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CHARMOMIUM PRODUCTION AT HERA

Andreas Meyer
Inst. f. Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

ABSTRACT

Recent measurements on inelastic J/ψ production in ep collisions at HERA are presented. The data from the H1 and ZEUS experiments are compared to model predictions of the Colour Singlet Model and of non–relativistic QCD.

1 Introduction

Inelastic J/ψ production in ep collisions is dominated by the process of photon–gluon–gluon fusion where a photon from the incoming electron and a gluon from the proton produce a $c\bar{c}$ pair. The process can be calculated within the framework of non–relativistic QCD (NRQCD) where the cross section is a sum over all possible intermediate $c\bar{c}$ states, including colour singlet (CS) and also colour octet (CO) states. The amplitude for each $c\bar{c}$ state with definite colour and

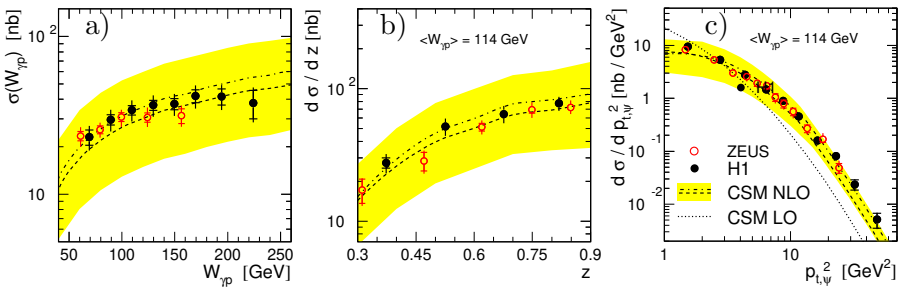

Figure 1: a) Total J/ψ photoproduction cross section as a function of $W_{\gamma p}$ and differential cross sections as functions of b) $p^2_{t,\psi}$ and c) z. The ZEUS points [3] are shifted by up to 12% to account for differences in the covered kinematic range. The CSM calculations in NLO is shown by the band. The normalization uncertainties are due to variations of α_s and the charm mass m_c.

angular momentum factorises into a short distance term which can be calculated in NRQCD and a long distance matrix element (LDME) describing the transition to a J/ψ. The LDME are not calculable and have been determined from J/ψ production data in $p\bar{p}$ collisions [1] where the CO contributions were found to be sizable. Previous HERA measurements show good agreement with the colour singlet term alone, which is the only term taken into account in the Colour Singlet Model (CSM), but small colour octet contributions could not be excluded. At HERA two kinematic domains are distinguished: In photoproduction ($Q^2 < 1\,\mathrm{GeV}^2$) the exchanged photons are quasi–real, in electroproduction they have a higher virtuality ($Q^2 > 2\,\mathrm{GeV}^2$).

2 Photoproduction Cross Sections

The H1 photoproduction data [2] are studied in the elasticity range $0.05 < z < 0.9$ and transverse momentum squared of the J/ψ meson $p^2_{t,\psi} > 1\,\mathrm{GeV}^2$. Remaining backgrounds to prompt J/ψ production coming from decays of B, ψ' or χ_c and mainly contributing at low values of z are not subtracted from the data. Figure 1 shows the H1 data in comparison with the ZEUS results [3]. Good agreement is found between the two experiments. The data are well described by a next–to leading order (NLO) calculation [4] in the Colour Singlet Model. In contrast, the LO calculation is much too steep in $p^2_{t,\psi}$. The elasticity distribution (Fig. 2 a) can also be described in the whole range by leading order

