CO.CO.MAT

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From Ultracold Fermi Gases to Neutron Stars

Ultracold dilute atomic gases can be considered as model systems to address some pending problems in Many-Body physics that occur in condensed matter systems, nuclear physics, and astrophysics. We have developed a general method to probe with high precision the thermodynamics of locally homogeneous ultracold Bose and Fermi gases [1,2,3]. This method allows stringent tests of recent many-body theories. For attractive spin 1/2 fermions with tunable interaction, we will show that the gas thermodynamic properties can continuously change from those of weakly interacting Cooper pairs described by Bardeen-Cooper-Schrieffer theory to those of strongly bound molecules undergoing Bose-Einstein condensation. First, we focus on the finite-temperature Equation of State (EoS) of the unpolarized unitary gas above and below the superfluid transition. Detailed comparisons with theories including Monte-Carlo calculations initially revealed some surprises but excellent agreement is found with a recent bold diagrammatic Monte-Carlo technique. Surprisingly, the low-temperature properties of the strongly interacting normal phase are well described by Fermi liquid theory. The Lee-Huang-Yang quantum corrections for low-density bosonic and fermionic superfluids are also directly measured for the first time. Despite orders of magnitude difference in density and temperature, our equation of state can be used to describe low density neutron matter such as the outer core of neutron stars.
[1] S. Nascimbène, N. Navon, K. Jiang, F. Chevy, and C. Salomon, Nature 463, 1057 (2010) [2] N. Navon, S. Nascimbène, F. Chevy, and C. Salomon, Science 328, 729 (2010) [3] S. Nascimbène, N. Navon, S. Pilati, F. Chevy, S. Giorgini, A. Georges, and C. Salomon, Phys. Rev. Lett., 106, 215303 (2011).

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