

Recent progress on inclusive quarkonium production and polarization

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Quarkonium production serves as a vital testing ground for quantum chromodynamics (QCD), offering critical insights into both perturbative and nonperturbative dynamics. In the nonrelativistic QCD (NRQCD) factorization framework, inclusive production cross sections of quarkonia are expressed as products of perturbatively calculable short-distance coefficients (SDCs) and nonperturbative long-distance matrix elements (LDMEs), which are hypothesized to be universal across production processes. For three decades, the validation of LDME universality has been central to understanding quarkonium production mechanisms. However, different groups extracted dramatically different sets of the three color-octet LDMEs of 3S_1 , 3P_0 , and 3P_1 , and none of them can describe all the data from collisions at LHC, HERA, LEP and Belle, respectively, challenging the universality of LDMEs. In this talk, we will report our recent progress on factorizing the LDMEs into products of wave functions and gluonic correlators based on the potential NRQCD (pNRQCD) effective theory and comprehensive phenomenological study on inclusive quarkonium production from collisions. We show that most of the data can be well described in the framework of NRQCD factorization and those still evade a consistent description coincide with “extensions” of endpoint regions.

Primary author: WANG, Xiangpeng (CCNU)

Presenter: WANG, Xiangpeng (CCNU)

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