# Spectral ratio: an observable to determine $K^+$ nucleus potential and $K^+$ N scattering cross section

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## Introduction

The change of the properties of mesons in dense hadronic matter has theoretically been investigated since many years [1, 2] and an experimental verification is still missing. The $t\rho$ approximation allows predicting the optical potential of the mesons in low-densities matter by experimentally measured phase shifts. At higher densities more sophisticated approaches have to be employed and in the last two decades many efforts have been made to investigate the properties of $\rho$, $\omega$, $K^+$ and $K^-$ mesons in matter. These calculations are complex because most of the mesons can form baryonic resonances which have other decay branches. Therefore, coupled-channels calculations have to be employed and the challenge has been met to calculate them self-consistently. Nevertheless, the theoretical predictions launched by different groups differ substantially because several of the quantities which enter such calculations, like in-medium coupling constants and the in-medium dressing of the different particles are only poorly known. These uncertainties render the theoretical prediction rather vague and it is highly desirably to have experimental information of properties of mesons around and above normal nuclear matter densities. Here we aim to show that the ratio of the momentum spectra of $K^+$ at small transverse momentum measured for symmetric systems of different sizes can be such an observable. For the present study we use IQMD model. For details please refer to [2]

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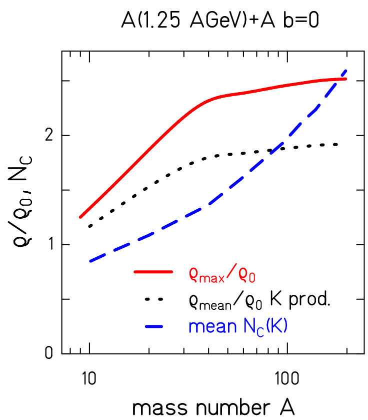


FIG. 1: Density and maximum number of collisions of $K^+$ as a function of mass of the system. Various lines are explained in the text.

## Results and Discussion

In fig 1, we display the maximum value of the central density (full line) as a function of the projectile mass number $A$ in symmetric reactions $A + A$ at 1.25 AGeV incident energy. The density rises strongly up to about $A = 40$ and then only slightly for the higher masses. A similar conclusion can be drawn when looking on the mean density at the production points of kaons (dotted line). These densities enter directly into the $K^+$ nucleus potential and have an important influence on the production yield of the kaons. Again, the yield rises up to $A = 40$ and then saturates at higher masses. In contrast, the mean number of collisions $N_C$(K) which a kaon suffers before leaving the system (dashed line), rises quite moderately with $A$ up to $A = 40$ and then increases much stronger for heavier systems. Therefore, the large mass region is the realm for measuring $\sigma^{\mathrm{medium}}(\mathrm{K^+N} \rightarrow \mathrm{K^+N})$.

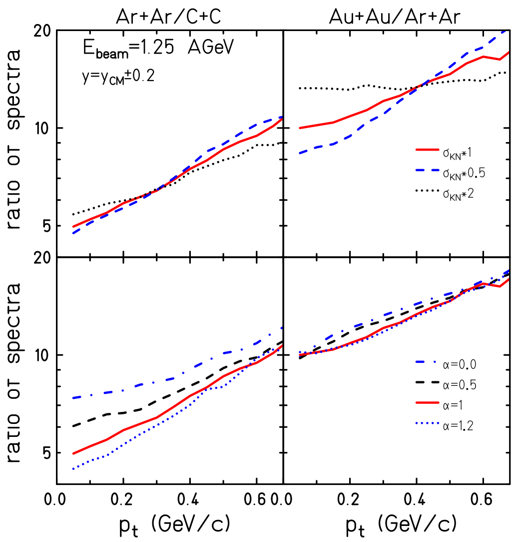


FIG. 2: Ratio of transverse momentum spectra for symmetric systems of different sizes. Various lines are explained in the text.

Below projectiles of mass 40 we see a strong increase of the densities with system size but few rescattering collisions because the systems are so small that rescattering does not become important. This is the realm for measuring $K^+$ nucleus potential.

Figure 2 shows the preliminary results of our calculations. It presents the ratio of the transverse momentum spectra close to midrapidity, obtained in Ar+Ar and C+C collisions (left) and Au+Au and Ar+Ar collisions (right). The top panels show the influence of the rescattering cross section. The free KN rescattering cross section has been multiplied by a coefficient between 0.5 and 2 while leaving all the other parameter unchanged. The bottom panel displays the variation of this ratio with the change of the strength of the $K^+$ nucleus potential by applying a factor $\alpha$ to the potential. As expected from the discussion above, the ratio of the yields for the two smaller systems is almost independent of the rescattering cross section but depends strongly on the strength of the $K^+$ nucleus potential. Rescattering is not very frequent in these light systems, therefore its influence on the spectrum is moderate. The $K^+$ nucleus potential, in the contrary, has a direct influence on the spectra, as shown in the lower left panel. The maximal density as well as the density profile is different for the both systems and due to this difference the $K^+$ nucleus potential acts differently. Whereas in C+C even the central density does not exceed much the normal nuclear matter density, in the Ar+Ar system the densities exceeds already twice normal nuclear matter density. By comparing the lighter systems one cannot learn much on the rescattering cross section but the spectra becomes sensitive to the strength of the $K^+$ nucleus potential. The slope of the ratio is a direct measure of this strength and present-day experiments are sufficiently precise to extract the strength of the potential.

If one compares the two heavier systems (right panel of Fig. 2, a completely different scenario emerges. Rescattering becomes very important in the Au+Au reactions where almost all $K^+$ undergo rescattering. Therefore, the influence of the rescattering cross section on the spectra is very visible as shown in the upper right panel. On the other side, the ratio is hardly influenced by the strength of the $K^+$ nucleus potential because the density at which the $K^+$ have their last collisional interaction with the surrounding nucleons is rather similar and therefore, the $K^+$ nucleus potential acts in a very similar way on the $K^+$, leaving the ratio unchanged.

## Acknowledgments

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## References

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