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Signals from the critical point in Bjorken fluid dynamics

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A non-monotonic net-proton kurtosis for very central collisions at $\sqrt{s}=200$ GeV has been suggested and may be confirmed by recent BES-II program results advocating the existence of the QCD critical point. Fluctuations at the origin of this peculiar behavior are produced in the highly dynamical environment of ultrarelativistic collisions. Especially, the violent longitudinal expansion and the associated temperature cooling may have a non-trivial impact on how we interpret the experimental data. The in- or out-of equilibrium nature of the fluctuations during this expansion is a crucial question in discriminating between critical contributions and purely dynamical features.

Here, we inspect the diffusive dynamics of the critical net-baryon density fluctuations coupled to energy and momentum fluctuations. Equations are expressed in the Milne coordinates to include the longitudinal Bjorken-type expansion in 1+1D. Fluctuations are connected to critical point physics using a stochastic diffusion equation in which the potential is derived from a free-energy functional including non-linear coupling and fully parametrized by the second a fourth order susceptibilities. The latter come from the 3D Ising model correlation length in the scaling region and lattice QCD calculations at vanishing baryo-chemical potential. We demonstrate the great sensitivity of the second and fourth order cumulants of the net-baryon and energy density fluctuations to the expansion dynamics. Via particlization the net-proton number cumulants are obtained. Special emphasis is put on the dependence on the diffusion length and the freeze-out conditions. The phenomenological consequences of these two parameters are discussed. We study the non-trivial rapidity dependence as a signal for the QCD critical point.

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