Modification of quarkonia production in Pb+Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV

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Introduction

The heavy ion collisions are performed at RHIC and LHC to create the strongly interacting matter at high energy density known as Quark Gluon Plasma (QGP). Several probes are used to study different properties of such matter. Among these probes the quarkonia suppression is considered one of the most important signal of QGP formation in heavy ion collisions. In ref. [1] we have presented the effect of various processes on quarkonia production in Pb+Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV. In that work the gluon dissociation rate has been estimated from Operator Product Expansion (OPE) method in the Coulomb approximation [2]. Recently Chen and He have revisited the gluon dissociation using QCD multipole expansion method [3]. They reproduced the result of ref. [2] as the color-electric dipole (E1) transition and also calculated the Color Magnetic Dipole (CMD-M1) transition. The CMD-M1 contribution is found to be quite significant specially for ground state quarkonia.

In the light of these new results from gluon dissociation we have revisited the quarkonia suppression in PbPb collisions using kinetic model approach. Our model includes dissociation due to thermal gluons (both electric and magnetic parts), shadowing corrections using EPS09 parameterization [4], modification of yield due to collisions with comover hadrons and regeneration by thermal heavy quark pairs. The goal is to obtain the nuclear modification factor of quarkonia as a function of transverse momentum and centrality of collision to be compared with the latest experimental data from LHC Pb+Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV.

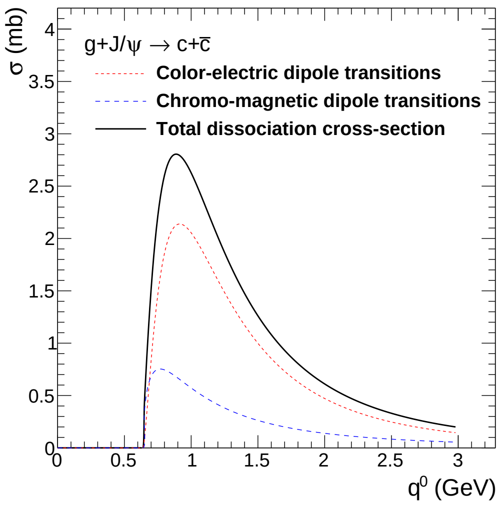

FIG. 1: Gluon dissociation cross section of J/ψ as a function of gluon energy (q^0) in J/ψ rest frame. The total dissociation cross-section is sum of both color-electric and chromo-magnetic dipole transitions.

Quarkonia modification in presence of QGP

In the kinetic equation approach [1] the number of quarkonia at freeze-out time τ_f can be written as

$$N_{QO}(p_T) = S(p_T)\, N_{QO}^{\rm PbPb}(p_T) + N_{QO}^{F}(p_T)$$

Here $N_{QO}^{\rm PbPb}(p_T)$ is the number of initially produced quarkonia per Pb+Pb collision as a function of p_T and $S(p_T)$ is their survival probability from gluon collisions written as

$$S(p_T) = \exp\left(-\int_{\tau_0}^{\tau_f} f(\tau)\lambda_{\rm D}(T,p_T)\,\rho_g(T)\,d\tau\right)$$

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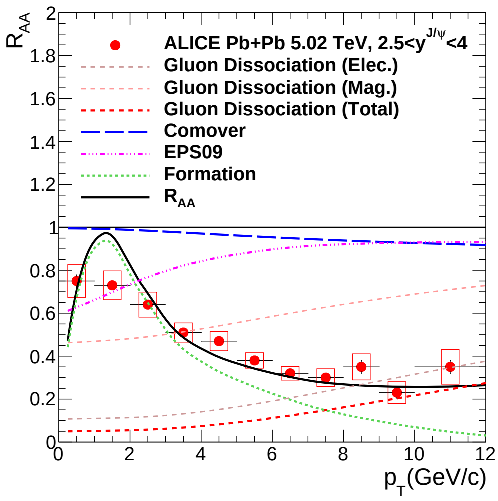

FIG. 2: Calculated nuclear modification factor (R_{AA}) as a function of p_T compared with ALICE measurements in Pb+Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV.

Here λ_D is the dissociation rate obtained by the dissociation cross-section averaged over the momentum distribution of gluons and ρ_g is the density of thermal gluons. The temperature $T(\tau)$ and the QGP fraction $f(\tau)$ evolve from initial time τ_0 to freeze-out time τ_f due to expansion of QGP and $N^F_{QO}(p_T)$ is the number of regenerated quarkonia per event. The nuclear modification factor (R_{AA}) can be written as

$$R_{AA}(p_T) = S(p_T)\, R(p_T) + \frac{N^F_{QO}(p_T)}{N^{pp}_{QO}(p_T)}$$

Here $R(p_T)$ is the shadowing factor. R_{AA} as a function of collision centrality is calculated by integrating over p_T coverage of different experiments. The suppression of quarkonia by comoving pions is calculated by folding the quarkonium-pion dissociation cross section ($\sigma_{\rm I}$) over thermal pion distributions.

Results and discussion

Figure 1 displays gluon dissociation cross section of J/ψ as a function of gluon energy in J/ψ rest frame. The cross-sections are shown for both color-electric and magnetic dipole transitions. The magnetic dipole transition cross-section has similar shape as of electric cross-section and gives significant contribution in low and intermediate gluon energies.

Figure 2 shows different contributions in nuclear modification factor (R_{AA}) of J/ψ as a function of transverse momentum compared with latest ALICE measurements at $\sqrt{s_{\rm NN}}$ = 5.02 TeV [5]. The contributions from electric and magnetic part of gluon dissociation are shown separately. At low p_T, regeneration of J/ψ is the dominant process and this seems to be responsible for the enhancement of J/ψ R_{AA} in the ALICE low p_T data. The gluon suppression is also more at low p_T and it reduces as we move to high p_T. The shadowing corrections are more pronounced at low p_T while comover corrections are small for the whole p_T range covered by the ALICE measurement.

Summary

We estimate the modification of quarkonia yields due to different processes in the medium produced in PbPb collisions at LHC energy. A kinetic model is employed which incorporates quarkonia suppression inside expanding QGP, suppression due to hadronic comovers and regeneration from charm pairs. The model is extended to include dissociation due to magnetic part of gluons. We plan to present the manifestation of all these effects, on both charmonia and bottomonia states, in different kinematic regions accessible at LHC detectors.

References

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