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Spin imbalanced Fermi gases in 1D and the crossover to 3D[1]

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The search for the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) phase, a polarized superfluid with a spatially varying order parameter, has generated large interest in both condensed matter and cold atoms communities. To date, there has been only indirect experimental evidence of FFLO in the heavy fermion superconductor CeCoIn5. A strongly interacting 3D polarized Fermi gas exhibits three phases at low temperature: an unpolarized superfluid, a partially polarized and a fully polarized normal phase, which phase separate in an optical trap. There is no experimental evidence for an FFLO phase in the 3D system and theory predicts that it occupies only a small region in the phase diagram. In a 1D polarized Fermi gas, the FFLO phase is predicted to occupy a large region of the phase diagram. We have implemented a 2D optical lattice in order to explore the phase diagram of an imbalanced spin mixture of ^{6}Li. In in-situ density distributions, we observe in the center of the cloud a partially polarized region surrounded by an either fully polarized or an unpolarized superfluid shell depending on the spin imbalance. The density profiles are quantitatively well described by a finite temperature Bethe ansatz and can be used to extract the 1d phase diagram of the imbalanced 1d Fermi gas. Moreover, the quantitative agreement of experiment and theory paves the way for directly observing the elusive FFLO phase in the system.

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