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Identified particles from viscous hydrodynamics

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Much of our understanding of the collision dynamics at RHIC and LHC relies on contrasting hydrodynamic or hydro+transport calculations with experimental data. For example, early evidence for rapid thermalization and quark-gluon plasma phase transition at RHIC came from particle spectra and the pion-proton splitting of differential elliptic flow. An inevitable component in these calculations is the conversion of the fluid to particles. For an ideal fluid the conversion is straightforward (the usual caveats of the Cooper-Frye treatment aside) because the phase space distributions are locally thermal for each species. For a viscous fluid, however, an infinite class of phase space corrections can reproduce the same hydrodynamic variables, even in a one-component system.

Present viscous hydrodynamic calculations routinely assume that phase space corrections induced by shear stress are quadratic in momentum and that they have the same coefficient for all particle species ("democratic" Grad ansatz), independently of microscopic details. However, in a gas of hadrons, equilibration is driven by scattering rates - species that scatter rarely tend to be further away from local equilibrium than those that scatter often.

We will present results from fully nonlinear covariant transport theory for the phase space corrections in an expanding multicomponent gas, and test the validity of Grad's quadratic ansatz and of the "democratic" assumption for sharing viscous effects between species. The findings will be compared to phase space corrections from linear response theory, which is applicable for small gradients and small deviations from local equilibrium. Finally, we will show how dynamical phase space corrections affect basic identified particle observables (spectra and elliptic flow) in the framework of viscous hydrodynamics.

Primary author: MOLNAR, Denes (Purdue University)

Presenter: MOLNAR, Denes (Purdue University)

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