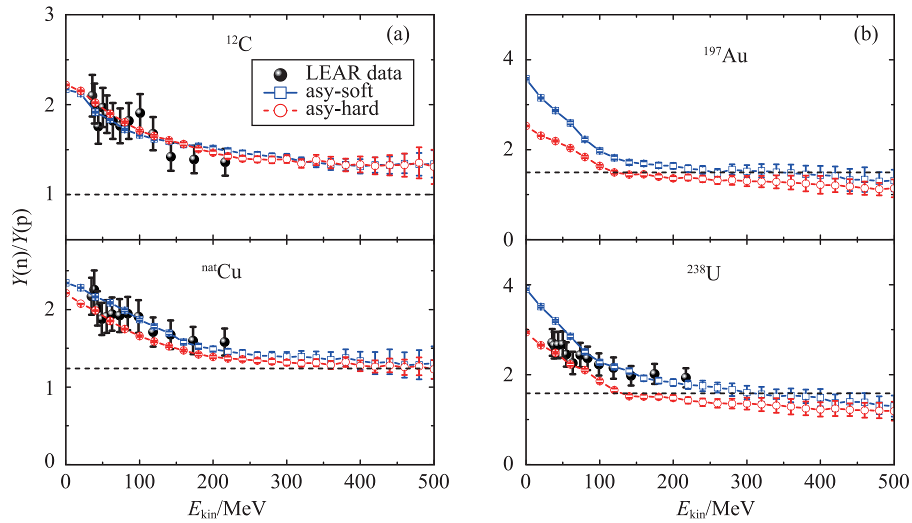

Fig. 2 (color online) The n/p ratios in antiproton induced reactions on ^{12}C, ^{nat}Cu, ^{197}Au and ^{238}U with different stiffness of symmetry energies and compared with the LEAR data[1].

References

[1] D. Polster, D. Hilscher, H. Rossner, et al., Phys. Rev. C, 51(1995)1167.

[2] Z. Q. Feng, Phys. Rev. C, 96(2017)034607.

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* Foundation item: National Natural Science Foundation of China Projects (11722546, 11675226) and Major State Basic Research Development Program in China (2014CB845405, 2015CB856903)

1 - 3 Modeling Pion Production in Heavy-ion Collisions at Intermediate Energies*

Yong Gaochan

The mechanism concerning to pion production in heavy-ion collisions at intermediate energies has increasing interests recently. We modeled pion production in nucleus-nucleus collisions at intermediate energies in the framework of the Isospin-dependent Boltzmann-Uehling-Uhlenbeck (IBUU) transport model. The effects of nucleon-nucleon short-range correlations in initialization and mean-field potential, isospin-dependent in-medium baryon-baryon elastic and inelastic cross sections and pion in-medium effect are all considered in this model. It is found that the ratio and yields of $\pi^-$and π^+ in Au+Au reaction at 400 MeV/u reproduce the FOPI/GSI data very well especially with a soft symmetry energy in the present transport model. Predictions on the single and double π^-/π^+ ratio are made for the isotope reaction systems ^{132}Sn+^{124}Sn and ^{108}Sn+^{112}Sn at 300 MeV/u since related experiments are being carried out at RIKEN/Japan[1].

Figure. 1 shows the numbers of charged pions produced with different symmetry energies[1]. It is first seen that both the produced π^- and π^+ by the IBUU model fit the FOPI experimental data quite well. Comparing the produced π^- and π^+ based on the IBUU model, it is seen that sensitivity of the number of the produced π^- to the symmetry energy is evidently larger than that of π^+. This is because the π^-'s are mainly from neutron-neutron collisions, thus more sensitive to the symmetry energy. It is also seen that for the soft symmetry energy $x = 1$, the produced π^- fits the FOPI experimental data very well. With stiffer symmetry energies $x = 0, -1$, the model gives smaller π^- numbers than the experimental data.

Figure. 2 shows the single ratios of the π^-/π^+ in neutron-rich and neutron-deficient reaction systems ^{132}Sn+^{124}Sn and ^{108}Sn+^{112}Sn at a beam energy of 300 MeV/u[1]. Owing to more neutron-neutron collisions, it is clearly seen that the ratio of π^-/π^+ is higher in neutron-rich reaction system than that in neutron-deficient reaction system. And due to larger asymmetry in neutron-rich reaction system, the effects of the symmetry energy on the π^-/π^+ ratio are evidently larger than that in neutron-deficient reaction system.

