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Cooper-Frye negative contributions and thermalization at FAIR energies

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Hydrodynamics is successfully applied as a theoretical model for the dynamics of heavy ion collisions at high collision energies reached at RHIC and the LHC. However, the applicability for collisions at lower beam energies remains unclear. Known limitations are both physical, such as possible lack of thermalization, large mean free path or large fluctuations, and technical, such as negative Cooper-Frye contributions. In this talk I will address the question: "What is the lowest collision energy, at which hydro-based approaches are still applicable?"

The question of hydrodynamics applicability cannot be answered within hydrodynamics itself. In order to investigate it we consider Au-Au collisions at energies Elab = 10-160 A GeV within a coarse-grained UrQMD approach. The energy-momentum tensor is calculated as a function of space and time to explore the degree of local equilibration of the system. In addition, UrQMD and viscous hydrodynamics are initialized in the same way and the resulting $T^{\mu\nu}$ during the space-time evolution is compared to quantify deviations from a hydrodynamic treatment.

At the end of the fluid-dynamical evolution particles are generated on the transition hypersurface according to the Cooper-Frye formula. This description suffers from the so-called negative contributions – particles flying from outside back to the fluid-dynamical region. By comparing the negative contributions in a coarse-grained transport approach to the ones obtained in a hydro-like treatment, the importance of the backstreaming effect of particles is assessed. We demonstrate, that the lower collision energy – the larger the negative Cooper-Frye contributions are. In our calculation they reach 12% at central 10 AGeV collisions for pions at midrapidity.

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