Major step toward confirming the existence of the majorana particle

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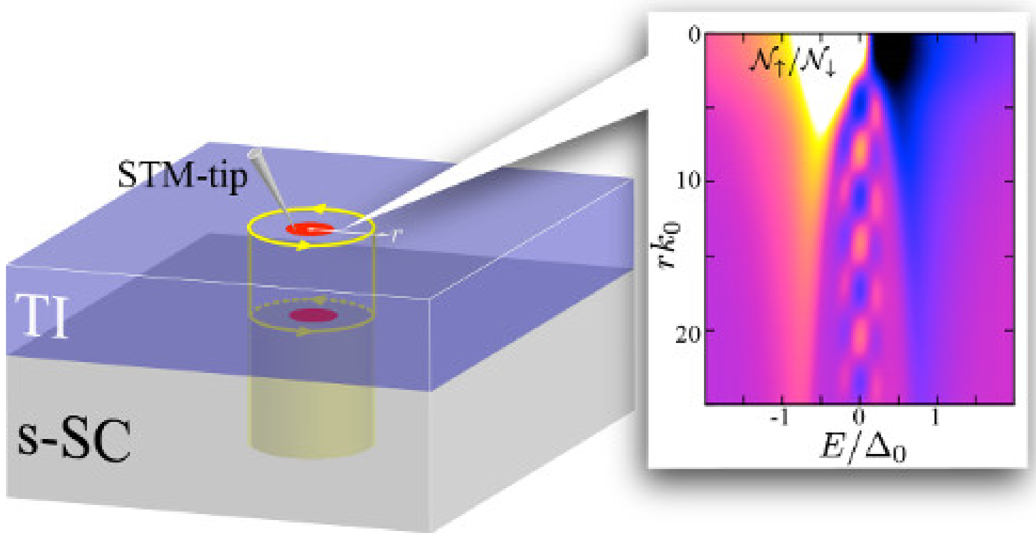

Schematic of Majorana particles localized inside the core of quantum vortex of a topological superconductor and the distribution of density of states of superconducting quasiparticle excitations based on the theoretical calculations.

A NIMS MANA group theoretically demonstrated that the results of the experiments on the peculiar superconducting state reported by a Chinese research group in January 2015 prove the existence of the Majorana-type particles.

A research group led by NIMS Special Researcher Takuto Kawakami and MANA Principal Investigator Xiao Hu of the International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for

Materials Science (NIMS) theoretically demonstrated that the results of the experiments on the peculiar superconducting state reported by a Chinese research group in January 2015 can be taken as a proof of the existence of Majorana-type particle.

The existence of Majorana particle was predicted in 1937 by the Italian theoretical physicist Ettore Majorana. Though it is fermion, it is equivalent to its own antiparticle. While its existence as an elementary particle still has not been confirmed today—nearly 80 years after the prediction, it was pointed out theoretically in recent years that quasiparticle excitations in special materials called topological superconductors behave in a similar way as Majorana particles. However, it is difficult to capture these Majorana particles in materials due to their unique properties of being charge neutral and carrying zero energy. There have been intense international competitions to confirm their existence.

The research group carefully examined the physical conditions of the experiments mentioned above, conducted extensive and highly precise theoretical analysis on superconducting quasiparticle excitations, and demonstrated that Majorana particles are captured inside quantum vortex cores of a topological superconductor by comparing the theoretical analysis with the results of the experiments. In addition, the group suggested a specific method to improve the precision of the experiments by taking advantage of the unique quantum mechanical properties of Majorana particles.

The collective behavior of Majorana particles—fermions that are equivalent to their own antiparticles—is different from that of electrons and photons, and it is expected to be useful in the development of powerful quantum computers. Furthermore, their very unique property due to zero-energy could be exploited for the creation of various new quantum functionalities. As such, confirming the existence of Majorana particles at high precision will leave a major ripple impact toward new developments in materials science and technology.

More information: Takuto Kawakami et al. Evolution of Density of States and a Spin-Resolved Checkerboard-Type Pattern Associated with the Majorana Bound State, *Physical Review Letters* (2015). DOI: 10.1103/PhysRevLett.115.177001

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