Synopsis

Lattice quantum chromo dynamics (lQCD) based calculations predict that at very high temperature, and densities the hadronic matter undergoes a phase transition to a new state of matter called quark gluon plasma (QGP) due to asymptotic freedom and Debye screening of color charges. QGP is a thermodynamic state of matter where the properties of the system is governed by quarks and gluons. It is expected that the magnitude of temperature and/or density required for QGP-hadron transition can be achieved by colliding heavy nuclei at relativistic energies (such as at SPS, RHIC and LHC energies). Because of the transient nature of the matter produced at relativistic nuclear collisions it is very difficult to confirm the formation of QGP. Electromagnetic (EM) probes, such as photon and dilepton spectra, have been proposed as one of the most promising tools to characterize the initial state of the collisions. Because of the very nature of their interactions, photons and dileptons suffer minimum rescattering but produced at every space time points, therefore, can be used as an efficient tool to extract the initial temperature of the system. By comparing the initial temperature and the transition temperature estimated from lattice QCD, one can infer whether QGP is formed or not. In the present work we study the EM probes emanating from the system formed in nuclear collisions at SPS, RHIC and LHC energies. The spectra of photons and dileptons have been studied considering an extensive set of partonic and hadronic interactions within the framework of thermal field theory. The space time evolution of the matter is studied using boost invariant relativistic hydrodynamic model. The theoretical results on the photon and dilepton spectra have been compared with experimental data obtained by PHENIX and NA60 collaboration (respectively for RHIC
and SPS energies). The transverse momentum ($p_T$) spectra of photons, dileptons and their ratios for various lepton pair mass bins have been evaluated and shown that a less model dependent information of the initial temperature of the system can be extracted from the ratio. We study the evolution of radial flow $v_r$ using both photon and dilepton spectra and argue that $v_r$ can be quantified from the simultaneous measurements of photons and lepton pairs with a judicious choice of kinematic variables.

Production of strangeness in heavy ion collisions has also been studied to detect the QGP expected to be formed in nuclear collisions. For the production of strange mesons and baryons a microscopic calculation has been employed using momentum integrated Boltzmann transport equation. The results have been compared with the experimental data for $K/\pi$ ratio obtained by CERES, NA49, STAR, PHENIX collaborations at AGS, SPS and RHIC energies. The ‘horn’ like structure observed in the measurement of $K^+/\pi^+$ ratio with different center of mass energies ($\sqrt{s_{NN}}$) has been explained with the assumption of an initial partonic phase beyond a threshold in center of mass energy. However an initial hadronic scenario fails to explain the data at higher center mass energies. $K^-/\pi^-$ data also have been explained within the same formalism.