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Dynamics and freeze-out of non-Gaussian fluctuations of hydrodynamic densities

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The traditional Cooper-Frye freeze-out procedure becomes inadequate in heavy ion collisions that pass near a critical point, where fluctuations in the hydrodynamic densities (not just the mean densities) must be passed faithfully from the fluctuating fluid before freeze-out to the fluctuating particles after. Furthermore, the dynamics of the fluctuations must be computed, since because of critical slowing down they will not be able to stay in equilibrium. In recent work [1], some of us introduced an extension to the Cooper-Frye prescription in order to convert not only the averages of the hydrodynamic densities, but also their two-point fluctuations into means and variances, respectively of the particle multiplicities. In this talk, we generalize this prescription for Gaussian cumulants to the more sensitive probes of the critical point, such as the skewness and the kurtosis of particle multiplicities. In an azimuthally symmetric and longitudinally boost invariant scenario [2], we study the evolution of the two, three and four-point fluctuations of the most singular hydrodynamic mode, corresponding to the entropy per baryon as the quark-gluon plasma traverses the phase diagram. We further perform the freeze-out for this numerical simulation of Hydro+ and investigate the dynamical effects of charge conservation and critical slowing down on the cumulants of proton multiplicity. We probe how the strength of critical slowing down, characterized by the proximity of the evolution trajectory to the critical point, and the diffusion rate of the hydrodynamic mode affects the magnitude of the rapidity correlations of proton multiplicity at freeze-out. We conclude by discussing the suppression of the non-Gaussian cumulants of proton multiplicity relative to the equilibrium expectations.

[1]. M. Pradeep, K. Rajagopal, M. Stephanov, and Y. Yin, Phys. Rev. D 106, 036017 (2022), arXiv:2204.00639 [hep-ph]

[2]. Ongoing work

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