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Electron Bubbles in Chiral Superfluid ^{3}He-A: Weyl Fermions and Anomalous Hall Effect[1]

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The A phase of ^{3}He is a chiral topological superfluid that spontaneously breaks parity and time-reversal symmetries. These broken symmetries were recently revealed by the RIKEN group in transport measurements showing electrons exhibit an anomalous Hall effect in superfluid ^{3}He-A. We report results based on our theory[2] of the anomalous Hall effect for electron transport in ^{3}He-A. The theory is based on a quantum mechanical treatment of multiple scattering of Bogoliubov quasiparticles by negative ions embedded in the chiral superfluid. The key ingredient to the scattering theory is the role of broken mirror and time-reversal symmetries on the quasiparticle scattering rate. Quantum interference of quasi-particles and quasi-holes leads to the formation of a branch of sub-gap Weyl Fermions bound to the surface of the ion, a mesoscopic realization of the bulk-edge correspondence. We show that these states are responsible for the ion's angular momentum which is inherited from the chiral ground state, and that the Weyl spectrum plays a central role in the skew scattering of thermally excited Bogoliubov quasiparticles off the negative ion in ^{3}He-A. Our theoretical results are shown to be in quantitative agreement with the RIKEN experiments for both the longitudinal and transverse forces acting on the ion, and our theory provides both a qualitative and quantitative explanation of the processes responsible for the anomalous Hall effect in ^{3}He-A.

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[2]O. Shevtsov and J. A. Sauls, Phys. Rev. B **94**, 064511 (2016).