Bottomonia in the quark-gluon plasma and their production at RHIC and LHC

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Bound states of bottom and anti-bottom quarks (bottomonia) are valuable probes to investigate the formation and properties of deconfined matter as believed to be formed in ultra-relativistic collision of heavy nuclei. They excellently complement the widely discussed charmonium production [1], due to their different binding energies and smaller bottom-quark production cross sections. The latter presumably imply less contributions from recombination into bottomonia, thus facilitating the study of the Debye screening through a cleaner window on suppression effects.

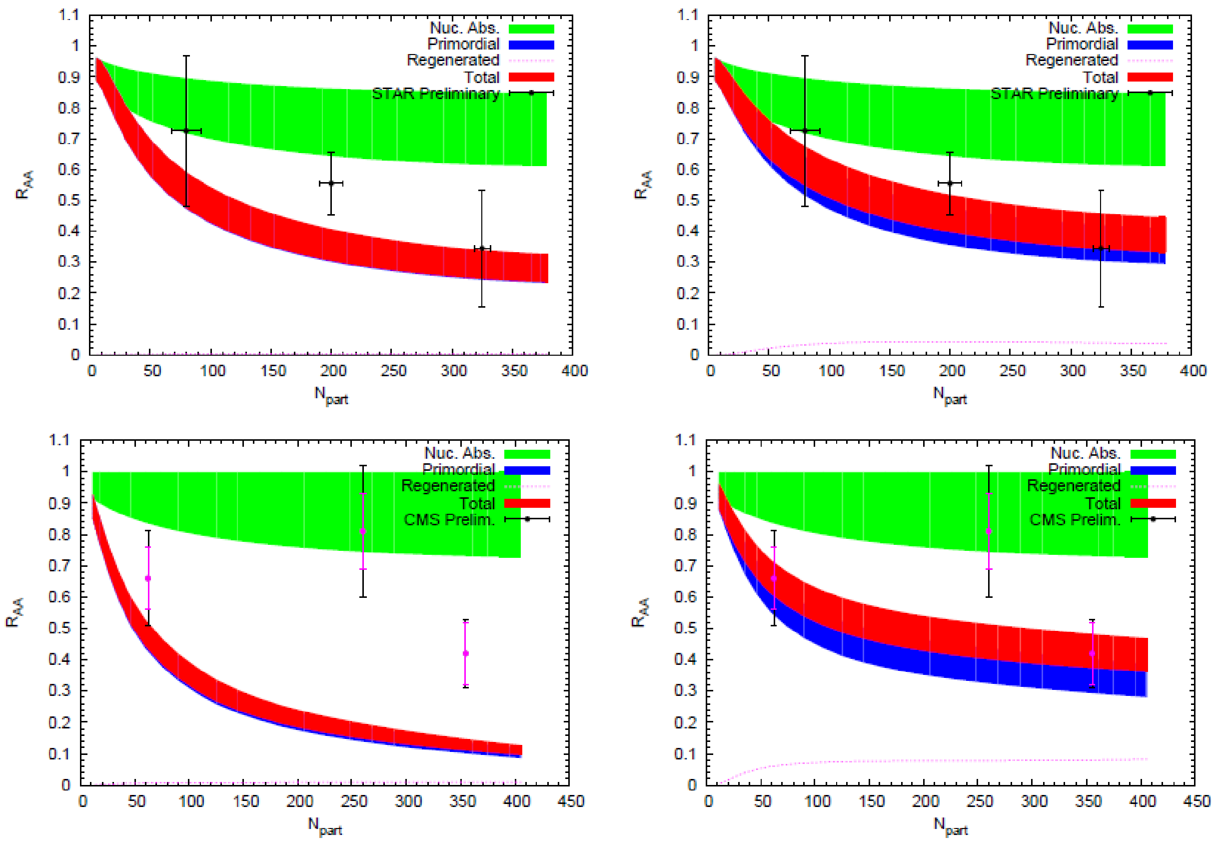

FIG. 1. Centrality dependence of the nuclear modification factor for the combined ϒ(1S+2S+3S) yield in Au-Au at RHIC (upper panels) and for the ϒ(1S) in Pb-Pb at LHC, compared to STAR [5] and CMS [6] data. Left and right panels correspond to the strong- and weak-binding scenarios, respectively. The green bands indicate uncertainties in pre-equilibrium nuclear absorption and shadowing effects.

In the present work [2] we have studied the suppression and regeneration of bottomonia at RHIC and LHC employing our previously developed thermal rate-equation approach for charmonia [3]. Paralleling the latter work, the bottomonium yields are evolved through an expanding thermal fireball model with input cross sections for bottomonia and bottom quarks extracted from existing data in p-p collisions, appropriately extrapolated to the heavy-ion collision energies and centralities under consideration. In addition, the main microscopic ingredients to the bottomonium rate equation, i.e. the inelastic reaction rates and the equilibrium limit, are deduced from spectral functions which are constrained by Euclidean correlator ratios computed in thermal lattice QCD. As in our systematic charmonium studies [3], we evaluate two binding scenarios, i.e. a strong- and a weak-binding one, corresponding to the use of internal and free energies from lattice QCD, respectively, in an underlying potential model [4]. This also determines the prevailing dissociation mechanism as gluo-dissociation and quasi-free destruction, respectively. In Fig. 1 we display our results for the centrality dependence of the combined Υ(1S+2S+3S) yield for Au-Au($\sqrt{s}$=0.2ATeV) at RHIC and for the ground-state Υ(1S) in Pb-Pb(2.76ATeV) at LHC in the two scenarios. The feed-down from the excited states, which are fully evolved through the rate equation as well, is included. We find that the weak-binding scenario appears to induce too much suppression, especially in comparison to the CMS data at the LHC. The strong-binding scenario leads to a more stable Υ(1S) well into the QGP, resulting in a better agreement with the current data. We also note a small but significant contribution from regeneration contributions in the strong-binding case, which becomes even more relevant for the more strongly suppressed excited states. Overall, the preference for the strong binding scenario is reassuring as it also was favored in the analysis of charmonium data [3] as well as in the calculations of heavy-quark diffusion coefficients [4].

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