W. Schäfer, I. Babiarz, A. Cisek et al.

W. SCHÄFER,[1] I. BABIARZ,[1] A. CISEK,[2] A. SZCZUREK[1]

[1] Institute of Nuclear Physics, Polish Academy of Sciences
  (152, Ul. Radzikowskiego, PL-31-142 Kraków, Poland; e-mail: wolfgang.schafer@ifj.edu.pl)
[2] Faculty of Mathematics and Natural Sciences, University of Rzeszów,
  (1, Ul. Pigonia, PL-35-310 Rzeszów, Poland)

RECENT RESULTS ON INCLUSIVE QUARKONIUM PAIR PRODUCTION IN PROTON-PROTON COLLISIONS

Recently, there has been much interest in the pair production of charmonia. One of the main motivations behind these studies is that the production of quarkonium pairs is expected to receive an important contribution from the double parton scattering (DPS) production mode. A large effective cross-section σ_{eff} is found from the empirical analysis of the J/ψ-pair production – about a factor 2.5 smaller than the usually accepted $\sigma_{\text{eff}} = 15$ mb. Here, we present the recent results of our calculations of the χ_c pair production, mainly in the single parton scattering (SPS) mode. An important feature is that the single-gluon exchange mechanism can to some extent mimic the behavior of the DPS production.

Keywords: perturbative QCD, quarkonia, multiparton processes.

1. Introduction

The production of J/ψ-pairs has been suggested as a probe of the double-parton scattering (DPS) processes [1]. More generally, the DPS production mode is expected to be especially important in the charm sector [2]. Therefore, recently, there has been much interest in the quarkonium pair production in proton-proton collisions also from the experimental side. Among others, the cross-sections for the production of J/ψ-pairs were measured at the Tevatron [3] and the LHC [4–7].

A number of puzzles remain with these data, however. For example, the single parton scattering (SPS) leading order of $\mathcal{O}(\alpha_S^4)$ (see, e.g., [8, 9]) does not describe well all the kinematic distributions in the case of the ATLAS and CMS data. Especially, when the rapidity distance Δy between two J/ψ mesons is large, it falls short of experimental data. If one ascribes the whole discrepancy to DPS processes, the normalization of DPS comes out a factor ~ 2.5 larger than in other hard processes. It is still an open issue at the moment whether this points to a nonuniversality of DPS effects or whether there are additional

single parton scattering mechanisms not taken into account up to now.

This problem motivated our recent studies of the χ_c-pair production in the k_T-factorization [10] and of the production of χ_c-pairs associated with a gluon (jet) in the collinear factorization [11]. We summarize these works in this contribution.

2. Production of χ_c-Pairs

In the standard hard scattering approach, the cross-section of the production of a pair of quarkonia a, b is calculated from a convolution of parton densities with a parton-level cross-section (see the left diagram in Fig. 1). However, at high energies, favored by a rise of the gluon distribution at small x, there is a sizable contribution from processes in which two or more hard processes proceed in the same proton–proton collision (see the right diagram in Fig. 1).

One commonly assumes the factorized ansatz for the production cross-section in the DPS mode:

$$\frac{d\sigma_{\text{DPS}}(pp \to abX)}{dy_a dy_b d^2\mathbf{p}_{aT} d^2\mathbf{p}_{bT}} =$$

$$= \frac{1}{1+\delta_{ab}} \frac{1}{\sigma_{\text{eff}}} \frac{d\sigma(pp \to aX)}{dy_a d^2\mathbf{p}_{aT}} \frac{d\sigma(pp \to bX)}{dy_b d^2\mathbf{p}_{bT}}. \quad (1)$$