Production of K^{*0} in Au+Au collisions at $\sqrt{s_{NN}} = 19.6$ GeV in BES-II from STAR

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Introduction

Relativistic heavy-ion collisions aim to study the deconfined state of matter, known as the Quark-Gluon-Plasma (QGP). Resonances usually have a smaller lifetime compared to that of the fireball, which makes them a useful probe to the late-stage evolution of heavy-ion collisionss [1]. K^{*0} mesons have a lifetime of $\sim$ 4.16 fm/c, hence they decay within the medium and their daughters experience various in-medium effects.
During the evolution of a heavy-ion collision, the temperature at which all the inelastic collisions stop is called the chemical freeze-out temperature (T_{ch}), and the temperature, at which all the elastic collisions seize as the distances between particles become larger than their mean free path, is known as the kinetic freeze-out temperature (T_{kin}). When a K^{*0} meson decays in between these two stages, its daughter particles, π and K, may re-scatter with other particles present in the medium and their momenta may change. This makes the reconstruction of the K^{*0} less probable and we may lose the prompt resonance created in the medium. Meanwhile it also can happen that π and K coming from different sources regenerate a K^{*0} via pseudo-elastic scattering. Hence the properties and yield of K^{*0} are highly dependent on the relative contribution of re-scattering and regeneration effects. Its comparison to the ϕ meson is of particular interest as the ϕ meson has a lifetime 10 times larger ($\sim$ 46 fm/c) than that of K^{*0}. Hence, the daughter particles of a ϕ meson may remain immune to the in-medium effects and there is a smaller probability of alteration in its properties and yield.
In this work, we will present measurements of K^{*0} production in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV from the Beam Energy Scan phase II (BES-II) program at STAR. The resonance to non-resonance ratios (K^{*0}/K and ϕ/K) are studied, which show the dominance of hadronic rescattering in heavy-ion collisions. The lower limit of the hadronic phase lifetime is also measured using a toy model.
In this analysis the sum of the K^{*0} and $\overline{K^{*0}}$ is denoted as K^{*0}, unless otherwise specified.

Analysis details and results

The $K^{*0}(\overline{K^{*0}})$ is reconstructed via the invariant mass method from its decay channel K^{*0} $(\overline{K^{*0}})\rightarrow K^{+}\pi^{-}$ $(K^{-}\pi^{+})$ (B.R $\sim$ 66%). The combinatorial background is estimated using the track rotation method. The vertex positions along the beam (V_z) and radial (V_r) directions are required to be within $|V_z| < 145$ cm and $V_r < 2$ cm. For particle identification, both the Time Projection Chamber (TPC) and the Time Of Flight (TOF) detector are used. During BES-II, the inner part of the TPC has been upgraded for better momentum resolution, wider transverse momentum (p_T) and pseudo-rapidity coverages.

The left panel of Fig. 1 shows the variation of particle ratios as a function of $\langle N_{part}\rangle$. The K^{*0}/K ratio decreases from peripheral to central collisions, while the the ϕ/K ratio remains almost independent of centrality. The thermal model predictions agree with the ϕ/K ratio but it overpredicts the K^{*0}/K ratio in central Au+Au collisions. All these observations are consistent with the dominance of hadronic rescattering over regeneration in central Au+Au collisions.
The time difference between chemical freeze-out and kinetic freeze-out is considered as the hadronic phase lifetime. Since the life span of the hadronic phase can not be measured

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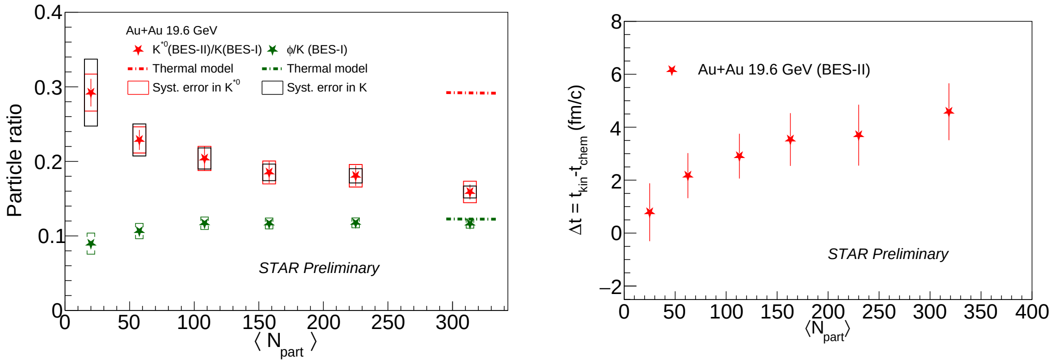

FIG. 1: Left panel: K^{*0}/K and ϕ/K as a function of $\langle N_{part}\rangle$. Here the K^{*0}/K represents $(K^{*0} + \overline{K^{*0}})/(K^{+} + K^{-})$ and the ϕ/K represents $2\phi/(K^{+} + K^{-})$ (BES-I) [2]. The bars and caps indicate statistical and systematic uncertainties respectively. Right panel: Hadronic phase lifetime (Δt) as a function of $\langle N_{part}\rangle$. The error bars are the quadratic sum of the statistical and systematic uncertainties.

directly from the experiment, we can use the K^{*0}/K ratio to estimate the lower limit of the hadronic phase lifetime [1] using the following relation [3]:

$$\left(\frac{K^{*0}}{K}\right)_{kinetic} = \left(\frac{K^{*0}}{K}\right)_{chemical} \times e^{-\Delta t/\tau_{K^{*0}}}, \quad (1)$$

Here the $(K^{*0}/K)_{chemical}$ and $(K^{*0}/K)_{kinetic}$ are taken to be the K^{*0}/K ratios measured in p+p and A+A collisions respectively. This method also takes assumptions that in between the chemical and kinetic freeze-out no K^{*0} regeneration takes place, and that all K^{*0} that decay before the kinetic freeze-out are lost due to the re-scattering effect. The calculated Δt is boosted by the Lorentz factor which is estimated as $\sqrt{1 + (\langle p_T\rangle/mc)^2}$ [4]. The right panel of Fig. 1 shows the variation of the lower limit of the hadronic phase as a function of $\langle N_{part}\rangle$, which increases with the centrality.

Conclusion

Production of K^{*0} at mid-rapidity ($|y| < 1.0$) in Au+Au collisions at 19.6 GeV (BES-II) is presented. The K^{*0}/K yield ratio in central collisions is observed to be less than that in peripheral collisions. On the other hand, the ϕ/K ratio remains almost independent of centrality. This suggests that the hadronic phase formed in A+A collisions is mostly dominated by the re-scattering effect. The lower limit of the hadronic phase lifetime is estimated using the K^{*0}/K ratio, which seems to increase with the centrality.

Acknowledgement

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References

[1] C. Adler et al. (STAR), Phys. Rev. C 66, 061901 (2002)

[2] J. Adam et al. (STAR), Phys. Rev. C 102, 034909 (2020)

[3] S. Singha et al. Int. J. Mod. Phys. E 24, 1550041 (2015)

[4] S. Acharya et al. (ALICE) PLB 802 (2020) 135225