Medium effects on pion production in heavy ion collisions

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We have extended the relativistic Vlasov-Uehling-Uhlenbeck (RVUU) model based on the nonlinear relativistic NLρ mean-field model [1] by including the isospin-dependent pion *s*-wave and *p*-wave potentials in nuclear medium [2], which are obtained from calculations based on the chiral perturbation theory [3] and the Δ-hole model [4,5], respectively. Their effects on the π^-/π^+ ratio in Au + Au collisions at E/A = 400 MeV have been studied in following six different cases: i) without the threshold and pion in-medium effects (free), namely, nucleons, Δ resonances and pions are treated as free particles in all reactions; (ii) with only the threshold effect (Th); (iii) with the threshold effect and the pion s-wave potential (Th+S); (iv) with the threshold effect and the pion p-wave potential (Th+P); (v) with the threshold effect and both the pion s-wave and p-wave potentials (Th+S+P); (vi) same as case (v) but with the coupling constant for the isovector-vector ρ meson to nucleon in the NLρ model reduced. It is seen from Fig. 1 that while the π^-/π^+ ratio is enhanced by the pion *p*-wave potential, it is significantly suppressed by the pion *s*-wave potential. As a result, the pion potentials in nuclear medium lead to a significant reduction (about 10 %) of the π^-/π^+ ratio, which is comparable to that due to the stiffness of nuclear symmetry energy at high densities. After including both the threshold effect and the pion in-medium effect, the π^-/π^+ ratio obtained from the RVUU model based on the relativistic NLρ model, which has a value of L = 84 MeV for the slope parameter of nuclear symmetry energy, is slightly larger than the experimental upper value from the FOPI Collaboration [6]. Using a softer symmetry energy of L=59 MeV, which is consistent with currently known empirical value [7,8], by reducing the ρ-nucleon coupling constant in the NLρ model can, however, well reproduce the experimental data on the charged pion ratio.

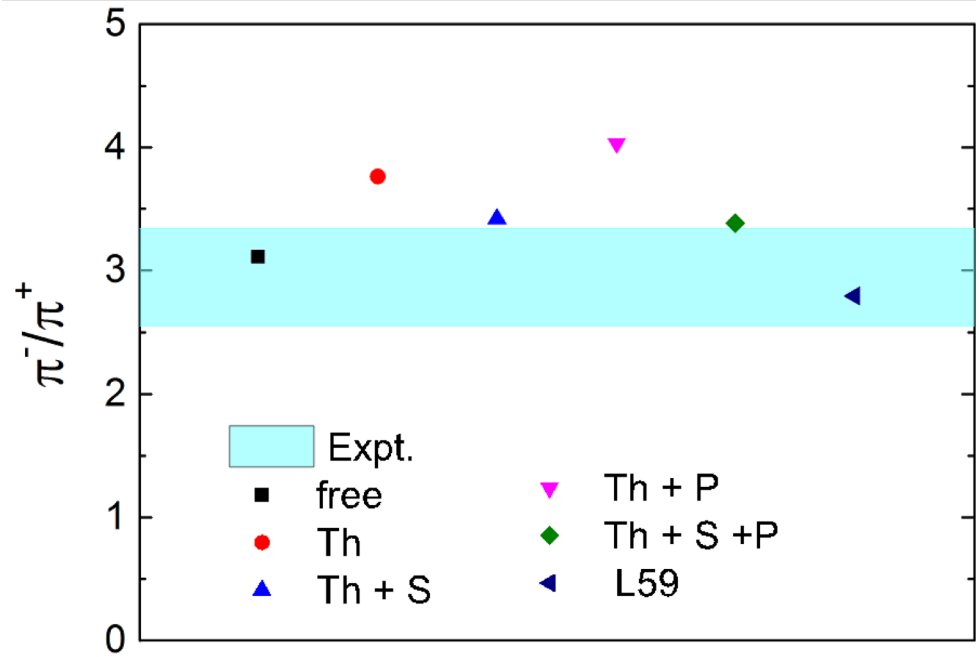

FIG. 1. The π^-/π^+ ratio in Au+Au collisions at impact parameter of 1.4 fm and energy of E/A = 400 MeV from the NLρ model in different cases (see text for details). Experimental data from the FOPI collaboration [6] are shown as the cyan band.

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