1D–3D crossover of a spin-imbalanced Fermi gas

Randall Hulet

Rice University

The issue of pairing of magnetized, or “spin-imbalanced” Fermi gases has been an open question in quantum many body physics for more than 50 years. It is still not known whether a material can simultaneously exhibit superconducting and magnetic order as embodied by the FFLO state, although the answer to this question has implications for fields as diverse as unconventional superconductivity to the equation of state of neutron stars.

I will review our experimental investigations of the phases of spin-imbalanced atomic quantum gases in 1D [1], 3D [2], and in the crossover regime between 1D and 3D [3]. The FFLO state has not been seen in 3D, and theory is ambiguous in this case. FFLO is pervasive in the $T=0$ phase diagram in 1D, but it may be unstable at experimentally achievable temperatures. The 1D–3D crossover, experimentally realized by a 2D optical lattice in which the quasi-1D tubes are weakly coupled to nearest neighbors, may be the optimum place to detect FFLO. The crossover is readily observable by in situ imaging of the density because phase separation between an unpolarized superfluid phase and polarized phases is inverted in a 1D trap compared with 3D. Progress on the direct detection of FFLO in this region will be reported.