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Spin-Imbalance in One and Three-Dimensional Fermi Gases[1]

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The FFLO modulated superconductor state was independently proposed by Fulde and Ferrell, and Larkin and Ovchinnikov, as a way of accommodating the excess spin in a spin-polarized superconductor. The pairs in the FFLO state have non-zero center-of-mass momentum, which can produce a periodic structure with a spatially-modulated order parameter. Although there is some evidence for FFLO pairing in certain heavy fermion compounds that are able to accommodate both magnetic and superconducting order, conclusive experimental proof remains elusive. Motivated by the search for exotic paired states, we have performed experiments with spin-imbalanced ultracold atomic Fermi gases in both 3D and 1D. We use two hyperfine levels of ^{6}Li to emulate the spin-up and down states. The *s*-wave pairing interactions are controlled via a magnetically-tuned collisional (Feshbach) resonance. In 3D, we find that the gas phase separates into an evenly paired BCS-like core, surrounded by the excess spin-up atoms [1]. For the 1D experiment, a two-dimensional optical lattice was used to create an array of 1D tubes that are each filled with $\sim$200 atoms. The weak axial confinement again produces a phase separation, but in contrast to 3D we find a partially-polarized central core surrounded by either fully-paired or fully-polarized wings, depending on the degree of overall spin-polarization [2]. Theory predicts that the partially-polarized phase is an FFLO superfluid. We are currently trying to obtain direct evidence for FFLO pairing, which may be revealed in the pair momentum distribution found by releasing the atoms axially and allowing them to expand in time-of-flight. We are also exploring the 1D-3D dimensional crossover that occurs when the coupling between tubes is reduced.

[1] G.B. Partridge *et al*, Science **311**, 503 (2006).
[2] Y.A. Liao *et al*, Nature **467**, 567 (2010).

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