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Searching for Perfect Fluidity in a Strongly Interacting Fermi Gas

An optically-trapped mixture of spin ½-up and spin ½-down ^{6}Li atoms provides a new paradigm for exploring strongly interacting Fermi systems in nature. This ultracold atomic gas offers unprecedented opportunities to test theoretical techniques that cross interdisciplinary boundaries. A bias magnetic field is used to tune the gas near a Feshbach resonance, where the s-wave scattering length diverges and the interparticle spacing sets the only length scale. Even though it is dilute, an atomic Fermi gas near a Feshbach resonance is the most strongly interacting nonrelativistic system known, enabling tests of recent theories in disciplines from high temperature superconductors to nuclear matter. Strongly interacting Fermi gases also exhibit extremely low viscosity hydrodynamics, of great interest in the quark-gluon plasma and string theory communities, where it has been conjectured that the ratio of the shear viscosity to the entropy density has a universal lower bound, which defines a perfect fluid. I will describe our all-optical cooling methods and our studies of the thermodynamic and hydrodynamic properties of the ^{6}Li cloud. Our measurements of the entropy reveal a high temperature superfluid transition, which occurs at a large fraction of the Fermi temperature. Our most recent estimates of the shear viscosity are obtained from observations of the hydrodynamic expansion of a rotating cloud. Together, these results suggest that a strongly interacting Fermi gas may be the most perfect quantum fluid ever studied.

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