Hot nuclear matter in strong magnetic field

Manu Kurian[1] and Vinod Chandra[2]

Indian Institute of Technology Gandhinagar, Gandhinagar-382355, Gujarat, India

September 6, 2017

[1]manu.kurian@iitgn.ac.in
[2]vchandra@iitgn.ac.in

Introduction

The prime focus is to understand the impact of strong magnetic field created in relativistic heavy-ion collisions to the hot QCD thermodynamics. Furthermore, setting up and effective kinetic theory in the presence of the magnetic field with appropriate particle distributions and non-trivial dispersions would be another interesting direction where the prime interest lies. As implications, computation of various transport coefficients in this set-up will be a matter of immediate future work.

Quark-gluon plasma is theoretically and experimentally studied in heavy ion collisions. During off-central heavy ion collision, magnetic field reaches $eB \sim m_\pi^2 - 15m_\pi^2$. Several phenomena like magnetic catalysis, chiral magnetic effect, occurred in quark gluon plasma in presence of magnetic field. In early cosmological stages $eB \sim 1$ GeV^2, magnetic fields may have affected many process that occurred in early universe. The changes in QCD thermodynamics by strong magnetic field are entering through two different aspects. One aspect is the propagator modification, in which magnetic field effects are absorbed by the propagator. In presence of strong magnetic field, the vacuum quark propagator gets modified. From this effective quark propagator , so called Schwinger propagator, and the gluonic propagator, one can study the changes in the QCD thermodynamics in strong magnetic field. The second aspect, *viz*, incorporating strong magnetic field effects in the distribution function.

Hot QCD thermodynamics in strong magnetic field

The presence of magnetic field change the QCD thermodynamics and thereby the transport coefficients like electrical conductivity, viscosity etc. Quasiparticle models are quite useful in the study of transport properties of quark gluon plasma. In quasiparticle model the system of interacting massless particles can be considered as the non interacting / weakly interacting particles either with effective fugacity or with effective mass. The latter includes effective mass models with Polyakov loop, effective mass models, models based on NJL and PNJL. The effective quasiparticle model EQPM interpreted QCD EOS as the non interacting quasigluons/quasiquarks (quasipartons) with an effective fugacities (quasigluon and quasiquark fugacities, $z_{\ g}$ and $z_{\ q}$ respectively), which encodes all the interactions.

$$f_{g/q} = \frac{z_{g/q} \exp\left(-\beta E_p\right)}{1 \mp z_{g/q} \exp\left(-\beta E_p\right)} \tag{1}$$

with the dispersion relation

$$\omega_{g/q}^2 = E_{g/q} + T^2 \partial_T ln(z_{g/q}) \tag{2}$$

where $\omega_{g/q}$ is the single particle energy of the quasipartons. We extend the EQPM in strong magnetic field background and observe QCD thermodynamics within this model. Relevance of this model is the description of equation of state dependence (EoS) in the thermodynamic quantities. Here, we plotted the variation of energy density for a temperature range in strong magnetic field background. Similarly we estimate other thermodynamic quantities in strong magnetic field for different equation of state. We are focusing on the recent (2+1)flavor lattice QCD EoS (LEoS) and 3 - loop HTL perturbative (HTLpt) EOS. The 3 - loop HTLpt EOS has been recently computed by N. Haque $et, al.$ which is very close to the recent lattice results. Velocity of sound is one of the fundamental property of hot dense medium. At very high temperature, we observe the velocity of sound reaches the Stefan - Boltzman limit 1/3 in presence of magnetic field for different equation of state. We compare our findings with those results in Phys.Rev.Lett. work by L.Levkova and C.DeTar. They studied the effects of an external magnetic field on the equation of state og