Imaging shapes of atomic nuclei in high-energy nuclear collisions at STAR experiment

Chunjian Zhang (for STAR Collaboration)

The shape and orientation of colliding nuclei play a crucial role in determining the initial conditions of the QGP formed in central collisions, which influence key observables such as anisotropic and radial flow. For instance, central collisions of near-spherical Au nuclei create a QGP with a fixed, circular geometry, whereas prolate-shaped uranium nuclei can collide in a variety of orientations, producing QGP droplets of diverse shapes and sizes. Hence, by comparing systems with similar mass numbers, such as ^{238}U and ^{197}Au, we can map out their shape differences and gain deeper insights into the initial conditions of heavy-ion collisions. In this talk, we present measurements of v_2, p_T fluctuations, and v_2-p_T correlations in ^{238}U+^{238}U and ^{197}Au+^{197}Au collisions. Our results reveal large differences in these observables between the two systems, particularly in central events. A comparison with hydrodynamic model calculations indicates a large deformation in uranium nuclei, consistent with previous low-energy experiments. However, data also imply a small deviation from axial symmetry in the ground states of the colliding ^{238}U nuclei [1]. Our work introduces a novel approach for imaging nuclear shapes, enhances the modeling of QGP initial conditions, and sheds light on nuclear structure evolution across different energy scales. The potential applications of this method for other nuclear species are explored.

[1] STAR Collaboration, Nature 635, 67-72 (2024), https://doi.org/10.1038/s41586-024-08097-2