Perfect Fluidity: From Strongly-Interacting Fermi Gases to Quark-Gluon Plasmas¹
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Strongly interacting atomic Fermi gases and quark-gluon plasmas share a common feature: They exhibit nearly ideal, minimum viscosity hydrodynamic expansion, which is a characteristic of a “perfect” fluid. A perfect fluid is defined to be a normal fluid (not a superfluid) with the minimum ratio of shear viscosity to entropy density permitted by the laws of quantum physics, $\frac{\hbar}{4\pi k_B}$, as derived recently using string-theory methods. We measure both the shear viscosity and the entropy of an optically-trapped, strongly-interacting gas of spin $\frac{1}{2}$-up and spin $\frac{1}{2}$-down $^6$Li atoms. A bias magnetic field tunes the gas to a collisional (Feshbach) resonance, where the s-wave scattering length, for collisions between atoms of opposite spin, diverges. At resonance, the system is universal and scale-invariant, so that the thermodynamic and hydrodynamic properties are universal functions of the density and temperature. Even though it is dilute, such an atomic Fermi is the most strongly interacting non-relativistic system known, enabling tests of recent theories in diverse disciplines from high temperature superconductors to nuclear matter, and even string-theory, via the minimum viscosity conjecture.

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