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Observation of hydrodynamic behavior with few strongly-interacting fermions: a zero-temperature small system puzzle

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Approaching zero temperature, a gas of strongly-interacting fermions undergoes a transition to a superfluid phase amenable to an ideal hydrodynamic description. At trillion-kelvin temperatures, hadronic matter melts into a quark-gluon plasma (QGP) that flows similarly as a near-perfect fluid. Collider experiments indicate that the signals of QGP formation are mysteriously persistent, emerging down to p-p collisions producing only a few dozen final-state hadrons. Here, we perform experiments to assess whether a similar behavior is displayed as well in small systems at the other end of the temperature spectrum.

States of strongly-interacting ultra-cold fermions are released from elliptical harmonic traps to investigate the emergence of elliptic flow, a smoking-gun of collective behavior. Borrowing techniques from high-energy collisions [1], we study the build-up of momentum anisotropy in the elliptical clouds and the inversion of their initial aspect ratios. Elliptic flow is then observed for systems with as few as 10 fermions and in absence of any separation between microscopic and macroscopic scales [2], opening a new small system puzzle outside heavy-ion collisions. We discuss prospects for future cross-disciplinary research aimed at elucidating further the apparent hydrodynamic behavior of mesoscopic quantum gases.

[1] Floerchinger et al., Phys.Rev.C 105 (2022) 4, 044908
[2] Brandstetter et al., arXiv:2308.09699

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