Collective Flow in Heavy-Ion Collisions from AGS to SPS Energies

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The collective transverse flow was analysed within the model of 3-fluid dynamics (3FD) [1]. Model parameters of our previous paper [1] were used, which were fixed to reproduce a great body of experimental data in the incident energy range $E_{lab} \approx (1–160)\text{A GeV}$. These parameters have been varied only in order to study sensitivity to stiffness of the equation of state (EoS). Thus, in addition to the default choice of the EoS with an intermediate incompressibility of $K = 210 \text{ MeV}$ [1] calculations were also performed for a hard (380 MeV), soft (130 MeV), and extra-soft (100 MeV) choice.

Various investigators have varied model parameters in order to study sensitivity to the character of the EoS. In Ref. [3] this mechanism was summarized as “a transition from hadronic to string matter”. As it was stated in Ref. [3], this “transition from hadronic to string matter” practically saturates at the top AGS energy. This agrees with our observation that no extra softening of the EoS is further required at SPS energies beyond that at top AGS energy. The transverse flow is very sensitive to the character of the nonequilibrium distributions of the transverse-momentum at the initial stage of the collision.

Alternatively the required EoS softening can be associated with a deconfinement transition. Therefore, other, more sophisticated EoS’s, including scenario of a phase transition to the quark-gluon plasma phase, should be tested within 3FD simulations. The present calculations provide a natural benchmark for the future analysis.

The flow is an “early-stage” observable, i.e. it is determined by the early-stage evolution of the collision. Our calculations with different freeze-out criteria (different freeze-out energy densities $\varepsilon_{frz}$) confirm this conjecture. The directed flow turns out to be fairly insensitive to such modifications. This low sensitivity on the freeze-out stage is not surprising. The directed flow is a measure of the collective momentum accumulated by matter during the expansion stage. The driving force of this collective momentum is the pressure gradient created at the early compression stage of the collision. If the freeze-out occurs not too early (e.g., not right after the compression stage), this pressure gradient has enough time to accelerate the matter, and hence the late-stage evolution does not noticeably change the earlier-accumulated collective momentum. The elliptic flow is a more subtle quantity. It is a measure of the difference of the in- and out-of-plane flows. Therefore, its sensitivity to the late stage is slightly enhanced.

A detailed report on this work can be found in Ref. [4].

References

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