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Space-time evolution of critical fluctuations in an expanding system

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The search for the QCD critical point is one of the main topics in high-energy nuclear collisions. There are active studies aiming to find signals of the QCD critical point and the first order phase transition, such as the BES programs at the Relativistic Heavy-Ion Collier (RHIC), and many future experiments such as FAIR, NICA, J-PARC-HI, and HIAF. For detecting the signals of the critical point in these experiments, we need a proper model describing the evolution of the dense QCD matter created in the nuclear collisions. To this end, it is very important to understand dynamical effects of the critical fluctuations on experimental observables.

Critical phenomena associated with the QCD critical point are characterized by the divergent fluctuations of the chiral condensate $\sigma = \langle \bar{q}q \rangle$ and the baryon number density n_B [1,2]. In the idealized case where the system is close to equilibrium, the fluctuations of (non-conserved) chiral condensate σ can be integrated out as a fast mode, and the critical dynamics is governed by fluctuations of the baryon number density and other hydrodynamic modes. However, it is quite non-trivial whether we can ignore the σ mode as the fast mode in the high-energy nuclear collisions because the time-scale separation is unclear there; The σ mode could affect the space-time evolution of the critical dynamics.

In our study, we construct a framework to describe the dynamics of the critical fluctuations including the relaxation time for baryon diffusion current and the coupling of the chiral condensate σ to the baryon density n_B. We apply this to one-dimensionally expanding system with the QCD critical point and investigate the effect of the relaxation time and the mode coupling on the correlation of baryon density n_B as a function of rapidity interval.

[1] H. Fujii and M. Ohtani, Phys. Rev. D 70, 014016 (2004)
[2] D. T. Son and M. A. Stephanov, Phys. Rev. D 70, 056001 (2004)

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