Title of the Ph.D. Thesis : Relativistic Nucleus-Nucleus Collisions and the Formation of Quark Gluon Plasma

Name of the Candidate : Waseem Bashir

Student Id. : 20080765

Name of the Supervisor : Prof. Saeed Uddin
Department of Physics
Jamia Millia Islamia
New Delhi-110025

SUMMARY

The Research work carried in this Ph.D. Thesis confronts the problem of quark-hadron phase transition. The emphasis is on understanding the dynamics of the quark gluon plasma (QGP) phase and the strongly interacting hadronic phase on the basis of a fundamental theory of strong interactions, Quantum chromodynamics (QCD). Further using this description for these two phases one would like to comment on the nature of phase transition and on the non equilibrium properties of strongly interacting dynamical fluid at the point of phase transition, the determination of which has become the core of the various experimentation's carried out at CERN, BNL, RHIC etc. Keeping into account the nature of both phases which comprise of strongly interacting matter, the description of such phases on the basis of QCD is far from trivial. This is mainly due to the reason that the quantum field theoretical analysis based on perturbative methods cannot be applied to such strongly interacting systems and therefore one has to look for alternate methods. Among the most common being the model based studies and effective field theoretical studies. However because of the well known advantages of effective field theoretical description over model based study, we try to formulate both of these strongly interacting phases and the associated phase transition from QGP phase to the Hadronic phase in terms of an effective field theory. Continuing with this thought we proceed as follows. First we develop an equation of state for the strongly interacting hadronic matter. This we achieve in relativistic field theoretical model under the mean field approximation. For the QGP phase a description using the Bag model for

interacting matter, composed of three quark flavors and the gluons was used. Using these descriptions the quark hadron phase transition diagram was studied. However the above description for the hadronic phase was achieved for the point like hadrons, as the geometrical size of these particles was totally neglected. But in certain model based studies of strongly interacting hadronic matter, for example hadronic resonance gas (HRG) models etc, it was shown that the geometrical size of the hadrons play an important role in determining the characteristic features of this phase. Therefore we modified the equation of state for the hadronic phase to take into account the finite size of hadrons. This was achieved in a thermodynamically consistent manner. This modification was achieved after realizing the fact that the thermodynamical variables for a system with two point interactions can be written in a form similar to those derived using field theoretical analysis. This modified equation of state for the hadronic phase together with the equation of state for the QGP phase, were used to study the QCD phase diagram. In particular the effect on the location of QCD critical point was studied. However all these calculations were performed in the mean-field approximation, which only serve as a first approximation to the entire calculation. But at higher temperatures all these higher order calculations (fluctuations) become very important in the description of the properties of the hadronic medium, particularly close to the point of phase transition, as the correlation length for a given system diverges close to the transition point.

To study the effect of such fluctuations on the properties of strongly interacting matter, we chose to calculate scaling behaviour of the transport co-coefficient's of the quasi-particle medium close to the QCD phase transition, which is in the same universality class as that of O(4) magnet. In particular we calculated the scaling behaviour of bulk viscosity. Near the transition region the bulk viscosity was found to be non-divergent. The presence of soft modes, Gold-stone modes in the medium were found to have no effect on the nature of this scaling.