Medium modification of pion production threshold in heavy ion collisions and the nuclear symmetry energy

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Using the relativistic Vlasov-Uehling-Uhlenbeck (RVUU) equation [1,2] based on mean fields from the nonlinear relativistic NLρ and NLρδ models [3], which have same nuclear equation of state and symmetry energy but different symmetry energy slope parameters of 83 MeV and 98 MeV, respectively, we have studied the effect of medium modification of the pion production threshold on the total pion yield and the π^-/π^+ ratio in Au+Au collisions [4]. We have found that the in-medium threshold effect enhances both the total pion yield and the π^-/π^+ ratio, compared to those without this effect. Furthermore, including the medium modification of the pion production threshold leads to a larger π^-/π^+ ratio for the NLρδ model with a larger symmetry energy parameter than the NLρ model with a smaller symmetry energy parameter, opposite to that found without the in-medium threshold effect. To reproduce the total pion yield measured by the FOPI Collaboration [5], we have introduced a density-dependent cross section for Delta baryon production from nucleon-nucleon collisions [6], which suppress the total pion yield but hardly changes the π^-/π^+ ratio. Because of the small difference in the stiffness of their symmetry energies, the π^-/π^+ ratios obtained from both the NLρ and NLρδ models are consistent with the FOPI data within the experimental errors as shown in Fig.1.

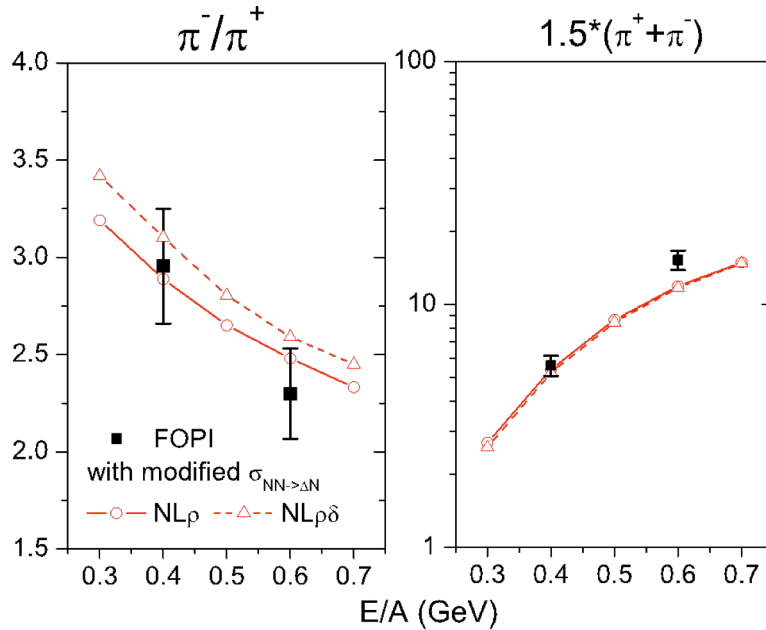**FIG. 1.** π^-/π^+ ratio (left panel) and total pion yield (right panel) as functions of the collision energy obtained with the threshold effect and the density-dependent Delta production cross section in Au+Au collisions at impact parameter of 1 fm for both the NLρ and NLρδ models. Experimental data are from the FOPI Collaboration [6].

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