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Quantum liquid crystals: spontaneously modulated Fermi superfluids[1]

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What happens to a BCS superconductor when the numbers of up and down fermions are unequal? This is a fascinating and difficult problem in many-body physics. The most exciting possibility is that pairing and polarization compete to produce a modulated superfluid state, known as an Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) phase. This is a quantum liquid crystal exhibiting microscale phase separation, in which the excess fermions self-organize into domain walls where the pairing amplitude changes sign. There is a growing body of indirect evidence for the existence of FFLO states. As an example, I present our recent work on Al thin film superconductors in parallel magnetic fields [1]. Just below the Chandrasekhar-Clogston spin paramagnetic transition, our tunneling density of states measurements reveal a significant population of subgap states. These excess states cannot be explained in terms of conventional superconductivity, but they are a natural consequence of disordered FFLO physics. There is also hope for realizing FFLO in ultracold gases of neutral fermionic atoms. Continuum FFLO states are very fragile, but our calculations suggest that FFLO states are greatly stabilized by an optical lattice. For a cubic lattice with suitable parameters, up to 80% of the fermions participate in the FFLO phase [2]. Furthermore, we propose an interferometric technique to detect pairing amplitude modulations, which may provide the first *direct* evidence of FFLO [3].

[1] Y. L. Loh, N. Trivedi, Y. M. Xiong, P. W. Adams, and G. Catelani, "Origin of Excess Low-Energy States in a Disordered Superconductor in a Zeeman Field," PRL 107, 067003 (2011)
[2] Y. L. Loh and N. Trivedi, "Detecting the Elusive Larkin-Ovchinnikov Modulated Superfluid Phases in Imbalanced Fermi Gases in Optical Lattices," PRL 165302 (2010)
[3] M. Swanson, Y. L. Loh, and N. Trivedi, "Proposal for interferometric detection of topological defects in modulated superfluids," arXiv:1106.3908

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