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Real time evolution of non-Gaussian cumulants in the QCD critical regime

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Enhanced near critical fluctuations can be quantified by the variance of the critical field (the Gaussian cumulant), as well as higher non-Gaussian cumulants such as skewness and kurtosis. These non-Gaussian cumulants are accessible through measurements of event-by-event fluctuations of various particle multiplicities. Non-Gaussian event-by-event fluctuations of multiplicities are generically expected to show nonmonotonic behavior in the proximity of the critical point. These expectations are entirely based on the assumption that the soft modes responsible for critical fluctuations are in equilibrium with the medium. However, the expanding medium created in heavy-ion collisions only spends a limited amount of time in the QCD critical regime and it is unlikely the critical modes remain in equilibrium in this duration.

We derive a coupled set of equations that describe the non-equilibrium evolution of cumulants of critical fluctuations for space-time trajectories on the cross-over side of the QCD phase diagram. In particular, novel expressions are obtained for the non-equilibrium evolution of non-Gaussian Skewness and Kurtosis cumulants. Utilizing a simple model of the space-time evolution of a heavyion collision, we demonstrate that, depending on the relaxation rate of critical fluctuations, Skewness and Kurtosis can differ significantly in magnitude as well as in sign from equilibrium expectations. Memory effects are important and shown to persist even for trajectories that skirt the edge of the critical regime. We use phenomenologically motivated parameterizations of freeze-out curves, and of the beam energy dependence of the net baryon chemical potential, to explore the implications of our model study for the critical point search in heavy-ion collisions.

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