009).
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[3] Y. Tanaka, T. Yokoyama, A.V. Balatsky and N. Nagaosa, Phys. Rev. B 060505 (2009).
[4]A. Yamakage, Y. Tanaka and N. Nagaosa, unpublished.