Experimental signatures of vortex core structures in superfluid ^{3}He

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The superfluid phases of ^{3}He were the first experimentally accessible macroscopic quantum systems where the multi-component order parameter supports a variety of quantized vortices with non-singular, i.e. superfluid, cores. Such vortices can possess hard cores with the radius of about the coherence length, filled with a superfluid phase, different from that in the bulk. An other alternative is a much larger skyrmion-like soft core, where only the orientation of the order parameter changes. These unconventional structures lead for example to the broken axial symmetry and spontaneous magnetization of vortex cores and to the existence of double- and half-quantum vortices. The Caroli-de Gennes-Matricon picture of the vortex-core-bound fermions is modified with the inclusion of zero-energy states or fermionic flat bands in the cores, the lifting of the spin degeneracy and other consequences of broken symmetries. A short overview of these features will be presented, in view of the growing interest in unconventional vortex structures in multi-component Bose-Einstein condensates of cold atoms, superconductors with p- and d-wave pairing and artificially engineered topological superconductors.
Many of these features of the vortices in superfluid ^{3}He were experimentally established by probing the order-parameter structure in a rotating sample with the nuclear magnetic resonance techniques and by measuring vortex dynamics. Recent work at temperatures below $0.2\,T_c$ provides new information on the interaction of the soft- and hard-core vortices at the interface between A and B phases of ^{3}He and on the fermions bound to the hard cores of the B-phase vortices. The core-bound fermions are detected using coherent spin precession of the BEC of magnon quasiparticles, while the rotational motion of the non-axisymmetric vortex cores provides the coupling mechanism between the two subsystems.

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