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Title of the Thesis: Dynamics of Heavy-Ion Collisions in Thermal Model Approach

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Abstract

The thesis entitled "Dynamics of Heavy-Ion Collisions in Thermal Model Approach" is divided into six chapters. The highlights of each chapter are presented below

Chapter 1 provides a brief introduction of historical background of elementary particles and the standard model which governs these particles and their fundamental interactions. The theory of strong interactions called Quantum Chromodynamics (QCD) and its important properties i.e. quark-confinement and asymptotic freedom have been briefly discussed. The possible formation of a new novel state of matter during relativistic nuclear collisions dubbed as quark gluon plasma (QGP) under extreme conditions of temperature and baryon density have been discussed briefly. Thermodynamics plays a vital role in dealing with nuclear matter & the ensemble theory in thermodynamics has been used here to obtain the various thermodynamic observables through which thermodynamic properties of the system is described well. The introduction to kinematical variables, the particle production process through thermal model and the thermal yield has been elaborated briefly.

Chapter 2 uses a unified statistical thermal freeze-out model of multi-particle production at various RHIC energies. The model incorporates the rapidity (collision) axis as well as transverse direction boosts developed within an expanding dense fire-ball. We have successfully re-produced the chemical potential dependence of various identified particle ratios at mid-rapidity in heavy-ion collisions ranging from SPS to LHC i.e, $\sqrt{S}$ = 9.2 GeV (SPS), 62.4 GeV (RHIC), 130.0 GeV (RHIC), 200.0 GeV (RHIC) and 2.76 TeV (LHC) respectively. The overall good agreement and the experimental data suggested the claim

that the thermal model gives a satisfactory description of the data. Moreover, it is also observed that the extracted value of the chemical freeze-out temperature is found close to the lattice QCD-predicted transition temperature, which in turn indicates that the chemical freeze-out occurs around the phase boundary shortly after hadronization.

Chapter 3 discusses the two flavour as well as three flavour Nambu-Jona-Lasinio (NJL) model for light quarks. We have successfully obtained the temperature as well as chemical potential dependent masses (dynamic masses) of quarks by taking iso-spin symmetry of two light quarks into account. Thus, the dynamic mass of nucleons is achieved and hence the various thermodynamic properties of the system are described. These results are compared with the properties of the system where finite size effects of nucleons are considered. A good comparison is seen between the two results. Moreover, the chiral condensate of two flavour model is obtained, which shows a rapid cross-over i.e. spontaneous symmetry breaking from hadronic matter to QGP matter. It serves as an order parameter i.e. in hadronic phase it is non-vanishing while as in QGP phase it vanishes where chiral limit of quarks is reached.

Chapter 4 deals with the properties of hot and dense matter, we make an attempt to analyse the properties of particle ratios like $\frac{K^+}{\pi^+}$, $\frac{K^-}{\pi^-}$ and $\frac{\Lambda}{\pi^-}$ for this matter and we also employ here the strangeness conservation criteria. It is observed that these theoretical results agree well with the experimental results for a specific range of centre of mass energies.

Chapter 5 elucidates the evaluation of the effect of spontaneous symmetry breaking on the transport properties of strongly interacting fermionic matter near QCD phase transition. To evaluate the behaviour of these transport coefficients near QCD phase transition region we make use of scaling analysis. It is found that the Nambu-Goldstone modes can result in singular behaviour of bulk viscosity to entropy ratio ζ/s along O(4) transition line and for Z(2) Universality class.

Chapter 6 lists the conclusions and overall summary of the work