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Thermodynamic properties and phase transitions in dilute fermion matter[1]

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If the average interparticle distance between fermions exceeds considerably the radius of the interaction, and if the scattering length is larger than the average interparticle separation, the properties of such fermion matter become universal. Under such conditions low density neutron matter has essentially identical properties to cold atoms in traps. While the properties of such low density neutron matter cannot be studied in the lab yet, that is not the case for cold atoms. This system shares also a number of properties with the high density phase of QCD, when quarks are deconfined. From the theoretical point of view the dilute fermion system is particularly attractive, as in many cases one can aim at a full and rather accurate solution of the Schrödinger equation either for the ground state or at finite temperatures, using Quantum Monte Carlo (QMC) and Density Functional Theory (DFT) techniques. This field became a beloved playing ground for many-body theorists, since many old and new techniques can be accurately validated against exact results and verified against accurate measurements. I shall present an overview of our current status of the theory, in particular what we have learned so far using QMC and DFT techniques both at zero and finite temperature, discuss the surprisingly rich phase diagram of such matter and the relevance of this new knowledge to nuclear physics and astrophysics.

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