HK 36: Focus Session II: Emergence of Collectivity in Few-Body Hadron Systems

Time: Wednesday 14:00–15:30 Location: HBR 14: HS 1

Invited Talk HK 36.1 Wed 14:00 HBR 14: HS 1

Hydrodynamic attractors and transport in small systems — •Aleksas Mazeliauskas — Institut für Theoretische Physik, Universität Heidelberg, Heidelberg, Germany

The emergence of a hydrodynamic attractor–a universal far-from-equilibrium fluid behaviour–is one of the dominant explanations for the success of hydrodynamic models in heavy-ion collisions [1]. QCD kinetic simulations have shown rapid thermalisation of Quark-Gluon Plasma and the applicability of hydrodynamic descriptions at times of 1fm/c in heavy-ion collisions. However, very similar computations indicate that in smaller proton-proton collisions hydrodynamics is inapplicable [2]. This poses the fundamental question on the origins of observed collectivity in few-body systems. Ultracold quantum gas experiments provide unique access to precisely investigate the applicability of different hydrodynamic frameworks in mesoscopic systems [3,4]. In this talk, I will discuss the status and prospects of testing different interpretations of collectivity using ultracold gas experiments and what these systems can tell us about few-body hadronic collisions.

Refs.:

1. J. Berges, M.P. Heller, A. Mazeliauskas and R. Venugopalan, Rev. Mod. Phys. 93 (2021) 035003
2. V.E. Ambrus, S. Schlichting, C. Werthmann, Phys.Rev.Lett. 130 (2023) 15, 152301
3. S. Floerchinger, G. Giacalone, L.H. Heyen, L. Tharwat, Phys.Rev.C 105 (2022) 4, 044908
4. S. Brandstetter, P. Lunt et al., arXiv:2308.09699v1 (2023)

Invited Talk HK 36.2 Wed 14:30 HBR 14: HS 1

Multi-particle correlations: from hot-and-dense quark-gluon matter to an ultracold-and-dilute system with few atoms — •Ilya Selyuzhenkov — GSI, Darmstadt

Multi-particle azimuthal correlations proved to be a powerful tool to study the hydrodynamic flow of the quark-gluon matter created in heavy-ion collisions and probe the collective behaviour in proton-proton interactions. Recently azimuthal correlations were used to search for collectivity in an even smaller hadronic system created in the ep and e+e- interactions. Experiments with ultracold atoms also revealed collective behaviour in a macroscopic system, and recently for a system with only a few atoms. These experiments have unique control over initial conditions and access to the time evolution, which opens a possibility to apply the existing correlation techniques to the cold-atom data and develop new observables, which could be later applied in heavy-ion experiments.

In this talk, after a brief introduction to the multi-particle azimuthal correlation techniques, the recent results for different hadronic collisions will be reviewed. A feasibility study of the two-particle correlations and the first application of the heavy-ion flow measurement techniques to extract time evolution of the spatial eccentricity and the elliptic flow in a system of 5+5 lithium atoms imaged at different expansion times will also be presented. An outlook towards the multi-differential analysis of the time evolution of the short- and long-range correlations to obtain new insights about collective phenomena and the equation of state for a few-body system will be discussed.

Invited Talk HK 36.3 Wed 15:00 HBR 14: HS 1

Observing the emergence of elliptic flow — •Sandra Brandstetter, Philipp Lunt, Carl Heintze, Maciej Galka, Keerthan Subramanian, Marvin Holten, Philipp Preiss, and Selim Jochim — Physikalisches Institut, Universität Heidelberg

Elliptic flow, the redistribution of energy between axes during the expansion due to anisotropic pressure gradients, is considered a signature of hydrodynamics. It has been observed in systems ranging from ultracold quantum gases (1) to heavy ion collisions (2), where surprisingly small systems show elliptic flow. Our cold atom experiment opens up a new pathway to study elliptic flow in few body systems with an unprecedented control over its microscopic parameters.

We start by deterministically preparing a small number of ultracold fermionic Li6 in the ground state of an elliptically-shaped optical trap and study the dynamics of the system after release from the trap at different interaction strengths and particle numbers (3). Owing to our experimental ability to measure both momentum- and real- space density with single particle resolution we observe the redistribution of momenta as well as the inversion of the aspect ratio over time. Additionally, we observe a formation of pairs as the system expands. In the near future, this will allow us to study the connection between the formation of pairs, entanglement and the emergence of collectivity in few body systems.

(1)K. M. OHara et al. Science 298.5601 (2002)

(2)Braun-Munzinger, P., Stachel, J. Nature 448, 302-309 (2007)

(3)S. Brandstetter, P. Lunt et al. arXiv: 2308.09699v1 (2023)