Abstract

Understanding the nature of the strong interaction between quarks is very important goal of particle physics. The work of this thesis focuses on the thermal properties of the quarkonium systems (like charmonium $c\bar{c}$, and bottomonium $b\bar{b}$) after deconfinment. The transformation from the hadronic matter to the quark–gluon plasma state is called deconfinement phase transition. The quark-gluon plasma (QGP) is the system of quarks and gluons, which are no longer, confined in the hadrons interiors.

In this work, the internal energy potential $U_1(r, T)$; in which, r is the separation distance between the two quarks and T is the temperature of the quarkonium system; is used to study the properties of these systems after and before deconfinment.

The non-relativistic radial wave equation is solved numerically using the internal energy potential; which is derived from the free energy to calculate the resonance masses of $c\bar{c}$ and $b\bar{b}$ systems at T=0. The calculated masses of $c\bar{c}$ and $b\bar{b}$ systems give good agreement with the experimental data.

The screening term; $e^{-m_D(T).r}$; is added to the quarkonium potential to study its effect at different temperature, where $m_D(T)$ is the Debye screening mass. The behavior of the Debye screening mass, and the running coupling constant are also studied at different number of quark flavors ($n_f = 0, 2, 3$).

The equation of state (EoS) and the energy density of the QGP using the internal energy potential is studied at different quark flavors by using two different theoretical models.

Abstract

Firstly, we have derived the (EoS) of the (QGP) using Mayer's cluster expansion theory; which depends on the entropy and its rate of change. The EoS and the energy density are calculated at different number of quark flavors according this model and a comparison between the theoretical calculations and the lattice results is given.

Secondly, the EoS is derived in the frame work of a phenomenological thermodynamical model, which describes the strongly coupled quark-gluon plasma (SCQGP). The plasma parameter; $\Gamma(T)$; which defined as the ratio of the expectation value of the potential energy to the expectation value of the kinetic energy is determined. A comparison between the calculated EoS and the energy density at different quark flavors with the lattice results is given.

Finally the interaction measure quantity (Δ), which is one of the most important quantities in the studying of the quark gluon plasma phase transition is calculated and compared with the lattice results.