Pairing in Unusual Places - Stretching the Realm of Superconductivity

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Ultracold atoms are emerging as a powerful new tool for exploring fundamental condensed matter physics. These gases are clean and well-characterized, whose parameters, such as interaction strength, temperature, density, and dimensionality, are readily tunable. With these systems, we have the potential for simulating unsolved models of condensed matter physics, and to perhaps uncover unexpected new physics. I will discuss experiments on the pairing of ^{6}Li, a composite fermion, under *extreme* conditions. The interaction strength can be tuned to the *unitarity limit*, where the pairing transition temperature as a fraction of the Fermi energy is higher than any other known paired system. While BCS theory expects equal densities, we have investigated two-component Fermi gases where the spin populations are *unequal*. We find phase separation between a fully paired core and the surrounding unpaired atoms (shown below). We have also determined the phase diagram of a spin-imbalanced Fermi gas in 1D, which is predicted to exhibit the elusive FFLO modulated superfluid state.