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Renormalization of equation of state by hydrodynamic fluctuations within dynamical model

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Event-by-event fluctuations measured in the heavy-ion observables such as the flow coefficients and their correlations play an important role in extracting the matter properties. While the major origin of the observed flows are the initial fluctuations, other sources of the fluctuations become also important in smaller systems and in the quantitative determination of the matter properties.

Recently, hydrodynamic fluctuations are one of the hot topics as one of the sources of the event-by-event fluctuations. Hydrodynamic fluctuations are the thermal fluctuations of hydrodynamic description and are introduced as random noise fields in hydrodynamic equations, and such a framework is called fluctuating hydrodynamics. In dynamical models, hydrodynamic fluctuations are shown to have a considerable effect on observables, particularly for the longitudinal dynamics [1-3]. However, one issue of the fluctuating hydrodynamic model is that *the hydrodynamic fluctuations shift the bulk properties of the background matter through the non-linear interactions of the fluctuations* [1]. The *bare* equation of state and transport coefficients appearing in the dynamical equations need to be *renormalized* as functions of the cutoff parameter of the hydrodynamic fluctuations so that the overall bulk properties (i.e., long-range behavior) of the matter become cutoff independent.

In this talk, we focus on the renormalization of the equation of state within the dynamical models. We first discuss the general properties of the renormalization of the equation of state and argue that the renormalization becomes important near the crossover or phase-transition temperature. We next reconstruct the bare equation of state from the lattice EoS based on the existing analytical results [4,5]. Such reconstruction is not unique in general, so we obtain the results assuming the existence of a single equation of state which is independent of the background. We examine the obtained equation of state in the dynamical code by calculating static equilibrium and find that the analytical results based on perturbation break down when the cutoff becomes shorter (i.e., higher in momentum space) and the fluctuations become large. We try to numerically improve the bare equation of state using the dynamical code for shorter cutoffs.

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