Radiation from mini bang

Sanjay K. Ghosh

According to conventional wisdom, the universe after the big bang must have gone through several phase transitions in quick succession. At a primordial epoch, a few microseconds after the big bang, according to the standard model, the universe must have consisted of quarks, gluons, leptons and photons. The universe, after cooling as it expands through space and time, made a phase transition at the critical temperature (T_c ~ 190 MeV) from quarks and gluons to hadrons, starting off the process of creation in right earnest.

Is it possible to mimic that primordial event in a laboratory? It is believed by now that physicists can create a similar plasma of quarks and gluons (QGP) by colliding two nuclei at ultra relativistic energy (mini bang). Unlike the big bang scenario (typical timescale ~10^{-5} s), the life time of QGP, created in the laboratory is short-lived; typical time is of the order of ~10^{-22} s. Among many other possible signals of QGP in the laboratory, Sinha (Variable Energy Cyclotron Centre and Saha Institute of Nuclear Physics, Kolkata) and his collaborators have been pursuing the possibility of detecting photons and lepton pairs, as thermal signals of QGP[1]. They have argued that out of annihilation of quark and anti-quark and quark gluon Compton scattering, thermal photons and lepton pairs from the first process can be excellent signals of QGP.

Recent experimental results[2] from the PHENIX collaboration studying gold–gold collision at centre of mass energy 200 GeV per nucleon at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, have been analysed by Sinha and his collaborators[3].

The data can be reproduced (Figure 1) by assuming a deconfined state of quarks and gluons with initial temperature of 400 MeV. Relativistic hydrodynamics has been used for the evolution of the matter formed after the collisions of gold nuclei. According to the lattice Quantum Chromodynamics (QCD), the temperature required for the formation of QGP is 190 MeV. Comparing the initial temperature obtained from their analysis with the lattice QCD prediction, one might conclude that the baby universe has been created in these collisions. The extracted average temperature from photon spectrum is found to be 265 MeV for the transverse momentum range 1.25 to 2.25 GeV, where thermal contributions dominate. When the flow effect is subtracted out from the average temperature, the 'true' temperature is found to be 215 MeV. The initial temperature must be more than 215 MeV because the thermal photon spectrum is a superposition of emission rates for all the temperatures from initial to final state of freeze-out. All these indicate that the temperature of the system formed after the collisions is higher than that required to create a mini bang in the laboratory, i.e. to form a system mimicking the microsecond old baby universe. Thus it is felt that the thermal photons[2] are a clear unambiguous signal of the formation of QGP.

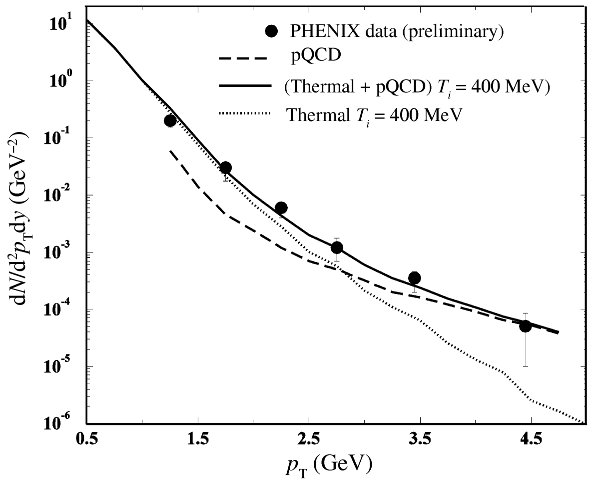

Figure 1. Direct photon spectra at RHIC energies measured by PHENIX collaboration. Solid line depicts total (pQCD + thermal) photon yield obtained from QGP state with initial temperature of ~ 400 MeV.

1. Alam, J., Raha, S. and Sinha, B., *Phys. Rep.*, 1996, **273**, 243–362.
2. Buesching, H., In 18th International Conference on Ultra Relativistic Nucleus – Nucleus Collisions, Budapest, Hungary, 4–9 August 2005.
3. Alam, J., Nayak, J. K., Roy, P., Dutt-Mazumder, A. K. and Sinha, B., arXiv: nucl-th/0508043.

Sanjay K. Ghosh is in the Department of Physics, Bose Institute, 93/1 A. P. C. Road, Kolkata 700 009, India.
e-mail: sanjay@bosemain.boseinst.ac.in