Contribution ID: **609**

Type: **Poster**

Dynamical Thermalization in the Quark-Meson Model

Tuesday, 15 May 2018 19:10 (30 minutes)

Understanding the early out-of-equilibrium dynamics of heavy-ion collisions (HIC) remains one of the biggest theory challenges. So far, there are no first principle calculations for the equilibration process of the quark gluon plasma and the dynamics close to the phase transition. In particular describing the behavior close to the conjectured critical point, where critical slowing down leads to off-equilibrium dynamics, poses difficulties.
Here we study the initial stages of a HIC using a low-energy effective theory of QCD, the quark-meson model, in order to gain insight into the thermalization process. This model manifests a central and physically relevant feature of QCD: chiral symmetry breaking in vacuum and its restoration at finite temperature and density. At the critical endpoint this model is expected to be in the same universality class as QCD and hence a viable model to explore dynamical critical phenomena.
We solve the non-perturbative real-time quantum equations of motions for the quark and meson fields in the two-particle irreducible effective action framework. Similar to a HIC, our system is prepared in a high-energy initial state and suddenly quenched out of equilibrium, evolving towards a thermal final state in the chirally broken phase.
In a first step, we investigate the time-evolution of both bulk and spectral properties of this system, which provides us with insight into the approach of thermalization over time and the properties of the relevant degrees of freedom dominating the real-time dynamics. For the thermal final state, this implies information about the mass spectrum and the thermalization temperature. Finally, the prospects of generalizing the simulations to finite baryon density and the approach to the critical point are discussed.

Content type

Theory

Collaboration

Centralised submission by Collaboration

Presenter name already specified

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Session Classification: Poster Session

Track Classification: Initial state physics and approach to equilibrium