

**Stony Brook University  
The Graduate School**

Doctoral Defense Announcement

**Abstract**

**QCD factorization for heavy quarkonium production  
and fragmentation functions**

By

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From Tevatron and the LHC data, it is clear that current models for heavy quarkonium production are not able to explain the polarization of produced heavy quarkonia at high transverse momentum  $p_T$ .

A new approach to evaluate heavy quarkonium production, expanding the cross section in powers of  $1/p_T$  before the expansion in powers of  $\alpha_s$ , was proposed recently. In terms of QCD factorization, it is proved that both the leading and next-to-leading power terms in  $1/p_T$  for the cross sections can be systematically factorized to all orders in powers 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  $m_Q$ . These FFs should be extracted from data in principle. However, fitting so many unknown multi-variable functions from data is formidable practically. The lack of knowledge of the input FFs impedes the application of QCD factorization.

In this dissertation, inspired by the fact that these input FFs depends on  $m_Q \gg \Lambda_{\text{QCD}}$ , we apply NRQCD to further factorize the non-perturbative interactions into a few NRQCD long-distance matrix elements (LDMEs). With our calculations, all input unpolarized FFs are expressed as complicated functional forms with a few unknown parameters (LDMEs). In addition, by general symmetry arguments, we generalize polarized NRQCD four-fermion operators to  $d$  dimensions and calculate the polarized FFs with Conventional Dimensional Regularization.

In the first application of QCD factorization on unpolarized  $J/\psi$  production, we find those NRQCD channels, which are expected to be important in  $J/\psi$  polarization, are actually dominated by next-to-leading power term at current collider energies. Therefore QCD factorization is very promising to solve the long-lasting heavy quarkonium polarization puzzle.

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