Quarkonium Formation from Heavy Quark Recombination

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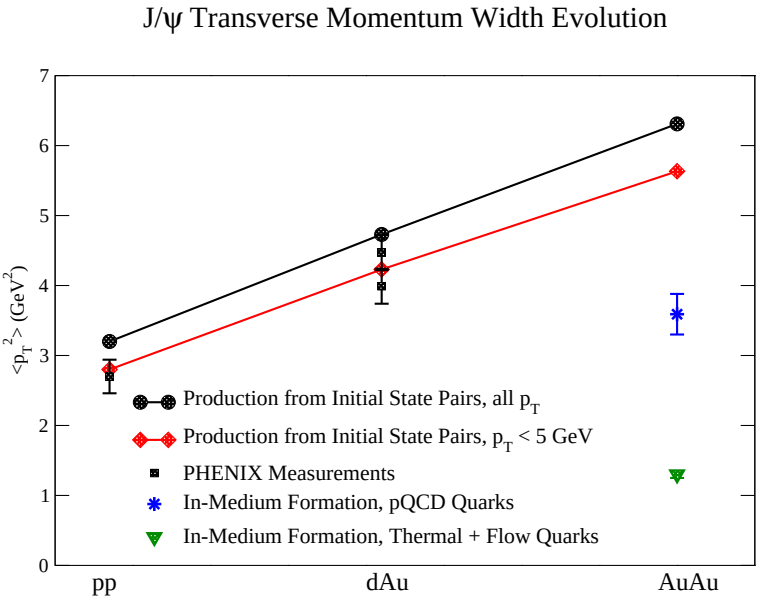
Heavy ion collisions at RHIC energy and above involve the production of multiple charm-anticharm pairs. This opens a new formation mechanism for charmonium states in a region of color-deconfinement. Coupled with the recent realization that deeply-bound states, including the J/ψ, continue to exist in a thermalized medium above the deconfinement temperature, this in-medium formation utilizes one charm and one anticharm quark which originate from different independent hard scatterings. Estimates of the efficiency of such formation suffer from substantial uncertainties at present, due in part to the dependence on the in-medium charm quark momentum distribution. We show that this dependence can be used to advantage, in that the observed momentum distribution of J/ψ formed in the medium will allow a probe of the medium properties through interactions with charm quarks. Model calculations show that the formation momentum spectra retain a memory of the underlying quark distributions.

We consider two different charm quark momentum distributions. At one extreme, we use quark distributions unchanged from initial production in pQCD processes, which would indicate a very weak interaction of charm quarks with the medium. At the other extreme, we use distributions for charm quarks in thermal equilibrium with an expanding medium, which would indicate a very strong interaction of charm quarks with the medium. In the case of distributions determined from pQCD charm production amlitudes, we find that both the rapidity and transverse momentum spectra of the formed heavy quarkonium will be narrower than those expected from $c\bar{c}$ pairs in the absence of a color-deconfined medium. Explicit calculations for J/ψ formation in Au-Au collisions at 200 GeV are performed, using initial data in pp and d-Au interactions to fix some parameters. A striking feature

is the non-monotonic behavior of the transverse momentum spectrum widths in the progression *pp* to pA to AA. This effect is maximum for central AA collisions, and will revert to the "normal" behavior for peripheral collisions. For distributions of thermal charm quarks which flow with the expanding medium, the resulting J/ψ spectra are substantially narrower and retain a form which reflects that of the underlying medium. The normalized spectra appear to be quite robust with respect to variations of the model parameters, in contrast to the overall magnitude of in-medium formation.

In order to extract these properties, it is essential that J/ψ production results are available in both pp and pA interactions. In particular the pp data allows the intrinsic transverse momentum due to confinement effects to be determined. Then the d-Au results lead to the additional nuclear effects on intrinsic transverse momentum which apply for Au-Au interactions. We show the nonmonatonic behavior predicted for formed J/ψ in the figure below.



References

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