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Quantifying fluctuation signatures of the QCD critical point using maximum entropy freeze-out

A key question about the QCD phase diagram is whether there is a critical point somewhere on the boundary between the hadron gas and quark-gluon plasma phases, and if so where. Heavy-ion collisions offer a unique opportunity to search for signatures of such a critical point by analyzing event-by-event fluctuations in particle multiplicities. To draw meaningful conclusions from experimental data, a theoretical framework is needed to link QCD thermodynamics with the particle spectra and correlations observed in detectors. The unknown Equation of State (EoS) of QCD near a critical point can be related to the universal Gibbs free energy of the 3D Ising model using four non-universal mapping parameters whose values are determined by the microscopic details of QCD. We use maximum entropy freeze-out of fluctuations to make estimates for the factorial cumulants of proton multiplicities, assuming thermal equilibrium, for a family of EoSs with a 3D Ising-like critical point, varying the microscopic inputs that determine the location and strength of the critical point. We quantify the effect of the non-universal mapping parameters, the distance between the critical point and the freeze-out curve, and the contribution of decay protons on the factorial cumulants of proton multiplicities.

Category

Theory

Collaboration (if applicable)

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