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Observation of a mesoscopic fluid of 10 strongly-interacting fermions

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Collective flow is observed in high-energy proton-proton and proton-nucleus collisions where particle multiplicities are small and a quark-gluon plasma description is hard to justify. Here, we address the origin of such observations from a new angle, by performing an experimental investigation of the emergence of hydrodynamics in two-dimensional ultra-cold Fermi gases with with controllable interactions and in the regime of small particle numbers. We study the inversion of the aspect ratio (akin to elliptic flow) in the expansion of samples of atoms initially prepared in elliptical traps. To overcome the finiteness of the samples, a statistical measure of the elliptic anisotropy is devised in full analogy with the methods employed in the analysis of high-energy collisions.

With ten or more fermions, we observe the emergence of elliptic flow due to inter-particle interactions, which justifies a hydrodynamic interpretation. We show that ideal hydrodynamic predictions using the equation of state of 2D Fermi gases in the many-body limit underestimate the measured elliptic anisotropy. Hence, we witness the breakdown of ideal hydrodynamics due to quantum corrections beyond standard dissipative ones but rather induced by the mesoscopic nature of our samples. We discuss how hydrodynamic equations could be generalized to account for these effects, and give an outlook on further possibilities with our experimental setup to advance our understanding of collective phenomena in few-particle systems.

Based on:

- Floerchinger et al., "Qualifying collective behavior in expanding ultracold gases as a function of particle number", Phys. Rev. C 105, 044908 (2022)
- Brandstetter et al., "A mesoscopic fluid of 10 fermions", arXiv:2305.XXXXX

Category

Experiment

Collaboration (if applicable)

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