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

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High-energy nuclear collisions have been recently proposed as a powerful tool to image the global structure of heavy atomic nuclei. We present the first quantitative demonstration of this method by extracting the quadruple deformation β_2 and triaxiality γ for ^{238}U nuclei, known for its large prolate shape. We achieve this by comparing several collective flow observables in collisions of ^{238}U with collisions of near-spherical ^{197}Au. Though the extracted β_2 of ^{238}U is consistent with low-energy experiments, the measurements indicate a small deviation from axial symmetry with non-zero γ value in their nuclear ground state [1]. A similar comparative measurement is carried out in collisions of ^{96}Ru and ^{96}Zr. Large differences are observed in almost all flow observables in the two collision systems, reflecting strong impacts from the structure differences between the pair of isobars. In particular, our measurements suggest an intriguing octupole deformation β_3 in ^{96}Zr which is not predicted by mean field model calculations, as well as a larger neutron skin in ^{96}Zr. The prospect of such imaging method for studying light ion ^{16}O structure compared to the state-of-the-art *ab initio* calculations is also explored. Our work introduces a novel approach for imaging nuclear shapes, enhances our understanding of quark gluon plasma initial conditions, and sheds light on nuclear structure across different energy scales.

[1] STAR Collaboration, Nature 635, 67-72 (2024)