THE ROLE OF HIGHER EXCITED BARYONIC RESONANCE IN HEAVY ION COLLISIONS AT AGS ENERGIES

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Space-Time structure of freeze-out of produced particles in ultra relativistic nucleus-nucleus collisions are studied in the framework of two different cascade models, either with or without higher baryonic resonances. While higher excited baryonic resonances do not influence the spatial source size of freezing out point, the freeze-out time distribution is shifted to be later by these resonances.

In recent years, it has become clear that the two heavy nuclei stop each other and hot and baryon dense matter is created in Au+Au collisions at AGS energy [1]. Such a matter might be characterized by the existence of abundant resonance particles. Among them, the importance of Δ resonance is widely confirmed, while there are some ambiguities in the treatment of higher barionic resonances [2–5]. In our previous work [6], we have revealed that the hadronic degrees of freedom (DOF) play an important role on the thermodynamical evolution during Au(11.6AGeV/c)+Au collision, by using two different cascade model, either with or without higher resonances; pions are produced through the decay of baryonic resonances up to 2 GeV as well as strings propagating in phase space (Model-A), or various direct multi-pion production processes involving only 3 types of baryon resonances are implemented (Model-B). The temperature calculated in Model-B (smaller DOF) is significantly higher than that in Model-A (larger DOF), although the hadronic spectra in the final stage of reaction are not largely affected by the DOF.

Although the temperature cannot be directly determined by the experimental data, the information on DOF may be extracted from the source size, because the life time of resonance particles would affect this source size which can be estimated experimentally by using the two particle correlations. In this work, therefore, we study the dependences of the source size on the degrees of freedom by using the above two models.

The correlation function $C(\boldsymbol{p}_1, \boldsymbol{p}_2)$ is defined as the ratio of the two-particle detection probability $P(\boldsymbol{p}_1, \boldsymbol{p}_2)$ to the product of the single-particle detection probability $P(\boldsymbol{p}_1)P(\boldsymbol{p}_2)$. Following the parameterization of E877, we adopt the form, $C(q_{\rm inv}) = 1 + \lambda \exp(-R_{\rm inv}^2 q_{\rm inv}^2)$, as a fitting function, where $q_{\rm inv}$ is the momentum difference in the pair center of momentum frame. Here source size is obtained as $R_{\rm inv}$ which includes spatial and temporal component. In the left panel of Fig.1 we show the correlation function of π^+ from Model-A and Model-B as well as experimental data [8], where we have used the model and program developed by Pratt et al. [7] to deduce the correlation functions from classical simulation. The results of fitting these correlation functions are summarized in Table 1.

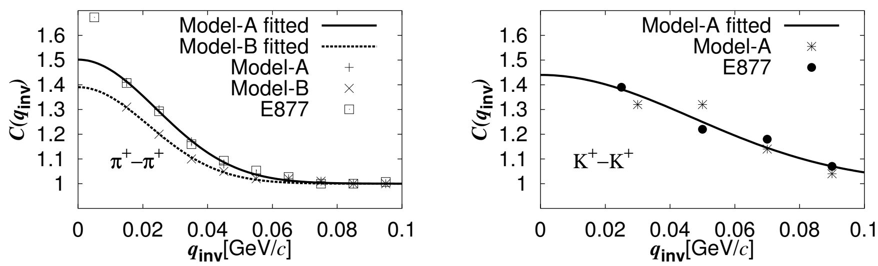

Figure 1: One dimensional $\pi^+-\pi^+$ and K^+-K^+ correlation function at the central collision of Au(11.6 AGeV/c)+Au. Correlation function is deduced by using the program by Pratt et al.[7] from the simulation calculation with Model-A (solid lines) and Model-B (dotted line).

Table 1: Source size of π^+ and K^+ in the central collision.

R[fm]	π^+		K^+	
	$R_{\rm HBT}$	$\sqrt{\langle r^2\rangle/3}$	$R_{\rm HBT}$	$\sqrt{\langle r^2\rangle/3}$
Model-A	5.8	8.5	3.0	4.6
Model-B	6.4	6.3		
Exp(E877)	5.4		3.1	

Since the resolving power of one-dimensional correlation function is limited, it is worthwhile to study the spatial and temporal distribution at freeze-out separately. In Fig.2 we show the normalized spatial and temporal distributions at π^+ freeze-out. We find that the two models give similar spatial distributions, but the temporal distribution in Model-A is shifted to be later in average than that in Model-B. In Model-A the collision energy is once stored in the mass of higher resonances, then pions are produced later. On the other hand, in Model-B, more pions are produced in the early stage through direct productions. In the latest stage, however, the yield of Model-B decrease slower because of long lived ω particles, which make many pions long after the collision. The root mean square radii of freeze-out points also show these non-Gaussian characters of particle freeze-out (see Table 1).

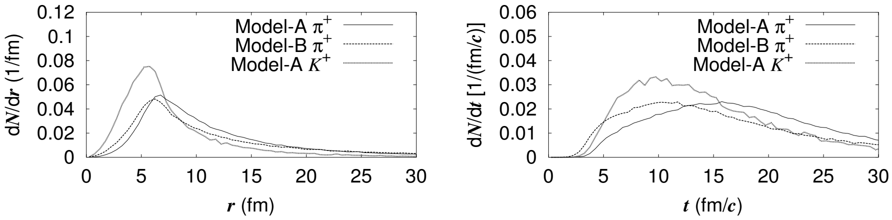

Figure 2: Normalized spatial (left) and temporal (right) distributions at freeze-out of π^+ and K^+ particles in the central collision.

We now turn to the distribution of kaon freeze-out. In the right panel of Fig.1 we show the correlation function of K^+ from Model-A and experiment. The source size of K^+ calculated from the correlation function is smaller than that of π^+ as expected from the smaller cross section with the nucleons, and it is in good agreement with the experimental ones. This can be also seen in the freeze-out point distribution (Fig. 2). At SPS energies, however, recent analysis shows that difference of source sizes is very small between π^+ and K^+ [9]. The source size might be sensitive the distributions of relative momenta between meson and nucleon because the cross section of kaon and pion in matter depend on the their momenta. We would like to study the source size at SPS energies with such an interest.

In summary, we have studied the role of higher baryonic resonances in the particle freeze-out. The calculated results suggest that Model-A (larger DOF) gives better agreement. However, since the spatial and temporal freeze-out point distributions cannot be described by a Gaussian with one parameter, it seems necessary to carry out multi-dimensional analysis. Investigation in wider incident energy region, including SPS energy, is also necessary.

References

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