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Isotropization of a longitudinally expanding plasma with the 2PI effective action

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A central question in heavy-ion collisions is how the initial far-from-equilibrium medium evolves and thermalizes. In this work we use the two-particle irreducible (2PI) effective action for the first time to answer this question. This requires including the fast longitudinal expansion that characterizes heavy-ion collisions. Our framework, the 2PI effective action, is non-perturbative and derived directly from the underlying quantum-field theory. It encompasses existing descriptions of the initial stages of heavy-ion collisions, such as classical-statistical field theory and kinetic theory, in different limits, and therefore gives a unified, microscopic picture of the initial stages. In this talk we focus on \(\phi^4\) theory (which shares many features with QCD) in the 2PI framework truncated at three loops. We calculate the evolution of energy density and pressure anisotropy, as well as the momentum distribution of quasiparticles in the medium and their thermal mass. This allows us to see for the first time the onset of isotropization in quantum field theory in a geometric setup relevant for heavy-ion collisions. We address open questions in the field that the 2PI effective action can answer rigorously, such as how strong classical fields become quasiparticles, the role of vacuum fluctuations and the dynamics of soft modes throughout the initial stages.

Category

Theory

Collaboration (if applicable)

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