Two Photon Correlation in Anisotropic Quark-gluon plasma (aQGP).

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1. Introduction

The prime objective of heavy ion collision (HIC) at relativistic energy is to create and explore the properties of novel state of partonic matter, known as Quark Gluon Plasma (QGP). The only way to obtain the space-time structure of HIC is through the study of two-particle momentum correlations, commonly known as Hanbury-Brown-Twiss (HBT) interferometry [1]. Owing to large mean free path compared to the size of the system formed in HIC, the EM radiations travel unscathed from the entire evolution of the fireball without further re-scattering with the surrounding medium and hence can provide information of the history of the evolution of the hot matter created in HIC. Thus the study of two-particle intensity interferometry of electromagnetic (EM) radiations, both photon [2] and dilepton interferometry [3], is more effective as they shed light on the dynamics of the collision from the entire evolution.

The thermalization in the HIC is a debatable issue. Also due to poor knowledge of isotropization and thermalization time scale (τ_{iso} and τ_{therm} respectively), one need not assume the hydrodynamical behavior from the early stage of the collision. In addition to this, the anisotropy arises in momentum space with $\langle p_L^2 \rangle \ll \langle p_T^2 \rangle$ in the local rest frame owing to rapid longitudinal expansion at the onset of QGP phase compared to partonic interaction rate which dies out later with further interactions. Beyond which the system is considered as isotropic and thermal at proper time τ_{iso} and beyond $\tau \geq \tau_{iso}$ the system can be treated hydrodynamically. To include such momentum anisotropy in pre-equilibrium stage of QGP, a simple phenomenological model is adopted from refs. [4]. In accordance with the model, there are two parameters , plasma momentum space anisotropy (ξ) and hard momentum scale (p_{hard}) which take care of the anisotropic effect. We assumed two time scales here; (1) the initial QGP formation time, τ_i, and (ii) the isotropization time, τ_{iso}, where the isotropy in momentum space is achieved and they should fulfill the criteria that $\tau_i \leq \tau_{iso}$. In absence of anisotropy, $\tau_i = \tau_{iso}$.

In this work we have studied photon interferometry with RHIC initial condition at $\sqrt{s_{NN}} = 200$ GeV [5]. Such an analysis helps in understanding the effect of anisotropy on the size of the source. Here we have relaxed the assumption of local isotropy and considered the plasma with local anisotropy in $p_T - p_L$ plane. We have assumed following two sets of initial conditions for the analysis; SET-I: τ_i=0.147 fm/c, T_i= 446 MeV and SET-II: τ_i=0.24 fm/c, T_i= 350 MeV.

2. Definition and Formalism

The Bose-Einstein correlation function (BECF) for two photons with momenta $\vec{k_1}$ and $\vec{k_2}$ is defined as,

$$C_2(\vec{k_1},\vec{k_2}) = 1 + \frac{\int d^4x_1 d^4x_2\ \omega(x_1,K)\omega(x_2,K)\ \cos(\Delta x^\mu \Delta k_\mu)}{P_1(\vec{k_1})P_1(\vec{k_2})} \tag{1}$$

where $P_1(\vec{k}) = \int d^4x\ \ \omega(x,k)$, x_i and k_i are the four co-ordinates for position and momentum variables respectively,

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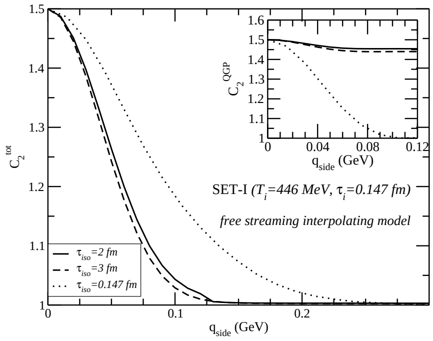

FIG. 1: Correlation function for photon as a function of q_{side} for three values of τ_{iso}(see text for details).

$K = (k_1 + k_2)/2$ is the average transverse momentum, $\Delta k_\mu = k_{1\mu} - k_{2\mu} = q_\mu$, where $\vec{k_i} = (k_{iT} \cos\psi_i, k_{iT} \sin\psi_i, k_{iT} \sinh y_i)$ is the three momentum of the two identical photons with $i = 1, 2$, and $\omega(x_i, K) = E \ dN(x, k)/d^4xd^3k$ is the source function. The inclusion of the spin of the real photon will reduce the value of $C_2 - 1$ by 1/2.

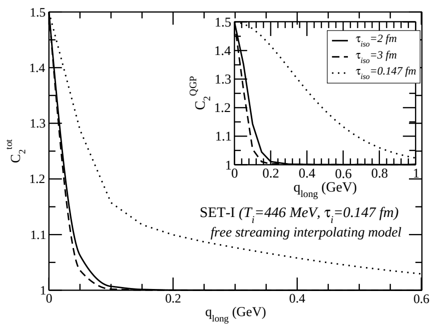

FIG. 2: Correlation function for photon as a function of q_{long} for three values of τ_{iso}(see text for details).

We shall be presenting the results as function of outward (q_{out}), side-ward (q_{side}) and longitudinal (q_{long}) momentum which can be expressed in terms of transverse momentum of individual pair [2, 3, 5]. Here in Fig. [1,2] the variation of C_2 as function of q_{side} and q_{long} is shown for SET-I initial condition only and for three different values of τ_{iso}. The solid and dashed line represents $\tau_{iso} = 2$ and 3 fm respectively and the dotted line is for $\tau_{iso} = \tau_0$ (which corresponds to isotropic scenario).

3. Summary

As photons are considered as penetrating probe, they carry informations from the anisotropic pre-equilibrium QGP. Hence HBT radii extracted from C_2 of identical photons in such a scenario provide us the spatial information of the anisotropic QGP. We have shown that in presence of initial momentum space anisotropy both longitudinal and sideward dimension of the emission zone is reduced considerably. As the out-ward size remains unaltered for initial momentum anisotropy, so it is not shown here.

References

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