Elliptic Flow in Heavy Ion Collisions at RHIC

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Elliptic flow in heavy ion collisions measures the anisotropy of particle momentum distributions in the plane perpendicular to the beam direction. It results from the initial spatial anisotropy in non-central collisions and is thus sensitive to the properties of the hot dense matter formed during the initial stage of heavy ion collisions [1, 2]. Recently, we have studied the elliptic flow in heavy ion collisions at RHIC using a multiphase transport (AMPT) model [3], that includes both initial partonic and final hadronic interactions. The AMPT model [4] is a hybrid model that uses as input the minijet partons from the hard processes and the strings from the soft processes in the HIJING model [5]. The dynamical evolution of partons are then modeled by the ZPC [6] parton cascade model, while the transition from the partonic matter to the hadronic matter is based on the Lund string fragmentation model [7]. The final-state hadronic scatterings are modeled by the ART model [8]. The AMPT has been quite successful in describing the measured rapidity distributions of charge particles, particle to antiparticle ratios, and the spectra of low transverse momentum pions and kaons in heavy ion collisions at RHIC [9].

Results on the charged particle elliptic flow from the AMPT model for Au+Au collisions at center-of-mass energy of 130A GeV are shown as a function of both the charged particle multiplicity in Fig. 1 and transverse momentum in Fig. 2. Theoretical values from the default AMPT model (no string melting) are much smaller than that measured in the experiments by the STAR collaboration [10]. This is mainly due to the small fraction of energy that is carried by minijet partons and the lack of transverse collective motion of the strings. As a result, the elliptic flow is significantly reduced after minijet partons combine with strings and fragment to hadrons.

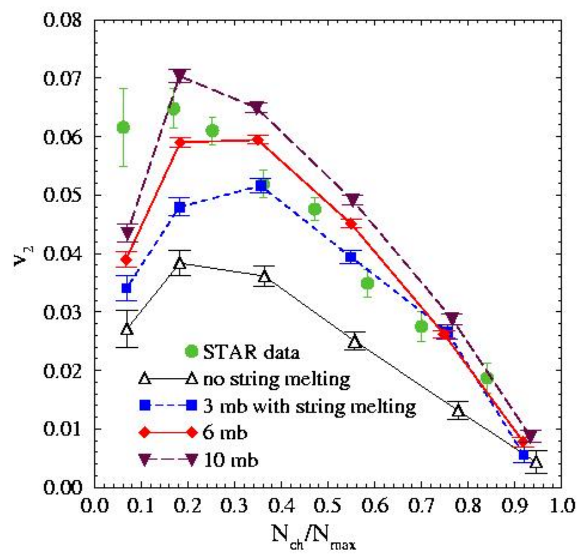

Figure 1: Charged particle multiplicity dependence of elliptic flow in Au+Au collisions at $\sqrt{s} = 130\ GeV$. Filled circles are data from the STAR collaboration [10], and theoretical results for different partonic dynamics are given by curves.

Since the energy density of initially produced matter in central Au+Au collisions at RHIC is more than an order of magnitude higher than the critical energy density ($\sim 1\, GeV/fm^3$) expected for the formation of the quark-gluon plasma, we have extended the AMPT model to allow the initially excited strings to fragment into hadrons using the LUND fragmentation model and then convert these hadrons to their constituent quarks but with bare masses, i.e., a meson is converted to a quark and an anti-quark, while a baryon is converted to three quarks. We further assume that quarks are produced isotropically in the rest frame of a hadron and start to interact only after a proper formation time given by the inverse of the hadron transverse mass. Scatterings among these quarks are then treated using the parton cascade ZPC. After the quarks stop interacting, we model the hadronization by combining the nearest quark and antiquark into a meson and three quarks into a baryon with the same flavor. The resulting hadrons are given an additional formation time of 0.7 fm/*c* in their rest frame and then imported to the ART hadronic transport model to take into account their rescatterings.

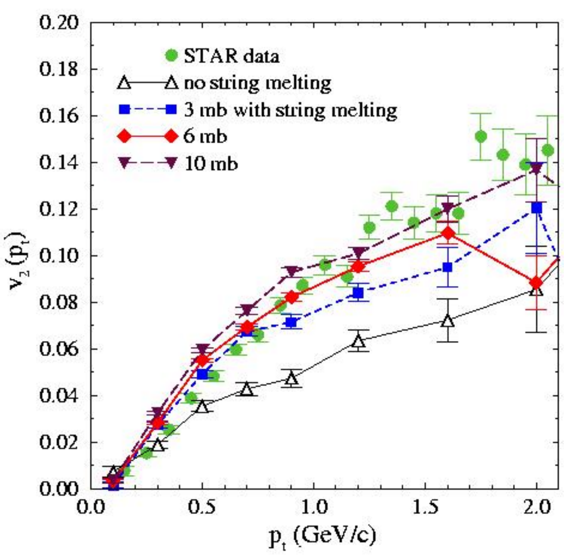

Figure 2: Same as Fig. 1 for the dependence of elliptic flow on the transverse momentum

With strings converted to partons, the initial energy originally stored in strings also contributes to the parton dynamics. This leads to a larger elliptic flow and also a stronger dependence on the parton scattering cross section, making it possible to determine the strength of partonic interactions from the final elliptic flow. As shown in Figs. 1 and 2, a large parton scattering cross section of 6-10 mb is needed to account for the observed dependence of charged particle elliptic flow on the total charged particle multiplicity and their transverse momentum.

Our study thus confirms earlier expectations based only on the parton cascade model [11] that elliptic flow is a sensitive probe of the initial partonic dynamics in heavy ion collisions at RHIC.

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