3D Hydro + UrQMD Model with QCD Critical Point

Chiho Nonaka[a], **S. A. Bass**[b] and **M. Asakawa**[c]

[a]Department of Physics, Nagoya University,
Nagoya, 464-8602, Japan, *nonaka@hken.phys.nagoya-u.ac.jp*
[b] Department of Physics, Duke University
Durham, NC, 27708, USA, *bass@phy.duke.edu*
[c] Department of Physics, Osaka University
Toyonaka, 560-0043, Japan, *yuki@phys.sci.osaka-u.ac.jp*

Lattice QCD calculations have predicted a critical point for the QCD equation of state where the 1st order phase transition on the phase boundary terminates. However at present its location on the phase diagram is not determined due to the difficulty of performing lattice QCD calculations with finite chemical potential. Therefore experiments and phenomenological quantitative analyses under varying conditions (such as collision energies and system sizes) are indispensable in determining the existence and location of the critical point.
Here, we construct a QCD equation of state with a critical point under the assumption that QCD has the same universality class as the 3d Ising Model. First we determine the singular part of the equation of state in the critical region around the critical point from the 3d Ising Model. Then we map the equation of state of the 3d Ising model onto the QCD phase diagram and match it to the usual QGP (bag model) and hadron (exclude volume model) equations of state [1].
We subsequently utilize a hybrid macro+micro transport model [2] to determine possible experimental signatures of the existence of the critical point in our calculations. This model combines a fully three-dimensional relativistic 3D-hydrodynamics for the QGP phase and phase transition with a microscopic non-equilibrium model for the later hadronic stage. Using an equation of state with a simple 1st order phase transition without a critical point, the hybrid hydro+micro approach has been very successful in describing the dynamics of hot, bulk QCD matter, which has been created in ultra-relativistic heavy ion collisions at RHIC [2]. We will show a detailed comparison between the results of calculations with both equations of state, focusing on reaction dynamics, hadronic freezeout, transverse flow and elliptic flow. In addition we shall explore the location of QCD critical point on the phase diagram via the analyses kinetic freezeout temperature, transverse momentum fluctuation and so on.

References

[1] C. Nonaka, and M. Asakawa, *Phys. Rev. C*, **71**, (2005) 044904.
[2] C. Nonaka and S. A. Bass, *Phys. Rev. C*, **75**, (2007) 014902.