Recent Results on π^-/π^+ Ratio for Constraining the High Density Behavior of Nuclear Symmetry Energy

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The large uncertainty of high-density (HD) behavior of the nuclear symmetry energy $E_{sym}(\rho)$ has attracted much attentions for its deeply impact in both nuclear physics and astrophysics fields. The π^-/π^+ ratio in heavy-ion collisions has been known as a particularly sensitive probe of the HD behavior of $E_{sym}(\rho)$. Very recently, by comparing the calculated results on π^-/π^+ ratio based on IBUU04 with the pion data from the FOPI collaboration, circumstantial evidence suggesting a rather soft $E_{sym}(\rho)$ was reported, while a very stiff $E_{sym}(\rho)$ was supported by IQMD calculations which is consistent with the conclusions at low densities. Therefore, the sensitivity of the probe π^-/π^+ ratio deserves further studies with different transport models in theory. On the other hand, more data on charged pion are expected to be accumulated in heavy-ion collisions at sub-GeV regime.

In the present work, we first calculate the π^-/π^+ ratio and its dependence on the behavior of $E_{sym}(\rho)$ in head-on collisions of ^{48}Ca + ^{48}Ca, ^{124}Sn + ^{124}Sn and ^{197}Au + ^{197}Au from 0.25 to 0.6 *A* GeV within IBUU04. With the similar isospin asymmetry in the above three systems, it is convenient to investigate the degree of isospin fractionation and the sensitivity of probing $E_{sys}(\rho)$ by separating the system size effect from the effect of varying the isospin asymmetry. It is shown that the π^-/π^+ exhibits an increasing deviation from isobar model prediction with increasing the system size or decreasing the beam energy, indicating a clear dependence of the degree of isospin fractionation on the space-time volume of the collisions. The sensitivity of probing the nuclear symmetry energy $E_{sys}(\rho)$ with π^-/π^+ exhibits a same dependence on the system size and beam energy in accordance with the behavior of the degree of isospin fractionation. Moreover, the calculated results show the differential π^-/π^+ ratios are more sensitive to $E_{sym}(\rho)$ at forward angles in laboratory reference by analyzing the pion emission in Au+Au collisions. Last, the feasibility of measuring the π^-/π^+ ratio to extract the $E_{sym}(\rho)$ at limited phase space with a dipole-type spectrometer is studied based on the Geant4 simulation.

References

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