Contribution ID: **720** Type: **Poster**

Monte-Carlo sampling of nucleon positions in the nuclear shell model for heavy-ion collisions

Recently, it has been shown that investigating the structure of atomic nuclei is essential for correct description of fluctuations imprinted into the initial stage of a heavy-ion collision event. In fact, the examination of the N-body density distributions has shown to be crucial for better understanding deeply inelastic scattering (DIS) and nucleus-nucleus collisions [1].
Motivated by the recent interest to represent quantitatively the structure properties of the incoming nuclei, we present a new sampling algorithm which takes on account quantum correlations of the nuclear many-body wave function. Using the nuclear shell model (NSM) as a proof of concept model, a Markov Chain Monte Carlo method algorithm was implemented in order to generate nucleon positions, according to the full N-nucleon probability distribution. We benchmark it by comparing our numerical results to the analytic one- and two-body densities. By using this algorithm, quantum correlations in the nucleus are then imprinted into the positions. Additionally, the usage of the NSM permits the extension of this algorithm to large systems, such as Au and Pb, which are still prohibitively expensive for full *ab-initio* computations.
We explore the impact of these new sources of fluctuation on the creation of long-range correlations by exploring initial state observables sensitive to the N-body densities, such as the initial eccentricities, extracted from the novel McDIPPER model [2].

Category

Theory

Collaboration (if applicable)

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Track Classification: Initial state of hadronic and electron-ion collisions & nuclear structure