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Quarkonium production and polarization, from elementary to Pb-Pb collisions

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Non-relativistic QCD (NRQCD) is commonly expected to describe the production of heavy quarkonium states in elementary collisions. It has been claimed to provide good descriptions of differential production cross sections of several quarkonia, while failing to reproduce the polarization measurements, a problem often attributed to the unreliability of the measurements. In this presentation we show how the very recent LHC measurements, both cross sections and polarizations, compare to NRQCD. We show that different NLO NRQCD approaches lead to seemingly contradictory conclusions and we offer some thoughts regarding what this surprising observation tells about the validity of the NRQCD framework and about quarkonium production. In particular, we explore the possibility that the long-distance matrix elements (LDMEs) describing the transitions from the colour octet states to the observable states, crucial non-perturbative ingredients of the calculations, might not be universal. In that case, the NRQCD framework remains valid, but hadroproduction and photoproduction data are not described by the same set of matrix elements. This observation, while not being as surprising as one might tend to think at first, triggers intriguing questions on the importance of the surrounding hadronic environment in the production of quarkonium states, already in elementary collisions.
This discussion shows that it is not unreasonable to expect different LDMEs in pp and PbPb collisions, where the abundance of gluons may favour otherwise suppressed transitions. Studies of quarkonium production in heavy-ion collisions, to probe QGP melting and/or recombination effects, are therefore remarkably intertwined with the ("cold") nuclear modifications of the LDMEs. We conjecture that accurate results on J/psi and Upsilon(1S) polarizations in Pb-Pb collisions, easily obtainable at the LHC, could provide unique measurements of the long-sought P-wave suppression patterns, thereby reliably probing sequential quarkonium melting, a signature of deconfinement mostly insensitive to "cold nuclear matter" effects.
We finish by proposing measurements of the polarizations of quarkonia in ultra-peripheral Pb-Pb collisions, as a way to study quarkonium production in still another environment, dominated by gamma-gamma interactions instead of gluon-gluon interactions. Such data could provide a clear-cut challenge to LDME universality.

Keywords

quarkonium production; quarkonium polarization; quarkonium suppression

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