QGP fireball creation in two loop correction in mean field potential

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Introduction

Matter formation during the early stage of Universe expansion is under the condition of two process viz a phase of deconfined matter of free quarks and gluons to a confined matter of hadrons. It is believed that process is very complicated phenomena as discussed in the present day of heavy-ion collider experiments. The theorist and the experimentalist have examined and searched about the creation of this Universe. They have analysed that very early universe is deconfined phase and subsequent cooling it becomes confined system of hadrons. This deconfined phase is believed to made of free quarks and gluons known as Quark-Gluon Plasma (QGP). For the study of this deconfined phase there are experiments running around the globe. So this study of quark-gluon plasma (QGP) fireball is called as Ultra Relativistic Heavy-Ion Collisions and since its existence it has become a very exciting field in the present day of heavy ion collider physics [1]. In this brief paper, we focus to calculate the QGP fireball creation in a two loop correction in the mean field potential. To calculate the free energy of the system, we modify the mean-field potential of one loop correction with two loop correction factor and construct the density of states (DOS) of particles in the system [2]. Thus the free energy evolution is obtained through this density of state of the constituent particles of quarks and gluons. Due to the correction factor in the mean field potential through coupling value, [3, 4] there are changes in the amplitude of QGP fireball expansion, and it also impacts in the stability of droplet with the variation of dynamical quark and gluon flow parameters, which is used in the construction of DOS.

In brief, we directly calculate the free energy with this corrected density of state with different quark and gluon flow parameter.

The paper is arranged as: In Sec.1 we present introduction. In Sec.2 we describe the free energy with density of state and in Sec.3 we give results and conclusion.

The free energy with two loop correction .

The free energy of the system is sum of the free energy of quarks, gluons,pions and interfacial energy $F_{interface}$. The interfacial energy is considered as bag energy in the system. Therefore, we obtain the free energy of quarks and gluons as [5]

$$F_i = \mp T g_i \int dq \rho_{q,g}(q) \ln(1 \pm e^{-(\sqrt{m_i^2+q^2})/T}) \ , \tag{1}$$

where,

$$\rho_{q,g}(q) = \frac{\nu}{\pi^2}[\frac{\gamma_{q,g}^3 T^2}{2}]^3 g^6(q) A, \tag{2}$$

in which

$$\begin{aligned} A \ &= \ \{1 + \frac{\alpha_s(k) a_1}{\pi} + \frac{\alpha_s^2(k) a_2}{\pi^2}\}^2 \\ &\times \ [\frac{(1 + \alpha_s(k) a_1/\pi + \alpha_s(k)^2 a_2/\pi^2)}{k^4} \\ &+ \ \frac{2(1 + 2\alpha_s(k) a_1/\pi + 3\alpha_s(k)^2 a_2/\pi^2)}{k^2(k^2+\Lambda^2)\ln(1+\frac{k^2}{\Lambda^2})}] \end{aligned} \tag{3}$$

and other symbols are the usual standard parameters [2]. So the total free energies of the system is sum as:

$$F_{total} = \sum_i F_i \ + \ F_{interface} \ + \ F_h, \tag{4}$$

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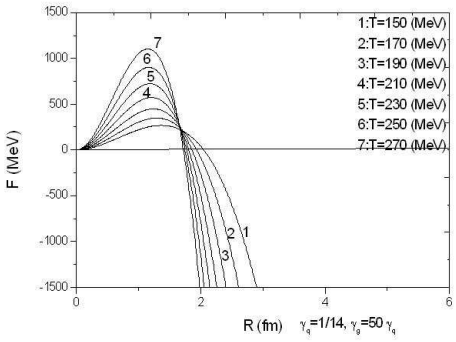

FIG. 1: Free Energy vs R.

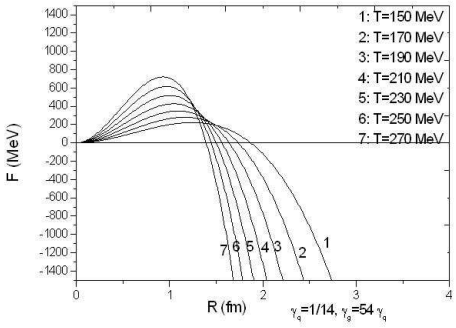

FIG. 2: Free Energy vs R.

where F_h is the standard energy of light hadrons. Now we calculate the free energy of the system. The evolution of the system are obtained from the above relations and they can be analysed from the figures.

Results and conclusions

The results are shown in the figures. We calculate the free energy creation for two particular flow parameters which are used in the creation of free energy fireball. From these particular flow parameters, we can obtain the stability of the droplet formation. The parameter is found to be $\gamma_q = 1/14$ and $45\gamma_q \leq \gamma_g \leq 54\gamma_q$. These parameters are searched as ad-hoc fashion to fit the evolution of QGP fireball. The calculated free energies through the two loop correction in the mean field potential shows the different amplitude in the scale of their evolution size. At the Fig.1, it shows the stability of droplet formation and its stable droplet size is around $R = 1.8$fm whereas the Fig.2 shows instability of droplet with different sizes.

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