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Freezing out critical fluctuations

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We introduce a novel freeze-out procedure connecting the hydrodynamic evolution of a droplet of quark-gluon plasma (QGP) that has, as it expanded and cooled, passed close to a critical point on the QCD phase diagram with the subsequent kinetic description in terms of observable hadrons. The procedure converts out-of-equilibrium critical fluctuations described by extended hydrodynamics, known as Hydro+, into cumulants of hadron multiplicities that can be subsequently measured. We introduce a critical sigma field whose fluctuations cause correlations between observed hadrons due to the couplings of the sigma field to the hadrons. We match the QGP fluctuations obtained via solving the Hydro+ equations describing the evolution of critical fluctuations before freeze-out to the correlations of the sigma field. In turn, these are imprinted onto fluctuations in the multiplicities of hadrons, most importantly protons, after freeze-out via a generalization of the familiar half-a-century-old Cooper-Frye freeze-out prescription which we introduce. This framework allows us to study the effects of critical slowing down and the consequent deviation of the observable predictions from equilibrium expectations quantitatively. We can also quantify the suppression of cumulants due to the conservation of baryon number. We demonstrate the prescription in practice by freezing out the Hydro+ simulation in a simplified azimuthally symmetric and boost invariant background discussed previously.

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