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Factorized power expansion for high pT heavy quarkonium production

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From the Tevatron and the LHC data, it is clear that current models for the heavy quarkonium production are not able to explain the polarization of heavy quarkonia produced at large transverse momentum pT in p-p collision. A new approach to evaluate the heavy quarkonium production, by expanding the cross section in powers of 1/pT before the expansion in powers of alpha_s, was proposed recently. In terms of the QCD factorization, it is proved that both the leading-power (LP) and next-to-leading power (NLP) terms in 1/pT for the cross sections can be systematically factorized to all orders of alpha_s. The predictive power of this new QCD factorization formalism depends on several unknown but universal fragmentation functions (FFs) at an input scale of the order of heavy quarkonium mass m_Q. Inspired by the fact that m_Q » Lambda_QCD, we apply the NRQCD factorization formalism to further separate the perturbative and non-perturbative interactions. With our calculations, all the input polarization-summed FFs are expressed as complicated functions with a few unknown NRQCD long-distance matrix elements (LDMEs). In addition, by general symmetry arguments, we successfully generalize the polarized NRQCD four-fermion operators to d dimensions and calculate the polarized FFs with conventional dimensional regularization. In the first application, we find those non-relativistic QCD channels, which are expected to be important in the J/psi polarization, are actually dominated by the NLP term in the pT expansion at current collider energies. Therefore the QCD factorization is very promising to solve the long standing heavy quarkonium polarization puzzle.

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