PHENIX Charmonium Measurement in p+p, d+Au, Au+Au and Cu+Cu collisions

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1 Summary of this talk

Results on the charm quarkonium production in p+p, d+Au, Au+Au and Cu+Cu collisions by PHENIX experiment at Relativistic Heavy Ion Collider (RHIC) are presented.

Charmonium production in A+A collisions is not simple compared to that in p+p collisions. As the initial state effects, J/ψ yield could be modified due to gluon shadowing and/or color glass condensate in the nuclei. Cold matter effect such as nuclear absorption could lead to the suppression of J/ψ yield as observed in lower energy collisions. When the hot and dense medium is created by A+A collisions, where quarks and gluons are deconfined, J/ψ yield could be suppressed due to the color Debye screening effect. Recent lattice QCD calculations show that the suppression of J/ψ and higher charmonium states (χ_c and ψ') would be occurred above $\sim 2\ T_c$ and $\sim 1.1\ T_c$, respectively.

On the other hand, recent theoretical predictions show that the J/ψ yield would be enhanced due to the recombination of uncorrelated $c\bar{c}$ pairs created at the initial stage of collisions at RHIC energies.

Therefore, to understand the J/ψ production in A+A collisions, it is very important to study J/ψ production in different collision systems and rapidity ranges.

PHENIX measured J/ψ yield in p+p, d+Au, Au+Au and Cu+Cu collisions at forward-rapidity ($1.2 < |\eta| < 2.2$) using $\mu^+\mu^-$ decay channel and mid-rapidity ($|\eta| < 0.35$) using e^+e^- decay channel to understand the J/ψ production at each stage of collisions.

From the J/ψ measurements in d+Au collisions, nuclear absorption cross section was found to be from 1 mb to 3 mb, which is smaller compared to that at SPS energies. Gluon shadowing is also weak in small X_{Au} region. The trend of Cronin effect observed by PHENIX is consistent with the results from lower energy experiments. PHENIX d+Au results give a modest baseline for A+A collisions. Further statistics are needed for the study of the cold matter effect.

The J/ψ measurements in Au+Au collisions show that a factor of 3 suppression can be seen at the most central collisions for both forward-rapidity and mid-rapidity. The suppression pattern is same between Au+Au and Cu+Cu collisions at forward-rapidity but not at mid-rapidity. The observed suppression is beyond the cold matter effects evaluated from PHENIX d+Au results. The comparison to the theoretical models show that the suppression is over-predicted by the suppression models which described the J/ψ suppression at SPS energies successfully and that suppression and recombination models can describe the J/ψ suppression at RHIC energies much better. On the other hand, $< p_T^2 >$and rapidity shape of J/ψ cannot clarify the recombination effects due to the current large errors. Since the recombination models assume the charm p_T, rapidity distribution, radial flow and thermalization of charm and do not take into account the longitudinal flow of the medium, charm production in A+A collisions at RHIC energies and its medium modification are needed to be understood. Feed down effect is also important at RHIC energies since melting of χ_c and ψ' can explain J/ψ suppression at SPS energies. Up to mid central collisions, feed down effect can described J/ψ suppression at RHIC energies. To understand the J/ψ suppression at RHIC energies, the production of χ_c and ψ' in different collision systems are also needed to be studied.