Mapping the phase diagram of a two-component Fermi gas with strong interactions

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The pairing of fermions is the underlying mechanism for superconductivity and superfluidity. Ultracold atomic Fermi gases present a highly controllable model system for studying interacting Fermi mixtures. Tunable interactions and the control of population among the spin components provide unique opportunities to investigate the stability of fermion pairs and possibly to search for exotic forms of superfluidity. In this talk, we present the phase diagram of a two-component Fermi gas of ^{6}Li atoms with strong interactions[1]. Using tomographic techniques, we determine the spatial structure of a trapped Fermi mixture, mapping out the superfluid phase versus temperature, density imbalance, and interaction strength. At low temperature, the sample shows spatial discontinuities in the spin polarization. This is the signature of a first-order superfluid-to-normal phase transition, which disappears at a tricritical point where the nature of the phase transition changes from first-order to second-order. At zero temperature, there is a quantum phase transition from a fully-paired superfluid to a partially-polarized normal gas. The critical polarization of the normal gas increases with stronger coupling strength and eventually, the partially-polarized normal phase disappears at a critical interaction strength, above which all minority atoms pair with majority atoms. The microscopic properties of the fermion pairs are studied with rf spectroscopy[2].

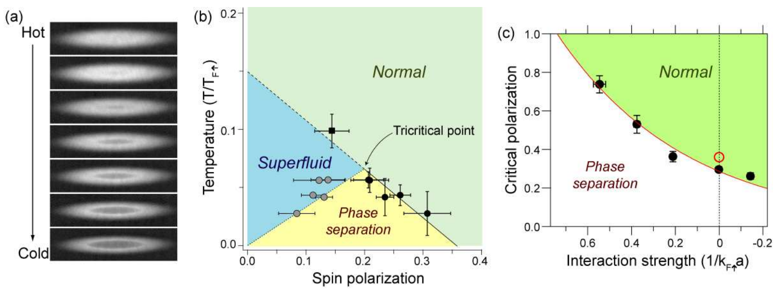

Figure 1: *(a) Phase transition in a trapped Fermi mixture. in situ distribution of column density difference for various temperatures. Phase diagram (b) with resonant interactions and (c) in the plane of interaction strength and spin polarization.*

[1] M.W. Zwierlein *et al.*, Science **311**, 492 (2006); Y. Shin *et al.*, Physical Review Letters **97**, 030401 (2006); Y. Shin *et al.*, Nature **451**, 689 (2008); Y. Shin *et al.*, arXiv:0805.0623.

[2] C.H. Schunck *et al.*, Science **316**, 867 (2007); C.H. Schunck *et al.*, arXiv:0802.0341.