Combining EVHRG and PNJL model in contrast to continuum LQCD data

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I. INTRODUCTION

Quantum choromodynamics provides a theoretical picture of strong interaction. It is believed that at some moderate temperature and density hadrons are malted to quarks and gluons to form quark gluon plasma(QGP). Study of such phase structure is now important branch of physics. The phase structure requires proper study of QCD which is quite difficult due to its non perturbative nature. Lattice formulation of QCD(LQCD) gives a robust way to understand the thermodynamics of strong interaction. Alternative way to study QCD is provided by effective QCD models. Polyakov loop enhanced Nambu Jona-Lasinio model provides information about QCD at High temperature and density. Whereas hadron resonance gas (HRG) gives quite satisfactory results of hadron yield. LQCD provides a good support to HRG results when we consider the excluded volume effect. Here we are motivated to connect EVHRG at low temperature to PNJL at high temperature through smooth switching.

II. EXCLUDED VOLUME HADRON RESONANCE GAS(EVHRG)

In this model, we include all the particles up to mass 3 GeV. The grand canonical partition function of a hadron resonance gas can be written as $\ln Z = \sum_i \ln Z_i$, where sum is over all the hadrons. In EVHRG model hadronic phase is modeled by a gas of interacting hadrons, where the geometrical size of the hadrons are explicitly incorporated to approximate a short-range repulsive hadron-hadron interaction [1, 2].

III. PNJL MODEL

PNJL model is extended Nambu Jona-lasinio model enhanced by Polyakov loop potential. Gluon dynamics is included through polyakov loop which is a normalized trace of Wilson line. The degrees of freedom of PNJL model are chiral condensates and polyakov loop fields. The form of PNJL model we use here is discussed detail in ref[3, 4].

IV. SWITCHING FUNCTION

To study the smooth switching from hadronic phase to QGP phase, we use a switching function defined in ref[5]

$$S(T) = exp(-(\frac{T}{T_0})^{-r}). \qquad (1)$$

In our calculations we consider $T_0 = 168$ MeV and $r = 6$. The form of switching function is constructed in such a way that it is zero in hadronic phase and smoothing to one in purely QGP phase. Switching function connect the pressure of hadronic phase and QGP

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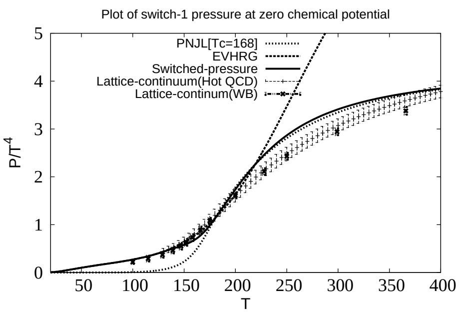

FIG. 1: Variation of pressure with T for $\mu_B = 0$. Solid line define the switched pressure

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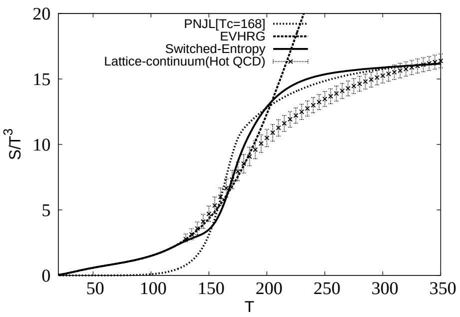

FIG. 2: Variation of entropy density with T for $\mu_B = 0$. Solid line difine the switched entropy

phase by the relation

$$P = S(T)P_{PNJL} + (1 - S(T))P_{EVHRG} \quad (2)$$

We first study smooth switching in free energy then its first order derivative. We are keen to observe the switching of higher order derivatives of free energy.

V. RESULTS

In Fig. 1 we have shown P/T^4 as a function of temperature at $\mu = 0$. We compare our results with recent LQCD continuum data[6]. It can be shown that below $T = 160$ MeV switched pressure coincides with EVHRG result whereas at high temperature ($T > 300MeV$) it coincides with PNJL result. At low T, LQCD data matches quite well with switched pressure. However, in the intermediate temperature our result overestimates LQCD data. At high temperature LQCD data again matches within an errorbar with our result. In Fig. 2 and Fig. 3 we have shown temperature dependence of entropy and energy density.

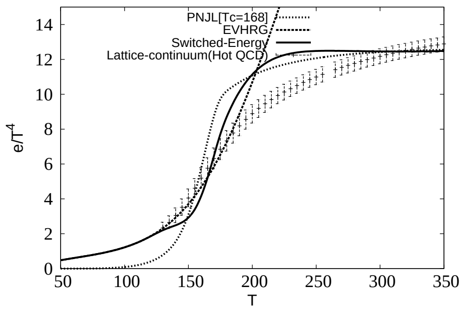

FIG. 3: Variation of energy density with T for $\mu_B = 0$. Solid line define the switched energy

VI. ACKNOWLEDGEMENT

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