Chemical freeze-out in relativistic heavy ion collisions

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One surprising result in relativistic heavy-ion collisions is that the abundance of various particles measured in experiments is consistent with the picture that they reach chemical equilibrium at a temperature much higher than the temperature they freeze out kinetically [1-3]. Using a multiphase transport model [4] to study particle production in these collisions, we find [5], as an example, that the effective pion to nucleon ratio, which includes those from resonance decays, indeed changes very little during the evolution of the hadronic matter from the chemical to the kinetic freeze-out, and it is also accompanied by an almost constancy in the specific entropy as shown in Fig.1. Starting from the chemical freeze-out state in the AMPT model, we have further studied the expansion and cooling of the system using the hadron resonance gas model, and found that only the scenario of an expanding and cooling hadronic matter with non-unity fugacities can lead to both constant specific entropy and effective pion/nucleon ratio. Our study shows that after chemical freeze-out in relativistic heavy-ion collisions, the system is no longer in chemical equilibrium, but the statistical model can still be used to extract the temperature and chemical potential at chemical freeze-out since the relative abundances of particle species remain constant during later hadronic evolution. The present study thus helps clarify our understanding of chemical freeze-out in relativistic heavy-ion collisions, and validate the use of the statistical model [1-3] in mapping out the phase diagram of the strong-interacting matter from relativistic heavy-ion collisions.

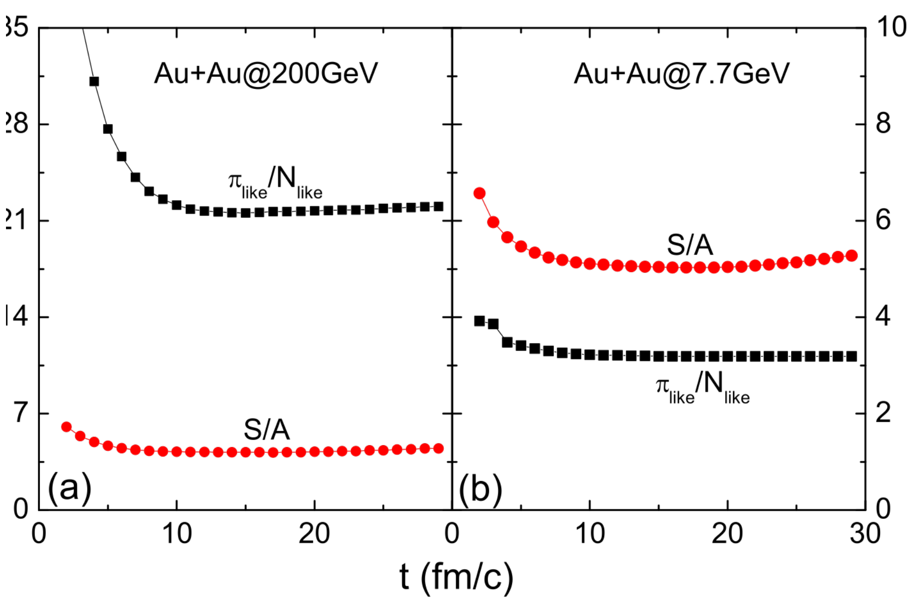

FIG. 1. Time evolution of the specific entropy (S/A) and the effective pion/nucleon ratio (π_{like}/N_{like}) in the hadronic phase of central Au+Au collisions at √sNN = 200 (a) and 7.7 GeV (b).

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