Contribution ID: **168** Type: **CONTRIBUTED TALK (25min +5)**

A mesoscopic fluid of 10 fermions

Monday, 14 November 2022 12:00 (20 minutes)

A very striking manifestation of collective behaviour of many particles is the emergence of hydrodynamics, the effective description of a system as a fluid. In addition to classical systems, hydrodynamic expansion has also been observed in different many-body quantum systems, ranging from heavy ion collisions (1) to ultracold quantum gases (2). However, the fundamental requirements for hydrodynamic behaviour are, especially in the mesoscopic limit - for example in the case of proton-proton collisions - still unclear (3). Our cold atom experiment opens up new pathways to address these questions starting from the smallest scales with deterministic control over the atom number, interaction strength and initial anisotropy. We observe the inversion of the initial aspect ratio after an interacting expansion –one signature of hydrodynamics - in a system comprised of as little as 10 particles.

For our experiments, we deterministically prepare closed shell configurations of a few fermionic ^{6}Li atoms in two different spin states in the ground state of an elliptical two-dimensional harmonic oscillator. A sudden switch off of the confining potentials in radial direction leads to an expansion in a 2D plane, which we perform at different interaction strengths. Our spin and single atom resolved imaging technique (4) allows us to study single particle resolved correlations of any order between the atoms. Two different matterwave magnification techniques (5,6,7) provide access to momentum or real space at different times during the expansion, such that we can directly observe the inversion of the aspect ratio, as well as the formation of pairs over time. In the near future, this will allow us to study the connection between the formation of pairs and the emergence of hydrodynamics in a few body system.

(1) Braun-Munzinger, P., Stachel, J. "The quest for the quark–gluon plasma ". Nature 448, 302–309 (2007)

(2) K. M. O'Hara et al. "Observation of a Strongly Interacting Degenerate Fermi Gas of Atoms". Science 298.5601 (2002)

(3) B. Schenke, "The smallest fluid on Earth", Rep. Prog. Phys. 84,082301 (2021)

(4) M. Holten et al. "Observation of Cooper pairs in a mesoscopic two-dimensional Fermi gas". Nature 606, 287–291 (2022)

(5) P. A. Murthy, et al. 'Matter-wave Fourier optics with a strongly interacting two-dimensional Fermi gas' Phys. Rev. A 90, 043611 (2014)

(6) P.A Murthy, S. Jochim 'Direct imaging of the order parameter of an atomic superfluid using matterwave optics', arXiv:1911.10824 (2019)

(7) L. Asteria, et al. 'Quantum gas magnifier for sub-lattice-resolved imaging of 3D quantum systems', Nature 599, 571–575 (2021)

Affiliation

Physikalisches Institut, University of Heidelberg

Financial Support

Primary author: Mrs BRANDSTETTER, Sandra (Physikalisches Institut, University of Heidelberg)

Co-authors: Mr LUNT, Philipp (Physikalisches Institut, University of Heidelberg); Mr HEINTZE, Carl (Physikalisches Institut, University of Heidelberg); GIACALONE, Giuliano (ITP Heidelberg); HEYEN, Lars (ITP Heidelberg); MAZELIAUSKAS, Aleksas (ITP Heidelberg); Mr SUBRAMANIAN, Keerthan (Physikalisches Institut, University of Heidelberg); Dr HOLTEN, Marvin (Physikalisches Institut, University of Heidelberg); Prof. FLOERCHINGER, Stefan (TPI Jena); Prof. JOCHIM, Selim (Physikalisches Institut, University of Heidelberg)

Presenter: Mrs BRANDSTETTER, Sandra (Physikalisches Institut, University of Heidelberg)

Session Classification: Morning session