Extracting symmetry energy information with transport models

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The nuclear symmetry energy plays important roles on the properties of the nuclei and neutron star, and takes the form of $E_{sym} = E_{sym}(\rho)\delta^2$ in a parabolic approximation. Here the $\delta = (\rho_n - \rho_p)/(\rho_n + \rho_p)$ is the isospin asymmetry and ρ_n, ρ_p are the neutron, proton densities, $E_{sym}(\rho)$ and describes the density dependence of symmetry energy. Theoretical predictions on the density dependence of symmetry energy from microscopic nucleon-nucleon interaction show large uncertainties, especially for the supersaturation density. Constraining the density dependence of symmetry energy becomes one of the main goals in nuclear physics and has stimulated many theoretical and experimental studies.

Heavy ion collisions with neutron-rich nuclei provide a unique opportunity to obtain the information of the density dependence of the symmetry energy in the laboratories because large range of density can be formed during the HICs. The reactions for $^{112,124}Sn + ^{112,124}Sn$ at $E/A = 50MeV$ for different impact parameters are studied using the Improved Quantum Molecular Dynamics model[1]. The influence of symmetry potential and in-medium NN cross section on the isospin sensitive observables of intermediate energy heavy ion collisions is explored with the ImQMD model. Our results show that the symmetry potential plays important role on the double neutron to proton ratio and the isospin transport ratio R_i rather than the in medium nucleon-nucleon cross section at the beam energy 50MeV per nucleon. The copious production of intermediate mass fragments is the distinguishing feature of intermediate-energy heavy-ion collisions. So, we also examine the influence of the cluster emission on the double n/p ratios and isospin transport ratios. Furthermore, three observables, double n/p ratios, isospin diffusion and the rapidity distribution the ratio R_7 for $^{112,124}Sn + ^{112,124}Sn$ at E/A=50MeV are analyzed with the Improved Quantum Molecular Dynamics model. The results show that these three observables are sensitive to the density dependence of the symmetry energy. By comparing these calculations to the data, the consistent constraint on the density dependence of the symmetry energy from these three observables is obtained[2].

[1] Yingxun Zhang,P. Danielewicz,M. Famiano, Zhuxia Li, W.G. Lynch, M.B. Tsang, Phys. Lett. B 664, 145 (2008), and reference there in.

[2] M.B. Tsang, Yingxun Zhang, P. Danielewicz, M. Famiano, Zhuxia Li, W.G. Lynch, A.W. Steiner, Phys.Rev.Lett 102, 122701 (2009).