Extracting information on the nuclear equation of state from K^+ production in heavy ion collisions

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In [1] we studied the question if decisive information on the nuclear EOS can be extracted from subthreshold kaon production in heavy ion collisions. The KaoS Collaboration has performed systematic measurements of the K^+ production far below threshold in heavy ($Au+Au$) and light ($C+C$) systems [2]. Looking at the ratio R built from heavy and light systems possible uncertainties which might still exist in the theoretical calculations should cancel out to a large extent which allows to draw reliable conclusions. Furthermore, far below threshold the kaon production is a highly collective process and a particular sensitivity to the compression of the participant matter is expected. In [1] we calculated this excitation function for a soft/hard EOS including the in-medium kaon potential shown in Fig. 1. The comparision to the KaoS data [2] strongly favours a soft EOS. To base this conclusion on even more model independent grounds Fig. 1 compares also to independent calculations from the Nantes group using IQMD [3]. Both calculations show an increase of R with decreasing incident energy down to 1.0 A·GeV. However, this increase is much less pronounced for both, the Tübingen and the Nantes results when the stiff EOS is employed. In our case R even decreases at 0.8 A·GeV whereas the soft EOS leads to an unrelieved increase of R. At 1.5 A·GeV which is already very close to threshold the differences between the two models become small. The strong increase of R can be directly related to higher compressible nuclear matter. The comparison to the experimental data from KaoS [2] where the increase of R is even more pronounced strongly favours a soft equation of state. For the soft EOS the IQMD calculations almost coincide with the present results [1]. For the hard EOS there exists still deviations concerning the slope of R going far below threshold. This can be due to the different in-medium kaon potentials used. Hence, the shaded areas in the figure indicate the present range of uncertainty concerning the theoretical description of this observable. This has still to be reduced by future investigations. The dependence of R on the various production channels is shown in Fig.2. There the ratios R_i are built separately for the production channels with initial states $i = NN, \pi N, N\Delta, \pi\Delta, \Delta\Delta$. Here one has to keep in mind that the NN and πN cross sections are quite well under control whereas the $N\Delta$, $\pi\Delta$ channels are experimentally unknown. Thus one has to rely on model predictions. However, the shape of R is not strongly influenced by these two channels which are the most insecure ones. The excitation function for the $N\Delta$ contribution varies only little as a function of energy and is similar using the different EOSs. The contribution of the $\pi\Delta$ channel is decreasing for both, a hard and a soft EOS. The shape of R is to most extent determined by the NN and πN contributions. In our calculations the latter channel is responsible for the decrease of R very far below threshold when the hard EOS is applied. Since we consider ratios theoretical uncertainties in the knowledge of elementary cross sections cancel out in first order anyway, which makes the conclusions drawn form this observable more reliable.

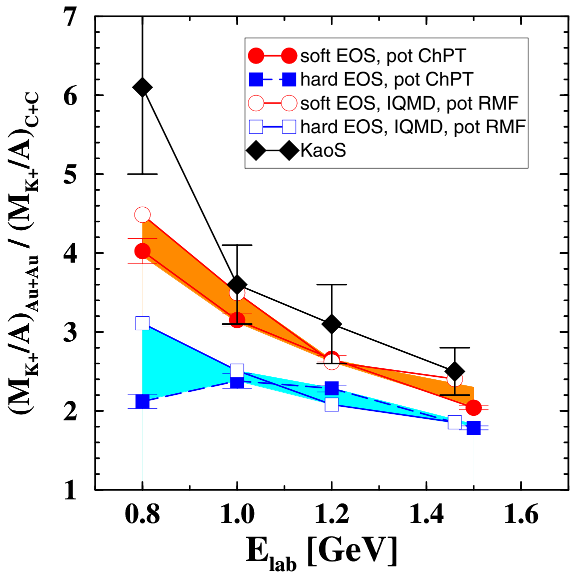

Figure 1: Excitation function of the ratio R of K^+ multiplicities obtained in inclusive $Au+Au$ over $C+C$ reactions. The calculations are performed with in-medium kaon potential and using a hard/soft nuclear EOS and compared to the data from the KaoS Collaboration [2]. results from independent IQMD calculations [3] are shown as well.

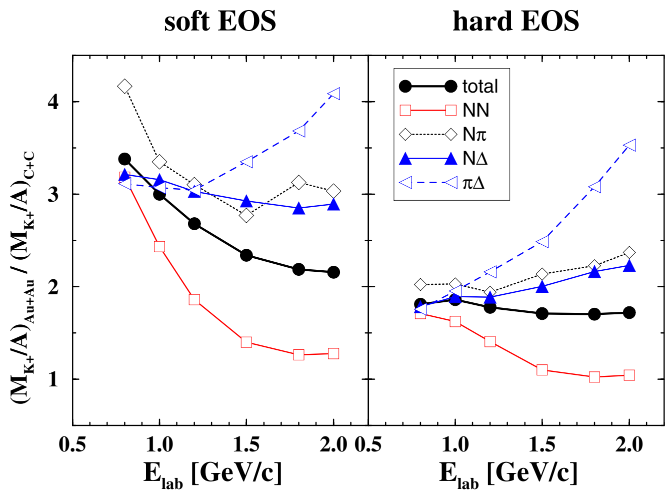

Figure 2: Dependence of the excitation function of R on the various K^+ production channels. Central (b=0 fm) $Au+Au$ and $C+C$ reactions are considered. The calculations are performed with in-medium kaon potential.

References

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