To obtain the information on the density-dependent symmetry energy, predictions on single and double pion ratios in isotope Sn reactions in ^{132}Sn+^{124}Sn and ^{108}Sn+^{112}Sn at 300 MeV/u are important for experiments at

RIKEN/Japan. Such studies may help one to constrain the density-dependent symmetry energy by pion production using a wide variety of advanced new facilities, such as the Facility for Rare Isotope Beams (FRIB) in the US, the Facility for Antiproton and Ion Research (FAIR) at GSI in Germany, the Radioactive Isotope Beam Facility (RIBF) at RIKEN in Japan, the Cooling Storage Ring on the Heavy Ion Research Facility at IMP (HIRFL-CSR) in China, the Korea Rare Isotope Accelerator (KoRIA) in Korea.

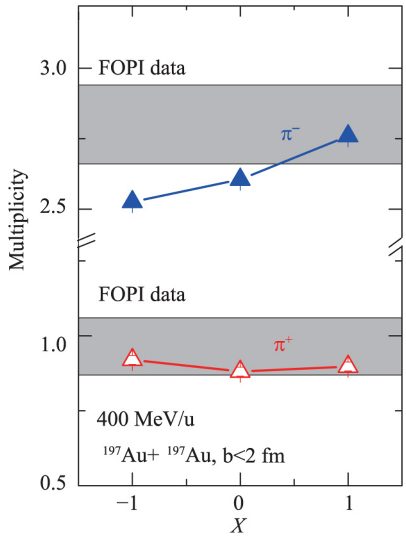

Fig. 1 (color online) Charged pion yields in Au+Au reaction at 400 MeV/nucleon with different symmetry energies. The shadow region denotes the FOPI data.

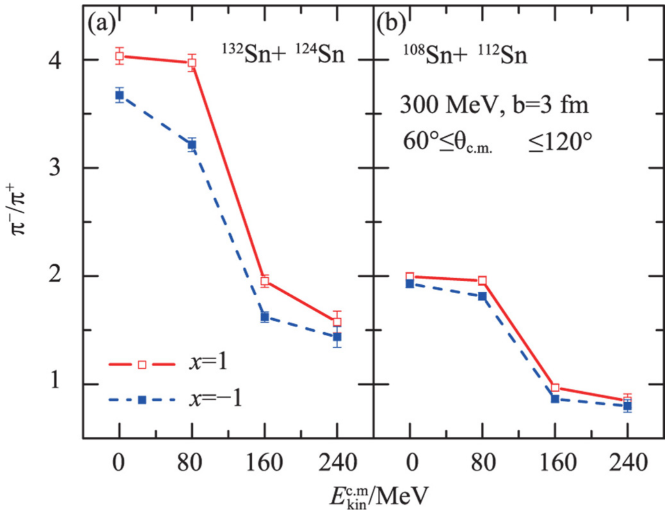

Fig. 2 (color online) The ratios of π^-/π^+ as a function of kinetic energy in isotope reaction systems of ^{132}Sn+^{124}Sn and ^{108}Sn+^{112}Sn at 300 MeV/nucleon incident beam energy with stiff (x= -1) and soft (x= 1) symmetry energies. θ_{cm} is polar angle relative to the incident beam direction.

Reference

[1] G. C. Yong, Phys. Rev. C, 6(2017)044605.

* Foundation item: National Natural Science Foundation of China (11375239, 11775275, 11435014)

1 - 4 Interplay of Short-range Correlations and Nuclear Symmetry Energy in Hard Photon Productions from Heavy-ion Reactions at Fermi Energies*

Yong Gaochan

Within an isospin- and momentum-dependent transport model for nuclear reactions at intermediate energies, we investigate the interplay of the nucleon-nucleon short-range correlations (SRC) and nuclear symmetry energy $E_{sym}(\rho)$ on hard photon spectra in collisions of several Ca isotopes on ^{112}Sn and ^{124}Sn targets at a beam energy of 45 MeV/u. It is found that over the whole spectra of hard photons studied, the effects of the SRC overwhelm those due to the $E_{sym}(\rho)$. The energetic photons come mostly from the high-momentum tails (HMT) of single-nucleon momentum distributions in the target and projectile. Since the underlying physics of SRC and $E_{sym}(\rho)$ are closely correlated, a better understanding of the SRC will in turn help to constrain the nuclear symmetry energy more precisely in a broad density range[1].

Figure. 1 shows the nucleon momentum distribution of Ca isotopes with or without the HMT. Compared with the ideal gas case, for the neutron-rich nucleus $^{48}_{20}$Ca, protons have a larger probability than neutrons to have momenta greater than the nuclear Fermi momentum. This feature is a consequence of the n-p dominance model where equal numbers of neutrons and protons are required to be in the HMT[1].

Figure. 2 shows the effects of the symmetry energy on the ratio of hard photons in neutron-rich (^{48}Ca+^{124}Sn) over neutron-poor ^{40}Ca+^{112}Sn reactions at an incident energy of 45 MeV/u with a 20% HMT using the soft and stiff