Equation of state of strongly interacting system using PNJL-HRG hybrid model

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The equation of state of a strongly interacting system under equilibrium conditions form the baseline upon which various possible scenarios in relativistic heavy-ion collision experiments are built. Many of these quantities have been obtained in the lattice QCD framework with reliable continuum extrapolations. Recently the Polyakov−Nambu−Jona-Lasinio model has been reparametrized to some extent to reproduce quantitatively the lattice QCD data. Though the agreement had been encouraging but there seemed to be two remaining issues because of which the agreement was not completely satisfactory. One issue was that the high temperature phase showed certain disagreements, possibly indicating the requirement of the NJL parametrizations. Secondly there were certain disagreements in the low temperature region, possibly due to the absence of effective hadronic degrees of freedom. Here we shall address the latter by introducing an interpolating function that switches between a hadronic model at low temperatures to a partonic model at higher temperatures.

Formalism

The basic procedure is similar to the one reported in [3]. The pressure of the system as taken to be a sum of partial pressures of the hadronic and partonic matter, weighted with a switching function is,

$$P(T) = S(T)P_P(T) + (1 - S(T))P_H(T), \quad (1)$$

where $P_P(T)$ and $P_H(T)$ are the pressures of partonic and hadronic sectors respectively and $S(T)$ is the switching function to interpolate smoothly from 0 at low temperatures to 1 at high temperatures and independent of chemical potential at zero chemical potentials.

$$S(T) = \frac{1}{1 + exp\left[-\dfrac{T - T_S}{\Delta T_S(T)}\right]}. \quad (2)$$

Here T_S and $\Delta T_S(T)$ are parameters

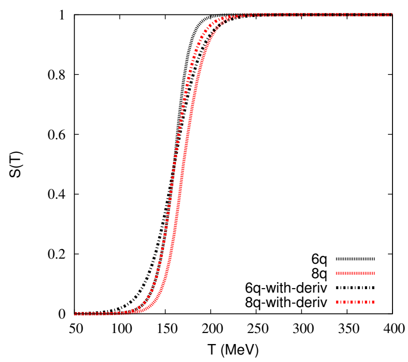

FIG. 1: Switching function as a function of temperature.

whose values should be closely related to the crossover temperature and width of the crossover region respectively. The pressures

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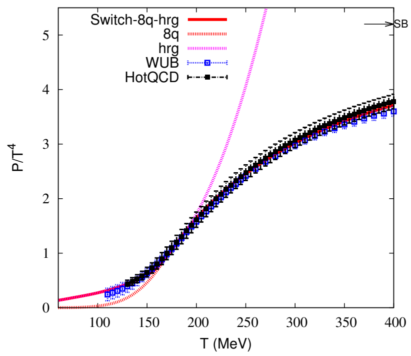

FIG. 2: Scaled pressure as a function of temperature. The continuum lattice QCD data are taken from Ref. [1] (HotQCD) and Ref. [2] (WUB).

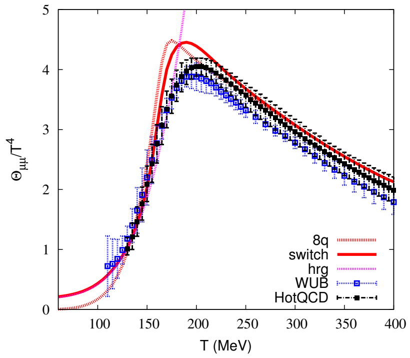

FIG. 3: $\Theta_{\mu\mu}$ plotted as a function of temperature. The continuum lattice QCD data are taken from Ref. [1] (HotQCD) and Ref. [2] (WUB).

for hadronic and partonic parts are obtained respectively from HRG and PNJL models. Once we have the pressure the other thermodynamic quantities like entropy, specific heat etc., are obtained from the temperature derivatives of the hybrid pressure. We however consider the switching function to be defined globally for all the observables considered, so that the effective function should be independent of the observable being measured.

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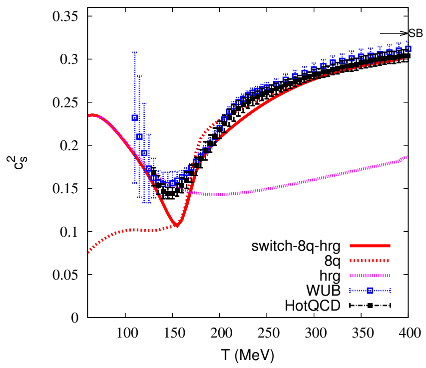

FIG. 4: The squared speed of sound plotted as a function of temperature. The continuum extrapolated lattice QCD data are taken from Ref. [1] (HotQCD) and Ref. [2] (WUB).

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