Initial conditions, hadronization and transport coefficients in heavy-ion collisions*

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Introduction

The study of the properties of the Quark-Gluon Plasma (QGP) – formed in heavy-ion collisons – requires to understand how the initial quark and gluon distributions affect the final observables through the expansion and hadronization phases.

Initial conditions

The issue of initial conditions in relativistic heavy-ion collisions is a subject of intensive debate. Especially the assumption of thermal equilibrium after ∼1 fm/c is currently not supported by microscopic transport approaches. In our study we compare the Parton-Hadron-String Dynamics (PHSD) with the novel transport approach RSP (Relativistic quantum molecular dynamics for Strongly interacting matter with Phase transition or crossover) – based on the Nambu–Jona-Lasinio (NJL) model [1] – employing the same initial conditions from PHSD, which have a 'lumpy' energy density profile (see Fig. 1).

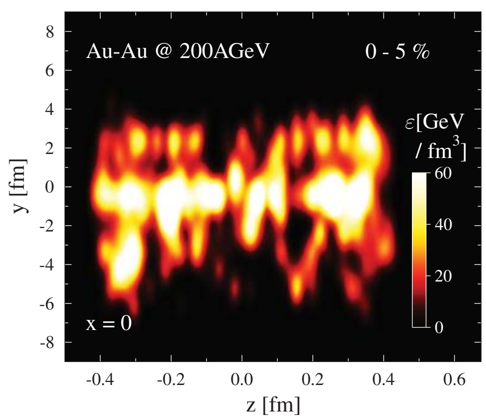

Figure 1: Initial energy density for cells in the local rest frame in the $y - z$ plane.

Comparison

Although we have the same initial energy density profile, the transport properties of bulk partonic matter in RSP and in PHSD are not the same [2]. The main difference between both approaches is that RSP uses light quarks which convert into hadrons using NJL cross sections, and that PHSD uses heavy partons (quarks and gluons) which combine into heavy hadrons with broad spectral functions which then decay into light hadrons.

The comparison of final hadronic observables (Fig. 2) shows that the initial parton distribution must be out of equilibrium in both approches (PHSD/RSP) in order to reproduce the multiplicity spectra dN/dp_T and $dN/d\eta$ and the elliptic flow v_2 for Au+Au at RHIC energies.

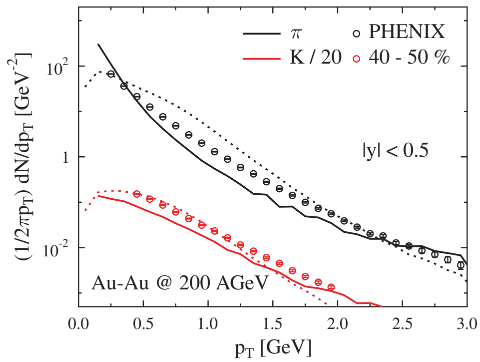

Figure 2: Transverse momentum distribution dN/dp_T of final charged pions and kaons in RSP (full lines) and PHSD (dashed lines).

Out of equilibrium

The conversion of fluid cells from one model to another – both out of equilibrium – keeps the interesting properties of the initial state: the anisotropy in momentum in p_T/p_z, the chemical mixture of species, and the particle density shift (for a given energy density in a cell, the equation of state gives a particle density which is not the one we really have in this cell in the out of equilibrium calculations).

Conclusion

This study shows the importance of non-equilibrium dynamics for the microscopic description of the quark-gluon-plasma created in heavy-ion collisions.

References

[1] R. Marty, J. Aichelin, Phys. Rev. C 87, 034912 (2013)

[2] R. Marty, E. Bratkovskaya, W. Cassing, J. Aichelin and H. Berrehrah, Phys. Rev. C 88, 045204 (2013)

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