Magnetic Field Induced A-B Phase Transition and Edge States of Superfluid ^{3}He Confined in a Slab Geometry

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Recent interest in the superfluid ^{3}He-B has been stimulated by the realization that a non-trivial topological invariant can be defined in the bulk. This invariant ensures the existence of gapless states bound at the edge or surface of ^{3}He-B. It has been revealed that gapless edge states which behave as Majorana fermions give rise to anisotropic spin susceptibility when the applied field is sufficiently weak.
Here, we study the thermodynamics and edge states of the topological superfluid ^{3}He confined in a slab geometry, based on both the quasiclassical Eilenberger theory and Bogoliubov-de Genes theory. The former provides a quantitative theory for ^{3}He, while the latter enables us to understand a full quantum nature of low-energy quasiparticles. In this work, we show the quantitative phase diagram of the superfluid ^{3}He in a plane of the thickness and the magnetic field. The first- and second-order phase transitions between A and B phases are induced by changing the thickness and applying magnetic fields, where their edge states exhibit completely different characteristics.[1] Based on the complete phase diagram, we discuss the spectrum of low-energy quasiparticles bound at the edge and magnetic anisotropy under the rotation of strong magnetic fields. We also clarify the role of magnetic dipole-dipole interaction on magnetic anisotropy.

[1]See for example, Y. Tsutsumi *et al.*, J. Phys. Soc. Jpn. **79**, 113601 (2010).