*J/*P Production from Relativistic Heavy Ion Collisions

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Suppression of J/ψ production in ultrarelativistic heavy ion collisions is one of the most studied signals for the quark-gluon plasma formed in these collisions [1]. Since the quark-gluon plasma has a finite size, exits for a finite time, and may not be in equilibrium, it is important to study how suppression of J/ψ is affected. We have recently carried out such a study [2] using the AMPT model [3], which includes both initial partonic and final hadronic interactions.

To include the effect of plasma screening, we have determined in the AMPT model a time-dependent critical radius within which the plasma density is higher than the critical density of about $5 fm^{-3}$, estimated from the critical Debye screening mass. A pair of charm-anticharm quark then cannot form a J/ψ if their separation is smaller than the critical radius after a formation time of 0.5 fm/c. In the quark-gluon plasma, a J/ψ may also be destroyed by collisions with gluons with a cross section of about 3 mb [4]. Furthermore, the J/ψ can be absorbed in the hadronic matter following the phase transition of the partonic matter, and the cross section is about 6 mb for absorption by baryons and 3 mb for absorption by mesons [5]. In both partonic and hadronic matters, J/ψ can also be produced from the inverse reactions of charm-anticharm quark and charm-anticharm meson annihilation.

We first obtain from the PYTHIA model [6] a midrapidity density of 1.5 charm-anticharm quark pair and 0.019 J/ψ in central Au+Au collisions at $200 AGeV$. In the partonic phase, the time evolution of the numbers of produced and destroyed J/ψ per unit rapidity as well as the net number of J/ψ per unit rapidity are shown in Fig. 1. The J/ψ number reaches the maximum at about 2 fm/c.

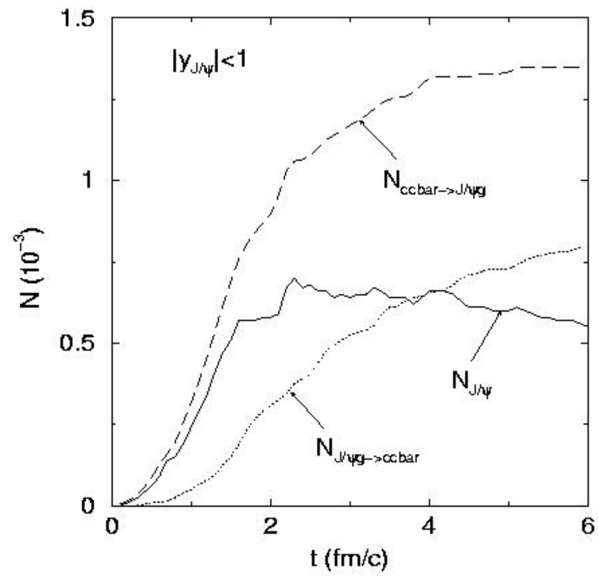

Figure 1: Time evolution of the produced number (dashed line), destroyed number (dotted line), and net number (solid line) per unit rapidity for J/ψ with $|y_{J/\psi}| < 1$ in the parton phase with color screening effect.

In the hadronic stage, the effect of charm mesons are studied by using the three charm meson masses of 1.70, 1.87, and 2.01 GeV to estimate the effects of D and D^* meson as well as the possible change of their masses in hadronic matter. In Fig. 2, we show the time evolution of the numbers of produced and destroyed J/ψ together with that of the net J/ψ number. For all three D meson masses, the number of produced J/ψ is always greater than the number of destroyed J/ψ, leading to a net production of J/ψ from the hadron phase of relativistic heavy ion collisions. The time evolution of the net J/ψ number in the three cases is similar, as it is largely determined by the heavy ion collision dynamics. In all three cases, the J/ψ number saturates at about 15-20 fm/c,

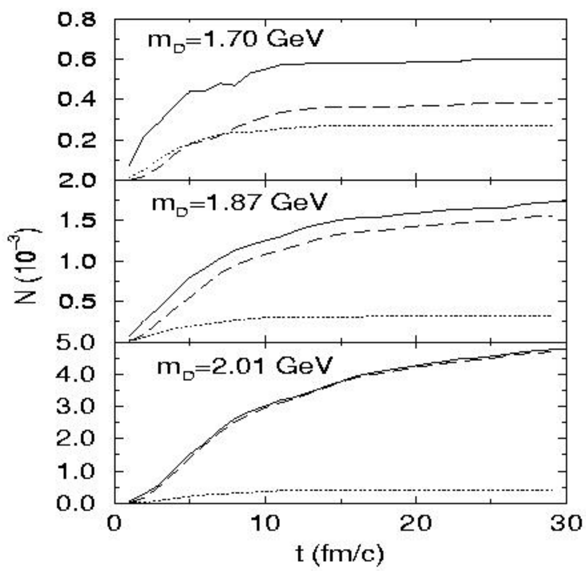

Figure 2: Time evolution of the produced number (dashed line), destroyed number (dotted line), and net number (solid line) per unit rapidity for J/ψ with $|y_{j/\psi}|<1$ for three values of D meson mass. The color screening effect is included in the initial parton phase.

which is about the lifetime of the hadronic matter. Quantitatively, the final net number of J/ψ per unit rapidity averaged over $|y_{J/\psi}|<1$ is about 0.0006 per event for $m_D = 1.70GeV$ and increases to 0.0017 for $m_D = 1.87GeV$ GeV and to 0.0048 for $m_D = 1.70GeV$ GeV. In all cases, the final J/ψ number is smaller than the primary J/ψ number of 0.019. Our study thus predicts a suppression of J/ψ production in heavy ion collisions at RHIC, and this is opposite to the enhancement predicted by the kinetic formation model [7].

To predict quantitatively J/ψ production in heavy ion collisions at RHIC, we need to include the effects due to ψ' and χ_c which are also produced in the initial collisions and can decay to J/ψ. Since these particles are less bound than J/ψ, they are more likely to be dissociated and absorbed in both the quark-gluon plasma and the hadronic matter. As a result, inclusion of ψ' and χ_c is expected to lead to an even larger suppression of J/ψ production than shown here.

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