Quarkonia suppression in PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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Introduction

Quantum chromodynamics (QCD) predicts that strongly interacting matter undergoes a phase transition to a deconfined state, often referred to as the quark-gluon plasma (QGP). Charmonia and bottomonia, which are bound states of charm-anticharm ($c\bar{c}$) or bottom-antibottom ($b\bar{b}$) quarks, respectively, are among the most sensitive probes of the characteristics of the QGP [1]. In this paper, we present the J/ψ and Υ production and suppression in a kinetic model which includes dissociation due to thermal gluons, modification of the yields due to shadowing corrections and due to collisions with comovers. Regeneration by thermal heavy quark pairs is also considered in the calculations. We obtain the nuclear modification factor of quarkonia as a function of the transverse momentum and centrality of collision and compare it to the latest experimental data from LHC at $\sqrt{s_{NN}}$ = 5.02 TeV.

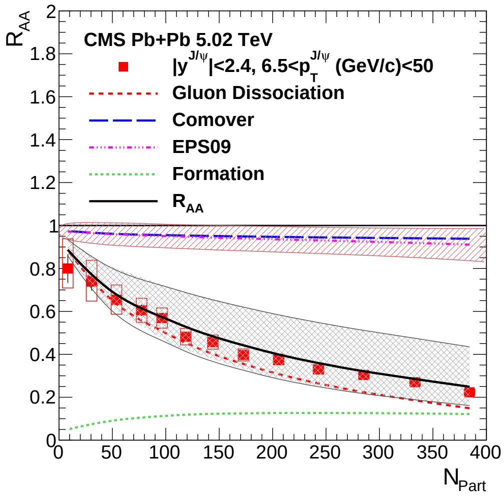

FIG. 1: Calculated nuclear modification factor (R_{AA}) of J/ψ as a function of centrality of collisions, compared with CMS measurements [2].

Modification of quarkonia in the presence of QGP

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

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

Here $N_Q^{\rm PbPb}(p_T, N_{\rm part})$ is the number of initially produced quarkonia in Pb+Pb collision including the shadowing correction and $N_Q^F(p_T)$ is the number of regenerated quarkonia per event. The $S(p_T, N_{\rm part})$ is survival probability of quarkonia from gluon collisions at freeze-out and is given by

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

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 and the QGP fraction $f(\tau)$ evolve from initial time τ_0 to freeze-out time τ_f due to expansion of QGP. The nuclear modification factor (R_{AA}) as a function of p_T can be obtained as

$$R_{AA}(p_T) = \frac{\Sigma_{\rm Centrality}\, N_Q(p_T, N_{\rm part})}{\Sigma_{\rm Centrality}\, N_{\rm coll}\, N_Q^{pp}(p_T)}$$

Here $N_Q^{\rm pp}(p_T)$ is the number of initially produced quarkonia in pp collision, $N_{\rm coll}$ is the number of

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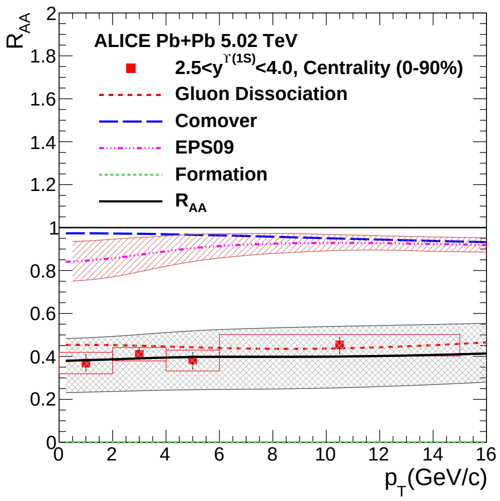

FIG. 2: Calculated nuclear modification factor (R_{AA}) of Υ(1S) as a function of p_T in the kinetic range of ALICE detector at LHC. The calculations are done for the most central 0-20% collisions [3].

nucleon nucleon collisions in PbPb system. The sum over the events is performed over the measured centrality range in the experiment. 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 over thermal pion distributions.

Results and discussion

Figure 1 shows calculations of different contributions to the J/ψ nuclear modification factor as a function of system size, along with the measurements from CMS [2]. The figure shows that the suppression of J/ψ due to QGP increases when the system size grows. The contribution from regeneration process also increases with the system size. The shadowing corrections are included using the EPS09 formalism [4]. The centrality dependence of the R_{AA} of J/ψ is well described by the model.

Figure 2 shows the forward rapidity ALICE measurement of the Υ(1S) nuclear modification factor [3] along with our calculations. The suppression due to thermal gluon dissociation describes the measured data after including the comover and shadowing corrections. The regeneration contribution is very small for the Υ states because the production cross-section of bottom quarks is small even at LHC energies.

The uncertainty band in the calculations is obtained by varying the gluon-quarkonia dissociation cross section and initial time τ_0 around the central value. The uncertainty in the shadowing corrections is not included in the total R_{AA} uncertainty band since these effects are not dominant effects.

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 to extract nuclear modification factors for J/ψ and Υ mesons as a function of centrality and transverse momentum. The feed down contributions from higher bottomonia states are taken in to accounts for the calculations of Υ meson. The nuclear modification factors have been compared to the measurements in PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. We plan to present the manifestation of all these effects, on both charmonia and bottomonia states, in different kinematic regions accessible at LHC detectors.

Acknowledgments

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