Contribution ID: **823** Type: **Poster**

Frisco3 - A three-fluid model with continuous freeze-out for intermediate energy heavy-ion collisions

Heavy-ion collisions in the energy regime of $\sqrt{s_{\mathrm{NN}}} = 2$ - 20 GeV, are relevant for the study of dense baryonic matter and the hunt for the critical end point of QCD. In this energy regime the well established hybrids of single-fluid hydrodynamics coupled to transport afterburners are reaching their limitation due to long interpenetration times and an intricate time evolution.

To address this shortcoming we present Frisco3, a novel 3-fluid hydrodynamical simulation model of relativistic heavy-ion reactions with a continuous transition from the fluid phase to the regime of free streaming hadrons, applicable at RHIC-FXT, GSI and FAIR energies. The time evolution of the reaction is consistently described in terms of three coupled ideal fluids, resembling the two nuclei, which couple to the third fluid, the fireball, via a local friction rate, and a continuous drain term, which is determined by the local thermal emissivity and the survival probability of produced hadrons given by their momentum differential, temperature and density dependent scattering rate in the medium. The model thus overcomes the conventional issues of i) single-fluid hydrodynamics loosing applicability at lower energies due to small Lorentz-contraction, long interpenetration times and an intricate geometry. Instead the fireball fluid is continuously generated by friction of the projectile and target fluids, thus capturing the time dependent equilibration of the system. (ii) The model avoids the common Cooper-Frye decoupling. Instead of an ad-hoc freeze-out hyper-surface the freeze-out is dynamically determined by local scattering and expansion rates and thus avoids common issues of Cooper-Frye regarding conservation laws, feedback to the fluid phase or reheating. Frisco3 moreover conserves energy, momenta and charges exactly on an event-by-event basis at any time in the evolution.

We will present first benchmarking results on hadron multiplicities, rapidity and transverse momentum spectra for Au+Au collisions ranging from 2.4 GeV to 20 GeV center of mass energy, in comparison to recently measured data by HADES and STAR. We will further present freeze-out properties and will relate them to the phase diagram.

Category

Theory

Collaboration (if applicable)

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Session Classification: Poster session 2

Track Classification: Collective dynamics & small systems