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Resolving negative cross section of quarkonium hadroproduction using soft gluon factorization

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It was found that, using nonrelativistic QCD factorization, the predicted χ_{cJ} hadroproduction cross section at large p_T can be negative. The negative cross sections originate from terms proportional to plus function in $^3P_J^{[1]}$ channels, which are remnants of the infrared subtraction in matching the $^3P_J^{[1]}$ short-distance coefficients. In this article, we find that the above terms can be factorized into the nonperturbative $^3S_1^{[8]}$ soft gluon distribution function in the soft gluon factorization (SGF) framework. Therefore, the problem can be naturally resolved in SGF. With an appropriate choice of nonperturbative parameters, the SGF can indeed give positive predictions for χ_{cJ} production rates within the whole p_T region. The production of $\psi(2S)$ is also discussed, and there is no negative cross section problem.

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