Quantum vortices in Fermi superfluids: structure, dynamics, and dissipation

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Quantum vortices are among the most prominent examples of topological excitations in superfluids. They arise in both bosonic systems, such as superfluid helium-4 and atomic Bose–Einstein condensates, and in fermionic systems, including superfluid helium-3, metallic superconductors, and neutron matter. While topology constrains many of their properties, key aspects of vortex behavior are governed by their internal structure, which depends on quantum statistics. In this seminar, I will review recent studies of quantum vortices in Fermi superfluids and contrast them with their bosonic counterparts. Particular attention will be given to the evolution of vortex core structure across the BCS–BEC crossover, spanning the transition from weak to strong coupling. I will then discuss how these structural changes influence vortex dynamics, focusing on the emergence of vortex inertia in Fermi systems and on microscopic mechanisms responsible for dissipation in their motion. The discussion will be supported by numerical results from density functional theory for Fermi superfluids, along with comparisons with experimental results for ultracold Fermi gases.