Flow from Electromagnetic radiation

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The hot and dense matter expected to be formed in the partonic phase after ultra-relativistic heavy ion collisions dynamically evolve in space and time due to high internal pressure. Consequently the system cools and reverts back to hadronic matter from the partonic phase. Just after the formation, the entire energy of the system is thermal in nature and with progress of time some part of the thermal energy gets converted to the collective (flow) energy. In other words, during the expansion stage the total energy of the system is shared by the thermal as well as the collective degrees of freedom. The electromagnetic (EM) probes, i.e., real and virtual photons (dileptons), constitute a privilege class of probes, since they are subjected to EM interaction and are not distorted by final state interaction in a strongly coupled medium. Hence once produced travel unscathed carrying information from each space-time point of interior of the hot and dense fireball created in ultra relativistic heavy-ion collisions. The study of evolution of flow by using EM probes will be very useful to determine the equation of state of the evolving matter. The analysis of flow from transverse momentum spectra of photon and dilepton have special importance, since they shed light on the evolution of collectivity unlike the hadrons which only give information of collectivity at freeze out surface.

An attempt has been made to extract the evolution of radial flow from the analysis of the experimental data on electromagnetic probes measured at SPS-CERN and RHIC-BNL energies. We use the ratio (R_{em}) of photon to dilepton transverse spectra to extract the flow [1, 2], where some model dependence are canceled out.

The R_{em} for different M windows can be parametrized as follows:

$$R_{em} = A\left(\frac{M_T}{p_T}\right)^B \exp\left(\frac{M_T - p_T}{T_{eff}}\right) \quad (1)$$

with different values of T_{eff} for different invariant mass windows. The argument of the exponential in Eq. 1 can be written as [2];

$$\frac{M_T - p_T}{T_{eff}} = \frac{M_T}{T_{eff2}} - \frac{p_T}{T_{eff1}} \quad (2)$$

where, $M_T = \sqrt{P_T^2 + M^2}$ is the transverse mass, $T_{eff1} = T_{av}\sqrt{\frac{1+v_r}{1-v_r}}$ is the blue shifted effective temperature for massless photons and $T_{eff2} = T_{av} + Mv_r^2$, is the effective temperature for massive dileptons. T_{av} is the average temperature and v_r is the average radial flow of the system. For a given p_T and M Eq. 2 can be written as $v_r = f(T_{av})$. The average flow velocity v_r versus T_{av} have been displayed for M=0.75 GeV and 1.2 GeV in

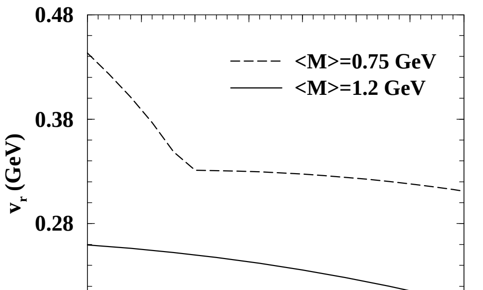

FIG. 1: The variation of radial flow velocity with average temperature of the system for $\langle M\rangle$= 0.75 GeV and 1.2 GeV at SPS energy.

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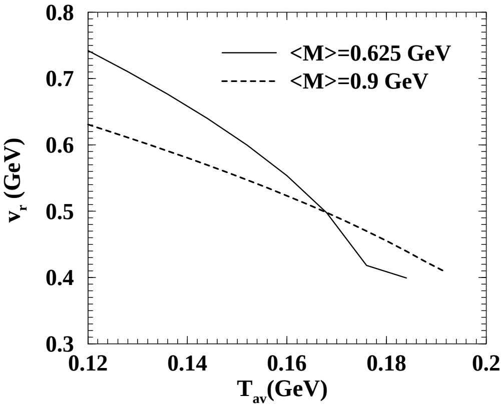

FIG. 2: The variation of radial flow velocity with average temperature of the system for $\langle M \rangle = 0.625$ GeV and 0.9 GeV at RHIC energy.

Fig. 1 for SPS . The variation of v_r with T_{av} is plotted in Fig. 2 for M=0.625 GeV and M=0.9 GeV for RHIC initial conditions.

Obtaining T_{eff1} and T_{eff2} from the individual spectra and eliminating $T_{\rm av}$ one gets the variation of v_r with M(Fig. 3). The radial flow velocity increases with M up to $M = M_\rho$ then drops. The value of v_r for M below and above the ρ-peak is small but around the ρ peak is large - with the resulting behaviour displayed in Fig. 3. The variation of v_r with M in RHIC (Fig. 3 right panel) is similar to SPS, though the values of v_r at RHIC is larger than that of SPS as expected due to higher initial pressure.

In summary the photon and dilepton spectra measured at SPS and RHIC energies by different experimental collaborations have been studied. The initial conditions have been constrained to reproduce the measured multiplicity in these collisions. The input to the calculation such as the EoS and transition temperature etc. have been taken from lattice QCD calculations. The deviation of the hadronic phase from chemical equilibrium is taken in to account by introducing non-zero chemical potential for each hadronic species. It is shown that simultaneous measurements

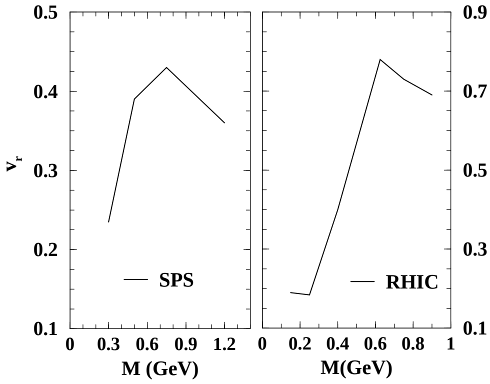

FIG. 3: The variation of radial flow velocity with invariant mass for SPS (left) and RHIC(right) energies.

of photon and dilepton spectra in heavy ion collisions will enable us to quantify the evolution of the average radial flow velocity for the system and the nature of the variation of radial flow with invariant mass indicate the formation of partonic phase at SPS and RHIC energy. Within the ambit of the present analysis we argue that the variation of the radial velocity with invariant mass is indicative of a phase transition from initially produced partons to hadrons at SPS and RHIC energies.

References

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