Systematic investigation of Cooper-Frye negative contributions *

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Many models of heavy ion collisions employ relativistic hydrodynamics to describe the system evolution at high densities. The Cooper-Frye formula [1] is applied in most of these models to turn the hydrodynamical fields into particles. However, the number of particles obtained from the Cooper-Frye formula is not always positive-definite. Physically negative contributions of the Cooper-Frye formula are particles that stream backwards into the hydrodynamical region.

We have investigated negative Cooper-Frye contributions and backscattering using a coarse-grained molecular dynamics approach. Au+Au collisions at $E_{\rm lab} = 5$–$160A$ GeV energies have been simulated using UrQMD [2], and a hypersurface Σ of constant Landau rest frame energy density has been constructed. On this surface we have calculated two quantities: The ratio of Cooper-Frye negative to positive contributions (r_{eq}), which assumes local thermal equilibrium, and the ratio of UrQMD particles crossing Σ inward to crossing Σ outward (r_{neq}), which does not assume equilibrium.

We found that at all collision energies $r_{eq} \gg r_{neq}$ [3]. We explain this by a deviation of pions in UrQMD simulation from equilibrium. A non-monotonous dependency of r_{eq} and r_{neq} on collision energy was found with a maximum at 10-20A GeV, maximal r_{eq} being around 13% (Fig. 1 a). The size of the negative contributions is a result of an interplay of several factors: the temperature on the hypersurface, the relative velocities between flow and surface, and the relative amounts of volume and surface emission.

Both r_{eq} and r_{neq} are smaller for hadron sorts with higher mass (Fig. 1 b) and decrease for peripheral events (Fig. 1 c).

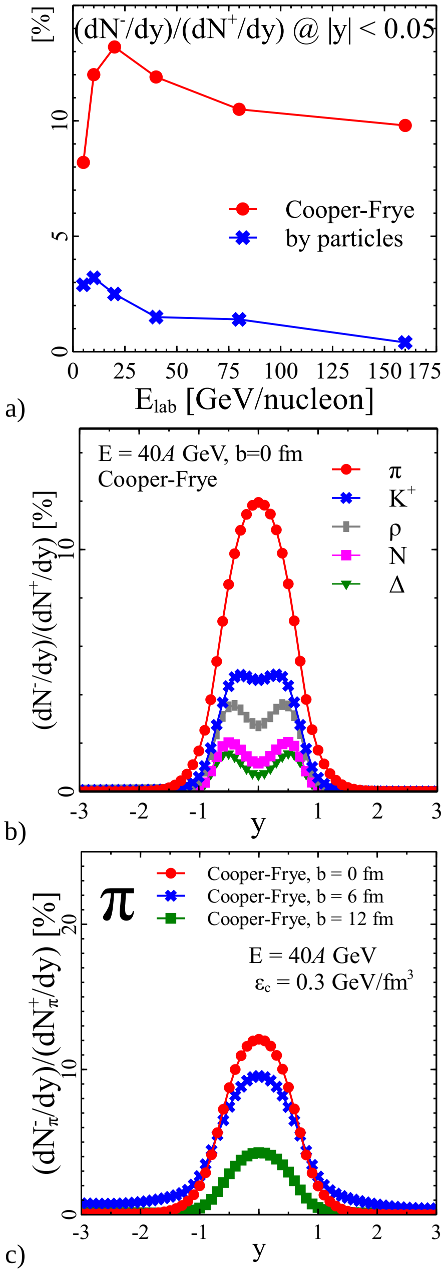

Figure 1: a) r_{eq} and r_{neq} for pions at midrapidity versus collision energy; b) r_{eq} rapidity distribution for different hadron species; c) r_{eq} for pions versus collision centrality

References

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