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Impact of the radial profile of atomic nuclei on observables in high-energy collisions

The nucleon density distribution within colliding nuclei is typically modeled using the two-parameter Woods-Saxon (WS) distribution. This conventional approach overlooks the fine radial structures arising from the quantal shell filling patterns of protons and neutrons. In this study, we incorporate these fine radial variations by utilizing density profiles from Skyrme-Hartree-Fock density functional theory. We extensively compare the WS parametrization with detailed radial profiles across nuclei possessing qualitatively different density distributions. Our analysis reveals consistent deviations in heavy-ion observables—such as initial eccentricity and participant distributions—that cannot be captured by simply readjusting WS parameters. These deviations exhibit similar behaviors across different nuclei and depend on collision centrality and specific observables. The exceptional sensitivity of isobar collisions to initial state variations offers a promising avenue to detect these fine radial effects. Our findings complement studies on nuclear deformation effects and highlight the necessity of incorporating realistic nuclear density profiles in advanced hydrodynamic simulations and in the extraction of the quark-gluon plasma's transport properties.

Reference:
[1] Z. Yan, J. Xu, and J. Jia, "Impact of the radial profile of atomic nuclei on observables in high-energy collisions," Phys. Rev. C 110, L041901 (2024). DOI: 10.1103/PhysRevC.110.L041901

Category

Theory

Collaboration (if applicable)

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