Directed flow of neutral strange particles at AGS

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Directed flow of neutral strange particles (K^0 and Λ) is being studied experimentally by the E895 collaboration [1] at AGS. Preliminary data show that while lambdas flow in the same direction as protons but with a smaller flow parameter, neutral kaons have an appreciable antiflow relative to that of nucleons. To understand these experimental observations, we have carried out a theoretical study using a relativistic transport (ART) model [2].

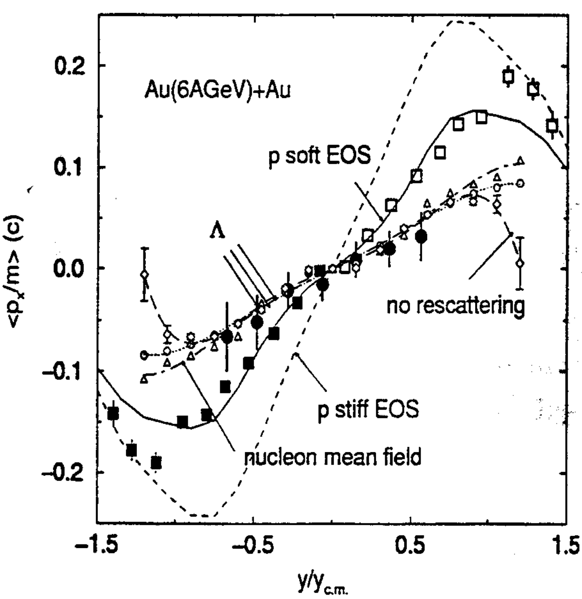

Figure 1: Proton and lambda directed flow from Au+Au collisions at a beam momentum of 6 GeV/c per nucleon. Results from the ART model are shown by lines. The preliminary E895 data are open squares for the proton flow and solid circles for the lambda flow. Filled squares are the reflected proton data.

For the lambda potential, we take it to be 2/3 of that of protons based on the light quark contents of proton and lambda. The nucleon potential used in the ART model is the standard Skyrme-type derived from either a soft nuclear equation of state with a compressibility of 200 MeV or a stiff nuclear equation of state with a compressibility of 380 MeV. In both cases, the lambda potential at normal nuclear density is about -33 MeV, which is consistent with that determined from the properties of hypernuclei [3]. We also include in the ART model the lambda-nucleon elastic scattering using the parameterized cross section of Ref. [4]. In Fig. 1, we show the results for the proton and lambda directed flow from the ART model together with the preliminary E895 data for Au+Au collisions at a beam momentum of 6 GeV/c. The theoretical results are obtained from the impact parameter range of 5 to 7 fm for protons and 0 to 8 fm for lambdas, while the experimental data are based on the analysis of 8500 semi-central events. We find that at central rapidities, the soft nuclear equation of state (solid curve) gives a better description of the measured proton directed flow, while at large rapidities ($y/y_{c.m.} > 0.7$), the stiff nuclear equation of state (dashed curve) describes the data better. However, inclusion of cluster formation near the beam and target rapidities, which has not been included in the ART model, is expected to change the proton directed flow at large rapidities. For the lambda flow (dotted curve), the ART model gives a smaller value at central rapidities than that for protons. As shown in Fig. 1, using the soft equation of state can indeed account for the experimentally observed weaker directed flow of lambdas. Using a lambda potential similar to that for a proton increases only slightly the lambda directed flow.

For the kaon mean-field potential, we use the impulse approximation based on the kaon-nucleon scattering length. It gives a kaon potential of about 30 MeV at normal nuclear matter density. Since the charge-exchange reactions between K^0 and K^+ have not been included in the ART model, an upper limit on its effect is obtained by including the Coulomb potential also for the K^0.

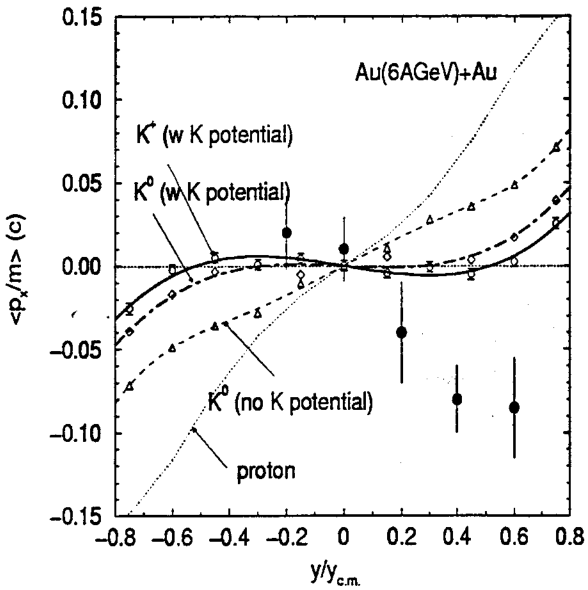

Figure 2: Comparisons of kaon flow from the ART model with the preliminary E895 data (solid circles).

In Fig. 2, we compare the kaon flow from the ART model with the E895 data, which are based on K_S^0's reconstructed from their charge pion decays. It is clearly seen that without kaon mean-field potential, K^0's flow with nucleons. The repulsive kaon mean-field potential makes kaons flow away from nucleons. In addition, charge-exchange reactions enhance the anti-flow of kaons with respect to protons due to the Coulomb repulsion acting on K^+'s. We see that even if all K^0's are K^+'s in the reaction, their average transverse velocity p_x/m is only about 0.01c which is almost five times smaller than that observed in the experiment.

Since the kaon directed flow is affected by the kaon potential in nuclear medium, using different potentials can give different values for the flow parameter. Considerations based on the chiral Lagrangian have shown that the repulsive kaon potential results from the cancellation of an attractive scalar potential, which depends on the scalar density, and a repulsive vector potential, which depends on the baryon density [5]. Since the scalar density becomes increasingly smaller than the baryon density when the latter is large, the kaon potential is expected to be more repulsive at high densities than that given by the impulse approximation. It will be of interest to see if this potential can describe the E895 data.

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