Rapidity distributions of $Z = 1$ isotopes and the nuclear symmetry energy from Sn + Sn collisions with radioactive beams at 270 MeV/nucleon[†]

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Heavy-ion collisions at intermediate energies provide a unique laboratory probe for the nuclear symmetry energy at suprasaturation densities. A copious production of light cluster nuclei is one of the distinctive characteristics in this energy domain, and needs to be understood for reliably extracting the symmetry energy.[1)] This is because an explicit consideration of cluster correlations in the collision dynamics may influence physical quantities sensitive to the stiffness of the symmetry energy, such as the neutron-proton dynamics and the consequent charged pion ratio.[2)] Thus, we measured the rapidity distributions of hydrogen isotopes emitted from head-on collisions of ^{132}Sn + ^{124}Sn and ^{108}Sn + ^{112}Sn systems at 270 MeV/nucleon with the SπRIT time projection chamber[3)] installed inside the SAMURAI magnet at RIBF.

The experimental results are compared with the antisymmetrized molecular dynamics (AMD) calculations, and the measured rapidity distributions can be reasonably reproduced by the model after adjusting the in-medium two-nucleon cross section and the bound phase space for $A = 2, 3$ clusters. To investigate the dependence on the symmetry-energy stiffness, two cases of the symmetry energy with slope parameters $L = 46$ MeV and $L = 108$ MeV were assumed in calculations. Figure 1 presents the deuteron-to-proton and triton-to-proton double spectral ratios ($DR_{d/p}$ and $DR_{t/p}$) together with the AMD predictions. A positive slope of the rapidity-dependent double ratios indicates a partial isospin mixing between the projectile and target nuclei. As shown in the right panel of Fig. 1, the experimental $DR_{t/p}$ supports the calculation with $L = 46$ MeV, rather than $L = 108$ MeV. The adjustments applied in calculations do not significantly influence $DR_{t/p}$, and its symmetry-energy dependence. To constrain the symmetry energy more accurately, a more comprehensive set of data including global observables, *e.g.*, collective flows, will be analyzed, and a comparison with different models for deducing theoretical uncertainties is desired.

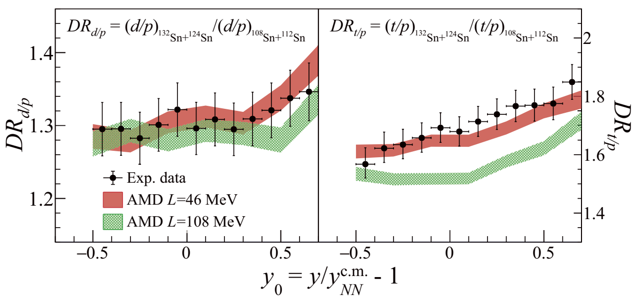

Fig. 1. Double ratio for the cluster-to-proton relative yield in the ^{132}Sn + ^{124}Sn system divided by that in the ^{108}Sn + ^{112}Sn, and the AMD predictions for two cases of the symmetry energy. Left: the deuteron-to-proton double ratio ($DR_{d/p}$). Right: the triton-to-proton double ratio ($DR_{t/p}$).

References
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