Equation of state of a strongly interacting system

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Introduction

Exploration of the behavior of strongly interacting matter has always drawn special interest. On the theoretical front, Lattice QCD provides a reliable measure. An equivalent approach is provided by QCD-inspired models. Here we carry out our studies within the framework of one such model viz. the Polyakov-Nambu-Jona-Lasinio (PNJL) model [1]. Latest lattice continuum results [2–4] called for the necessity to reparametrize the model [5] after which the overall consequence though satisfactory was not perfect. The main disagreement was in the low temperature region due to lack of hadronic degrees of freedom. One way to address this issue is to consider a switching function [6] which connects the hadronic phase to a partonic one. In this work however instead of including external switching function, we have considered temperature-dependent lower lying meson masses to provide a suitable description of the lattice QCD equation of state for the whole temperature window of interest.

In the range of $T < T_c$, the pressure is dominated by the hadrons, mainly by lightest mesons in terms of pions, sigma etc. Study of basic thermodynamics from this model necessitates incorporation of temperature-dependent mesonic fluctuations in addition to the mean field result [7].

Formalism and Results

Pressure and other thermodynamic observables can be obtained from the thermodynamic potential in the usual manner [5]. Coming to the lower temperature zone $T < T_c$ (here T_c ∼166MeV), PNJL model under mean-field approximation produces a close to zero pressure quantitatively in contrast to continuum lattice QCD data and HRG predictions which show a non-zero value in this domain. This directly indicates the lack of

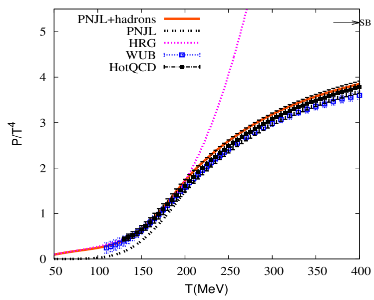

FIG. 1: Pressure plotted as a function of temperature.

*Electronic address: sudipa.09@gmail.com proper hadronic contribution in this model. At this point, it is evident from Fig.(1) that consideration of hadronic degrees of freedom proves to be a good effective way which raises the pressure to a non-zero value giving excellent match with lattice results.

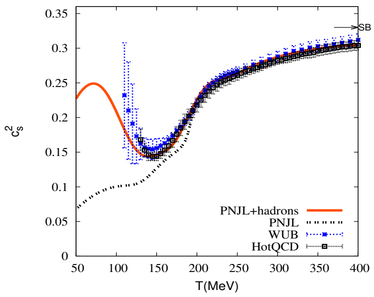

FIG. 2: Speed of sound as a function of temperature.

Speed of sound, c_s^2 on the other hand matches well with the lattice results within errors for the whole temperature domain. Near the conjectured softest point of EoS, c_s^2 shows a desired minima and quantitatively falls well within the lattice errorbars. At this point, we would again like to comment on the importance of incorporation of hadronic degrees of freedom without which we were not being able to get this minima.

Fluctuations are obtained in the usual manner from pressure by reading off the Taylor coefficients. There is quite a difference between PNJL and lattice results for c_2^Q below crossover temperature T_c. This is expected since charge sector has dominant contribution from light hadrons, which are absent in the PNJL model. On inclusion of these hadronic contributions, the results agree with lattice data very well.

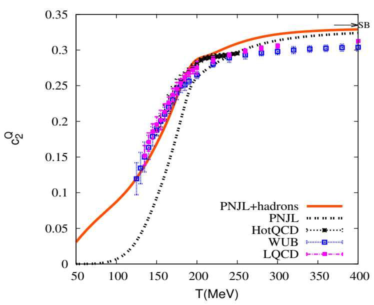

FIG. 3: Charge fluctuation plotted as a function of temperature.

Acknowledgments

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