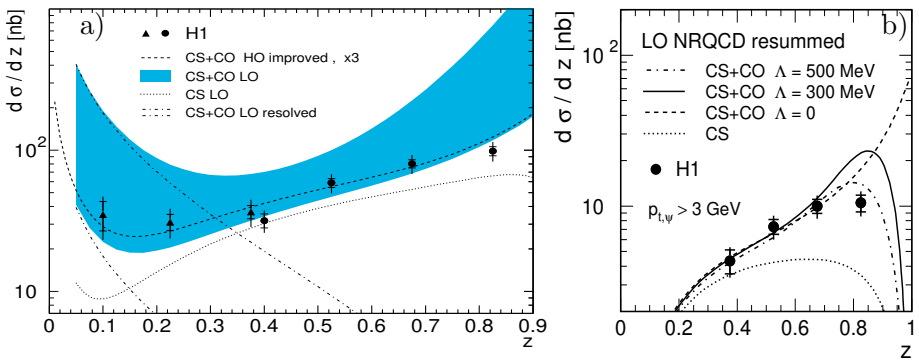

Figure 2: Differential J/ψ photoproduction cross section as a function of z a) in comparison to NRQCD calculations [5]; b) for $p_{t,\psi} > 3\,\mathrm{GeV}$ in comparison with a resummed NRQCD calculation [6] (scaled by a factor 3). The parameter Λ describes the energy loss of the J/ψ due to soft gluon emission.

NRQCD calculations [5] with LDMEs for the colour octet contributions at the lower end of the range allowed by the Tevatron data. The steeper rise of the NRQCD calculations towards high z than that in the data may be due to phase space limitations for the emission of soft gluons in the transition from the $c\bar{c}$ state to the J/ψ meson which are not considered in [5]. A resummation [6] of the non–relativistic expansion, which is valid at large $p_{t,\psi}$, leads to a considerable reduction of the increase and better agreement with the data (Fig. 2 b).

3 Electroproduction Cross Sections

The inelastic electroproduction of J/ψ mesons [2] is studied in the region $2 < Q^2 < 100\,\mathrm{GeV}^2$ for medium elasticities $0.3 < z < 0.9$ and the squared transverse momentum of the J/ψ meson in the photon–proton center–of–mass system $p^{*2}_{t,\psi} > 1\,\mathrm{GeV}^2$. Neither the full NRQCD calculation [7] nor the colour singlet part can describe the data in normalisation (Fig. 3 a,b). At high Q^2 and $p^{*2}_{t,\psi}$ agreement with the full NRQCD prediction is found. The CSM prediction falls too steeply in $p^{*2}_{t,\psi}$. This may be due to missing higher order contributions in this LO calculation (cf. Fig. 1 c) in photoproduction). The dependence of the cross section on z, however, is well described by the CS contribution. The calculation including the CO contributions rises too strongly towards large z.

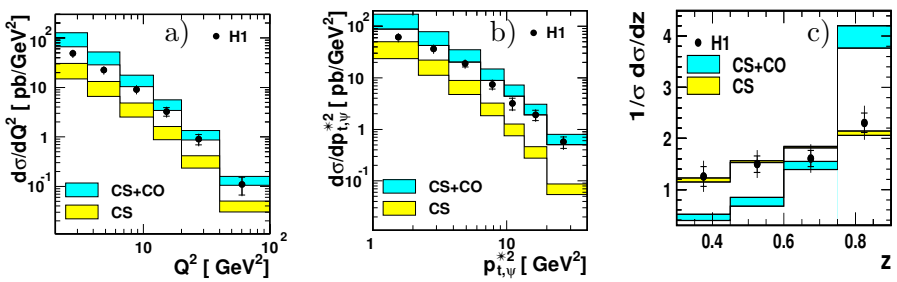

Figure 3: Differential J/ψ electroproduction cross section as a function of a) Q^2 and b) $p^{*2}_{t,\psi}$. c) Normalized differential cross section as a function of z. The data are compared to a full NRQCD calculation [7] (dark band) and to the colour singlet contribution alone (light band).

4 Summary

New results on inelastic J/ψ photo– and electroproduction have been presented. In photoproduction agreement is found with the CSM in next–to leading order and also with NRQCD calculations in leading order with small colour octet contributions. In electroproduction the leading order CSM does not describe the normalisation of the data. The full NRQCD calculation is in agreement with the data at large Q^2 and $p^{*2}_{t,\psi}$, but fails to describe the elasticity distribution.

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