

Hydro+ : Hydrodynamics for the QCD critical point

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The search for the QCD critical point in heavy-ion collision experiments requires dynamical modeling of the bulk evolution of the QCD matter as well as of the fluctuations near the critical point. Critical slowing down means that fluctuations are significantly deviating from equilibrium near the critical point. We generalize hydrodynamics to quasi-equilibrium conditions where the state of the system is characterized by the off-equilibrium magnitude of fluctuations in addition to the usual hydrodynamic variables – conserved densities. We find that the key ingredient of the formalism – the extended entropy taking into account the off-equilibrium fluctuations – is remarkably similar to the 2PI action in quantum field theory. We use the new formalism to demonstrate the major effects of critical fluctuations on the bulk evolution: the strong frequency dependence of the anomalously large bulk viscosity as well as the stiffening of the equation of state with increasing frequency or wave-number.

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