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Surface Majorana cone of the topological superfluid ^{3}He B phase

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Topological superfluids and superconductors are characterized by a non-trivial topological number in the gapped bulk state and gapless edge states on their surfaces. The surface states are proposed to be Majorana fermions as they satisfy the Majorana condition, i.e., a particle and its antiparticle are equivalent, and their linear dispersion is called Majorana cone. It is an urgent issue in condensed matter physics to confirm the realization of the topological matters in nature and their bulk-edge correspondence. Superfluid ^{3}He is a suitable system to reach a definite conclusion since the spin-triplet p-wave symmetry is well established in the bulk state. We measured transverse acoustic impedance of the superfluid ^{3}He B phase changing the boundary condition of a wall from a diffusive scattering up to practically specular limit by coating the wall with thin layers of superfluid ^{4}He. A growth of low-energy peak in the transverse acoustic impedance was observed at higher specularities, which is the clear evidence of low-lying quasiparticle states in the vicinity of the wall. A self-consistent theoretical calculation reproduces the experimental results well and shows that the observed growth of the peak is the reflection of the linear dispersion of the surface Andreev bound states. Thus, we experimentally confirmed Majorana fermions on the surface of the superfluid ^{3}He B phase and showed that the superfluid ^{3}He B phase is truly a topological superfluid with the bulk-edge correspondence.