Pairing versus imbalance in ultracold atomic gases

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Abstract

A series of experiments on systems of trapped cold atomic gases were aimed at studying the effects of polarization on superfluid pairing. Two different experimental groups encountered surprising qualitative and quantitative discrepancies which seemed to be a function of the confining geometry and the cooling protocol. Despite long familiarity with fermionic superfluids, these observations had defied theoretical explanation. Using novel numerical algorithms we study the solution space for a three-dimensional fully self-consistent mean-field formulation of realistic systems with up to 100,000 atoms. Our studies demonstrate a tendency towards metastability as the geometry is elongated and suggest an explanation for the observed discrepancy. From our calculations, the most likely solution which is consistent with the experiments at high aspect ratio supports a state strikingly similar to the so called FFLO state (after Ferrell, Fulde, Larkin and Ovchinnikov), which had been theorized but eluded detection so far. Moreover, this scenario is consistent with the predictions for one-dimensional systems of dilute polarized attractive gases, and yet another set of cold-atom experiments use optical lattices to test this limit. The measurements are in quantitative agreement with theoretical calculations (using a wide array of numerical and analytic techniques) in which a partially polarized phase is found to be the 1D analogue of the FFLO state. More calculations and experiments are under way, testing the inter-dimensional stability and crossover.