The Hottest Perfect Fluid: Relativistic Hydrodynamics of the Quark-Gluon Plasma

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When two heavy nuclei collide at velocities approaching the speed of light, at the Large Hadron Collider or Relativistic Heavy-Ion Collider, they briefly create a droplet of matter as hot as ten trillion Kelvin: the Quark-Gluon Plasma (QGP), a deconfined state in which quarks and gluons roam freely. Remarkably, rather than behaving as a weakly coupled gas as was expected from the asymptotic freedom in the underlying theory of strong interactions, hte QCD, the QGP turns out to be a strongly coupled, nearly perfect fluid, exhibiting one of the lowest shear viscosity-to-entropy density ratios (η/s) ever measured, approaching the quantum lower bound conjectured by Kovtun, Son, and Starinets.

In this talk I will introduce the fluid-dynamic framework used to model these collisions — from the fluctuating initial nuclear geometry through relativistic viscous hydrodynamic evolution to observable signatures such as anisotropic flow and femtoscopic correlations which we measure in experiments. I will discuss the limits where the fluid-dynamic approach seems to effectively work, more recent developments about vorticity generation in such fluid and related experimental observables.