Fluctuations and correlations in strongly interacting system from reparametrized Polyakov−Nambu−Jona-Lasinio model

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Fluctuations and correlations of conserved charges in strongly interacting matter under extreme conditions are being actively studied theoretically as well as experimentally. A first principle approach is provided by the finite temperature lattice formulation of quantum chromodynamics (QCD). In this context various QCD inspired models are found to be useful in describing such aspects. In the present article fluctuations and correlations of conserved charges in strongly interacting matter are investigated within the framework of Polyakov loop enhanced Nambu−Jona-Lasinio (PNJL) model [1]. The effective Polyakov loop potential is chosen to be of the form,

$$\frac{\mathcal{U}(\Phi,\bar{\Phi},T)}{T^4} = -\frac{b_2(T)}{2}\bar{\Phi}\Phi - \frac{b_3}{6}(\Phi^3+\bar{\Phi}^3) + \frac{b_4}{4}(\bar{\Phi}\Phi)^2 \quad (1)$$

The coefficient $b_2(T)$ is chosen to have a temperature dependence of the form[2],

$$b_2(T) = a_0 + a_1 exp(-a_2\frac{T}{T_0})\frac{T_0}{T}, \quad (2)$$

and b_3 and b_4 are chosen to be constants.

Fluctuations and correlations of conserved charges are considered important for determining the state of strongly interacting matter at high temperatures and densities [3]. They may also be useful as signatures of a possible phase transition or crossover [4]. The pressure of the system at a given temperature and arbitrary chemical potentials may be expanded as a Taylor series around zero chemical potentials. The coefficients of this series are directly related via fluctuation dissipation theorem [1], to the fluctuations and correlations of conserved charges at various orders. These are related to the experimentally observed fluctuations of baryon number B, electric charge Q etc. The diagonal Taylor coefficients $c_n^X(T)$ ($X = B, Q,$) of n^{th} order in an expansion of the scaled pressure $P(T, \mu_B, \mu_Q/T^4$ may be written in terms of the fluctuations $\chi_n^X(T)$ of the corresponding order as,

$$c_n^X(T) = \frac{1}{n!}\frac{\partial^n(P/T^4)}{\partial(\frac{\mu_X}{T})^n} = \frac{T^{n-4}}{n!}\chi_n^X(T) \quad (3)$$

where the expansion is carried out around $\mu_B = 0 = \mu_Q$. The off-diagonal coefficients $C_{n,m}^{X,Y}(T)$ ($X, Y = B, Q;\ X \neq Y$) in the $(m+n)^{th}$ order in the Taylor expansion are related to the correlations between the conserved charges $\chi_{n,m}^{X,Y}(T)$ as,

$$C_{m,n}^{X,Y} = \frac{1}{m!n!}\frac{\partial^{m+n}(P/T^4)}{(\partial(\frac{\mu_X}{T})^m)(\partial(\frac{\mu_Y}{T})^n)} = \frac{T^{m+n-4}}{m!n!}\chi_{n,m}^{X,Y}(T) \quad (4)$$

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Results

Here we present a comparative study of these quantities with the present parametrization of the PNJL model. The second sus-

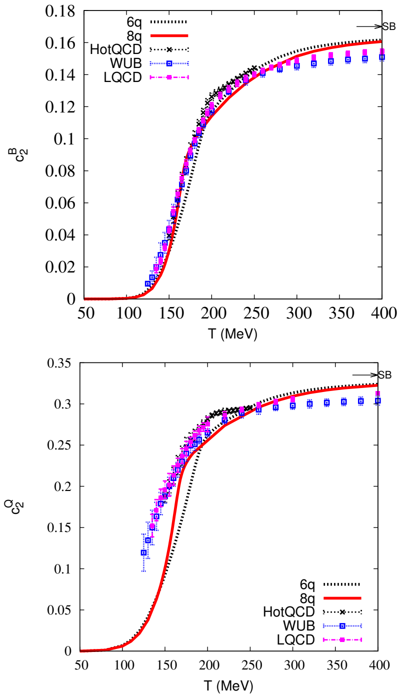

FIG. 1: Variation of c_2^B and c_2^Q as functions of temperature. The continuum extrapolated dataset for c_2^B and c_2^Q of HotQCD and Wuppertal-Budapest (WUB) collaborations are taken respectively from [5] and [6].

ceptibility of the baryon number was again found to be in reasonable quantitative agreement with the lattice data. For the electric charge susceptibility we found some disagreement for $T < T_c$. The disagreement in this region for susceptibility could possibly be due to absence of light hadrons in the present formulation of the PNJL model. Significant disagreement was observed for baryon-charge correlation. This could possibly be due to the difference in the bare strange quark masses used in the PNJL model and the lattice formulations.

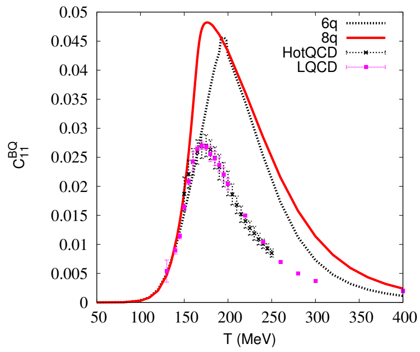

FIG. 2: Leading order correlation coefficients as a function of temperature. HotQCD continuum dataset have been taken from [5].Lattice data from [7] have denoted as LQCD.

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