Azimuthal angle dependence of the longitudinal spin polarization in relativistic heavy ion collisions

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Using the chiral kinetic approach [1-3] with initial phase-space distributions of quarks taken from the AMPT model [4] and their helicities randomly assigned, we have studied the effect of the transverse components of local vorticity field in the transverse plane of a heavy ion collision on the longitudinal spin polarization of quarks along the beam direction [5]. We have found that the quark longitudinal spin polarization depends not only on the longitudinal component of the vorticity field but also on its transverse components due to the resulting axial charge redistribution. Using a constant and isotropic quark scattering cross section of 10 mb, we have obtained a quark longitudinal spin polarization that has an azimuthal angle dependence and amplitude, shown in Fig. 1, similar to those measured in experiments for lambda hyperons by the STAR Collaboration at RHIC [6], as a result of the dominant effect of the in-plane component over those of the out-of-plane component and the longitudinal component of local vorticity field. We have also found that decreasing the quark scattering cross section leads to a reduction of the quark longitudinal spin polarization. Our study thus demonstrates the importance of nonequilibrium effects as well as the local structure of the vorticity field and its time evolution on the spin polarizations of quarks in relativistic heavy ion collisions. This is in contrast to results obtained from assuming local thermal equilibrium of the spin degrees of freedom in the thermal volticity field at the kinetic freeze-out of heavy ion collisions [7,8], which show an opposite sign from the measured azimuthal angle dependence.

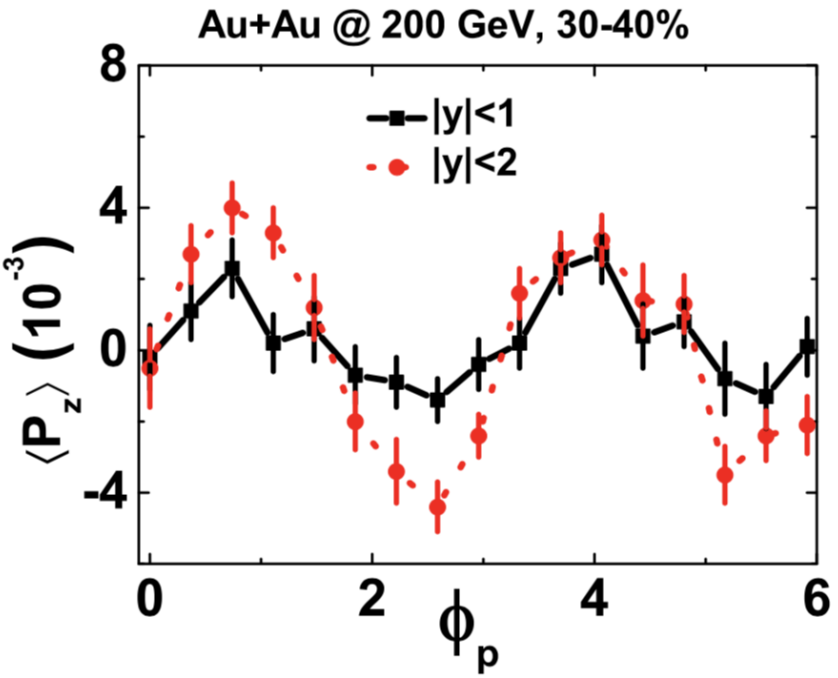

FIG. 1. Average longitudinal spin polarization of strange quarks as a function of azimuthal angle φ_p of the quark momentum in the transverse plane of heavy ion collsions for different rapidity ranges.

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