

Collectivity of J/ψ mesons in heavy-ion collisions

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Quarkonia - bound states of a heavy quark and antiquark - are excellent probes of the in-medium QCD force in ultrarelativistic heavy-ion collisions (URHICs). While bottomonia are increasingly suppressed when the collision energy and centrality rises, the production of J/ψ mesons is significantly enhanced in 5.02 TeV Pb-Pb at the Large Hadron Collider (LHC), relative to 0.2 TeV Au-Au collisions at the Relativistic Heavy-Ion Collider (RHIC). Since the higher energy densities reached at the LHC lead to a stronger suppression of the primordially produced J/ψ mesons relative to RHIC conditions, the enhancement is believed to be caused by a recombination of copiously produced charm and anticharm quarks in the hot QCD medium [1]. The implementation of this mechanism into kinetic transport models enables a comprehensive description of the collision energy and centrality, and momentum dependence of J/ψ observables at SPS, RHIC and the LHC [2,3], and recently also correctly predicted $\psi(2S)$ observables at the LHC.

However, measurements of the elliptic flow (v_2) of J/ψ mesons at the LHC are not well described by existing calculations of J/ψ recombination for transverse momenta $p_T > 4$ GeV. Here, we revisit these calculations in two main aspects [4]. Employing the resonance recombination model (RRM) [5], we implement distribution functions of charm quarks transported through the quark-gluon plasma using state-of-the-art Langevin simulations and account for the space-momentum correlations (SMCs) of the diffusing charm and anti-charm quarks in a hydrodynamically expanding fireball [6]. This extends the relevance of the recombination processes to substantially larger momenta than before. We also revisit the suppression of primordially produced J/ψ 's by propagating them through the same hydrodynamic medium, leading to a marked increase of their v_2 over previous estimates. Combining these developments

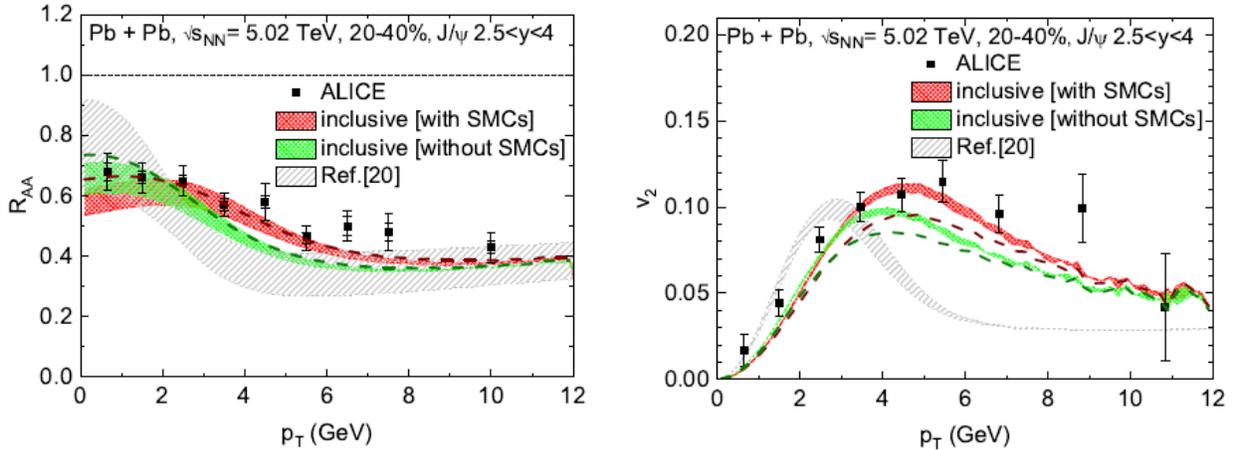


Fig. 1. Inclusive- J/ψ R_{AA} (left) and v_2 (right) in Pb-Pb collisions at the LHC, compared to ALICE data [7]. The red (green) bands employ c -quark spectra in RRM evaluated with(out) SMCs (the widths reflect a 15-25% charm and charmonium shadowing range). The dashed lines are for an earlier production time, with 15% shadowing (brown (dark-green): with(out) SMCs). Inclusive results from previous calculations [1] (grey bands) are shown for comparison.

into a calculation of the p_T -dependent nuclear modification factor (R_{AA}) and v_2 of inclusive J/ψ production in semi-central Pb-Pb collisions at the LHC, we find a good description of the experimental results by the ALICE collaboration [7], see Fig. 1. Our results resolve the above-mentioned v_2 puzzle and imply the relevance of recombination processes for up to $p_T \sim 8$ GeV.

- [1] X. Zhao and R. Rapp, Nucl. Phys. **A859**, 114 (2011).
- [2] R. Rapp and X. Du, Nucl. Phys. **A967**, 216 (2017).
- [3] M. He, H. van Hees, and R. Rapp, Prog. Part. Nucl. Phys (Submitted); e-print arXiv:2204.09299.
- [4] M. He, B. Wu, and R. Rapp, Phys. Rev. Lett. **128**, 162301 (2022).
- [5] L. Ravagli and R. Rapp, Phys. Lett. B **655**, 126 (2007).
- [6] M. He and R. Rapp, Phys. Rev. Lett. **124**, 042301 (2020).
- [7] S. Acharya *et al.* (ALICE Collaboration), J. High Energy Phys. **02**, 041 (2020); J. High Energy Phys. **10**, 141 (2020).