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Topological aspects of superfluid ^{3}He investigated by ions trapped at the surface

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Topology is a key concept for understanding fundamental aspects of quantum states of matter. The p-wave superfluid ^{3}He offers a textbook example of topological superfluids, showing a number of exotic phenomena associated with its topology and complex broken symmetry. Here we present investigations of topological aspects of the A and B phases of the superfluid ^{3}He by transport of electrons (electron bubbles) trapped below the free surface. The A phase (^{3}He-A) is a chiral p-wave superfluid with broken time-reversal and parity symmetries. This phase is recently recognized as a Weyl superfluid with Weyl points in momentum space. In this phase, we found that electron bubbles trapped below the free surface show the anomalous Hall effect[1]. The observation of the anomalous Hall effect provides a direct demonstration for broken time-reversal and parity symmetries of ^{3}He-A. Furthermore, this observation could be a strong evidence for the spectrum of Weyl fermions in ^{3}He-A[2]. The B phase (^{3}He-B) is a time-reversal invariant topological superfluid, which hosts Majorana bound states at a surface. To show the presence of the bound states, we measured mobility of electron bubbles trapped just below the free surface. The observed mobility is suppressed from that in bulk ^{3}He at low temperatures[3]. The recent theoretical calculation[4] shows that the suppression of mobility is caused by the scattering of surface bound states by the electron bubble, and the theoretical mobility perfectly reproduces our experimental data. This agreement provides a direct evidence of the presence of the surface bound states at the free surface of ^{3}He-B.

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