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Probing the nuclear matter equation of state with light nuclei

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We investigate the sensitivity of the light nuclei and hypernuclei production to the strongly interacting nuclei matter equation-of-state (EoS) within the Parton-Hadron-Quantum-Molecular Dynamics (PHQMD) microscopic transport approach.

PHQMD is an n-body microscopic transport approach based on Quantum Molecular Dynamics (QMD) propagation of baryonic degrees of freedom, where clusters are formed through potential interactions between nucleons and hyperons. The Minimum Spanning Tree (MST) algorithm is employed to identify bound clusters based on the baryon correlations in the coordinate space. In addition to this, a 'kinetic' mechanism for deuteron production is incorporated, utilizing the catalytic hadronic reactions that account for all isospin channels. This approach enhances the deuteron production while considering its quantum nature through the finite-size excluded volume effect and projection of the relative momentum of the interacting pair of nucleons onto the deuteron wave function, leading to a significant reduction of deuteron production, especially at target/projectile rapidities.

We find that static density-dependent and momentum-dependent interactions, although yielding the same EoS for cold matter, have markedly different effects on observables in heavy-ion collisions. We analyze their impact on the flow coefficients, the transverse momentum spectra and the fragment yields of different clusters as a function of rapidity. Our results, compared to HADES and STAR BES data, show a significant sensitivity of the elliptic flow coefficient to the momentum-dependent potential.

Furthermore, we propose a method to experimentally distinguish between various deuteron production mechanisms in heavy-ion collisions across the range of energies from SIS to RHIC.

Primary author(s) : KIREYEU, Viktar (JINR)

Presenter(s) : KIREYEU, Viktar (JINR)

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