Kaon Differential Flow in Relativistic Heavy-Ion Collisions

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Theoretical studies have shown that kaon has a weak repulsive potential in nuclear matter while antikaon has a strong attractive one. In heavy ion collisions the repulsive kaon potential in nuclear medium would reduce its flow relative to that of nucleons [1], while the flow of antikaons would be similar to that of nucleons due to their attractive potential [2]. Indeed, all experiments have indicated that kaons have a very small flow [3].

To better understand the physics underlying the observed vanishing kaon flow, we have carried out a differential flow analysis for heavy-ion collisions at AGS energies by studying the transverse momentum dependence of kaon flow, i.e., $< \cos\phi > (y, p_t)$ with ϕ being the azimuthal angle with respect to the reaction plane [4]. Our study is based on a relativistic transport model (ART1.0) [5]. For the kaon potential, we use the one determined from the impulse approximation using the kaon-nucleon scattering length. At normal nuclear matter density, this gives the kaon a repulsive potential of about 30 MeV.

In Fig. 1, the average kaon transverse momentum (scaled by the kaon mass) in the reaction plane is shown as a function of rapidity (scaled by the beam rapidity) for Au+Au collisions at an impact parameter of 4 fm and a beam momentum of 6 GeV/c per nucleon. Experimental data from this reaction are being analyzed by both the E917 [6] and E895 [7] collaborations. The open (filled) circles are results obtained without (with) the kaon mean-field potential. As one expects, in the absence of potential kaons flow in the same direction as nucleons. However, there is essential no flow in the whole rapidity range when the kaon mean-field potential is included in the transport model. This observation is in agreement with earlier findings at both lower [1] and higher energies [8], i.e., the kaon potential reduces its flow or even changes the flow direction.

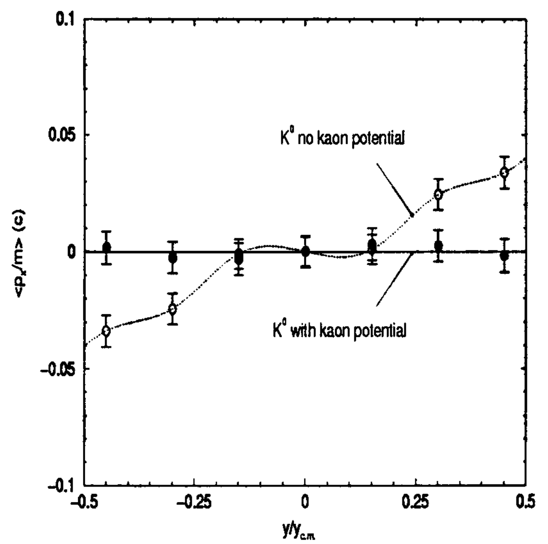

Figure 1: The average transverse momentum of K^0 in the reaction plane for Au+Au reactions at $P_{\mathrm{beam}}/A = 6$ GeV/c and an impact parameter of 4 fm. The open (filled) circles are the results obtained without (with) the kaon mean-field potential.

The results for the kaon differential flow are shown in Fig. 2, and it is seen that irrespective of the kaon transverse momentum its differential flow is always positive when no potential is included. The value at p_t around 1 GeV/c is significantly below those at other transverse momenta, and this is related to the fact that these kaons are mainly produced when both the projectile and target spectator matters are still present. With a repulsive kaon potential, the differential flow of kaons with transverse momenta less than about 0.8 GeV/c becomes negative while that of kaons with higher transverse momenta remains positive. This change in the dependence of kaon differential flow on the transverse momentum follows from the fact that the force acting on a kaon is inversely proportional to its energy, so low energy kaons are more strongly repelled by baryons than high energy ones, which remain to flow in the same direction as baryons. Integrating over the transverse momentum distribution leads to a cancellation between opposite flows at low and high transverse momenta. The resulting kaon in-plane flow is therefore small as shown in Fig. 1.

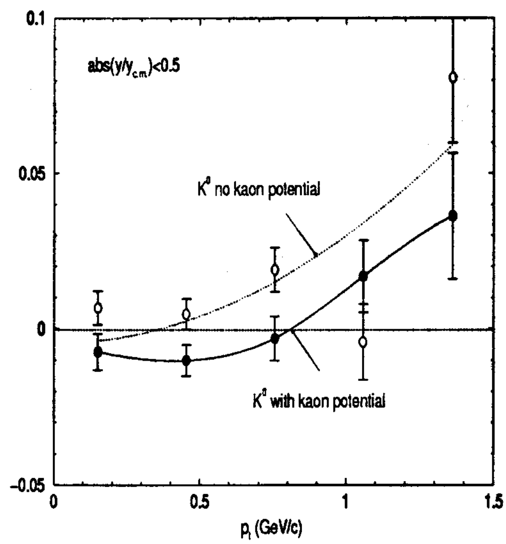

Figure 2: The K^0 azimuthal asymmetry as a function of transverse momentum for the same reaction as in Fig. 1. The open (filled) circles are the results obtained without (with) the kaon mean-field potential.

The differential kaon flow has recently been studied by the E877 collaboration [9, 10], and it has indeed been found that there is a negative (positive) flow for K^+ with low (high) transverse momenta.

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