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INCLUSIVE DIFFRACTIVE DISSOCIATION IN PHOTOPRODUCTION AT HERA*

R. Heremans

Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussel, Belgium
e-mail: heremans@hep.iihe.ac.be

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A new measurement of the differential cross section $M_X^2\ d\sigma/dM_X^2$ for the process $\gamma p \to XY$, with a large rapidity gap between the systems X and Y and with Y a proton or a low mass proton excitation, is presented at three centre-of-mass energies $\langle W\rangle = 91$, 187 and 231 GeV. The slope parameter $\alpha_{\rm eff}(0)$ obtained from a single regge type parameterization with a single effective trajectory is presented as a function of M_X^2. A combined triple regge fit is performed over these data together with leading proton data from the same experiment and lower energy fixed target data. The pomeron intercept $\alpha_{\mathbb{P}}(0)$ is extracted from this fit and was found to be $\alpha_{\mathbb{P}}(0)= 1.127\pm0.004(\text{stat})\pm0.025(\text{syst})\pm0.046(\text{mod})$.

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1. Introduction

A diffractive dissociation cross section measurement using the H1 detector at HERA is presented, based on an integrated luminosity of $\sim$2 pb^{-1}. The cross section $M_X^2\ d\sigma/dM_X^2$ is measured for the process $\gamma p \to XY$, in the kinematical domain: $Q^2 \leq 0.01$ GeV^2, $M_Y < 1.6$ GeV and $|\ t\ |< 1$ GeV^2 at three γp center of mass energies $W_{\gamma p} = 91$, 187 and 231 GeV. Here M_X and M_Y represent the dissociative masses respectively at the photon and proton vertices. Q^2 is minus the square of the four-momentum carried by the exchanged photon and t is the square of the four-momentum transferred to the proton.

From the present measurement an effective regge trajectory intercept has been derived. The same measurement, together with previously measured leading proton data [2] and fixed target data [3] were subjected to a triple regge analysis.

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2. The differential cross section $M_X^2 d\sigma(\gamma p \to XY)/dM_X^2$

2.1. Rapidity gap measurement

The sample of diffractive photoproduction events was selected by requiring an electron in one of the electron taggers at 33 m or 44 m and a large rapidity gap ($\Delta\eta \geq 4$) in the forward direction by requiring no activity in the forward detectors and $\eta_{\max} < 3.2$. Fig. 1(a) shows the cross section for $M_Y < 1.6$ GeV and $\mid t \mid < 1$ GeV^2 and is compared with an earlier measurement [1] at center of mass energies $W_{\gamma p} = 187, 231$ GeV. The statistical error decreased by a factor of three, but the measurement is still dominated by a large systematic uncertainty on the acceptance factors obtained from the Monte Carlo programmes PHOJET and PYTHIA.

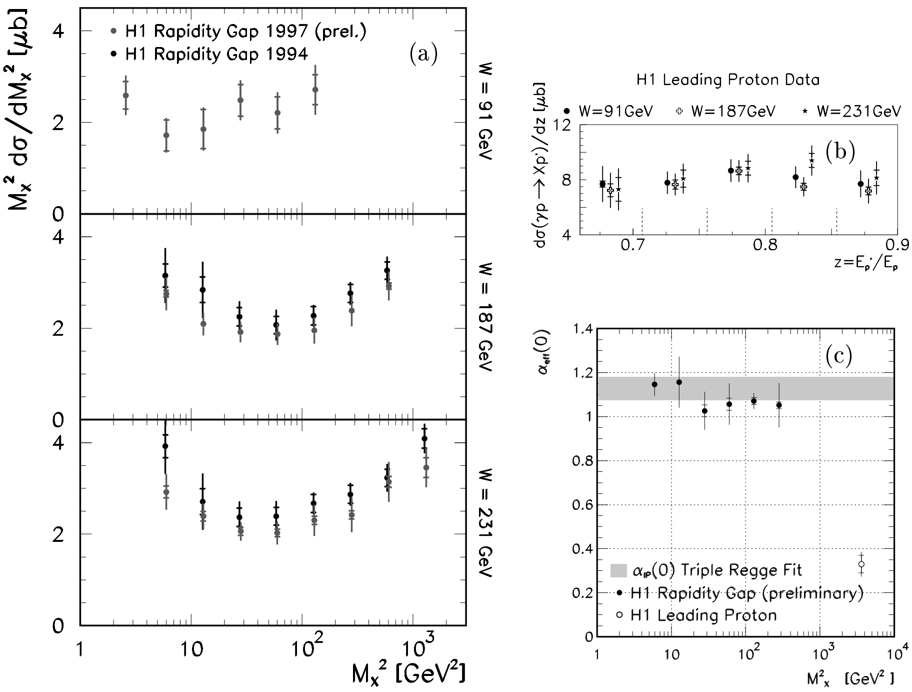

Fig. 1. (a) Comparison of the present differential cross section $M_X^2\ d\sigma(\gamma p \to XY)/dM_X^2$ with that of an earlier measurement [1]. (b) Leading proton differential cross section $d\sigma(\gamma p \to Xp)/dz$ from [2]. (c) Effective intercept $\alpha_{\rm eff}(0)$ as function of M_X^2 (black dots), together with the result of the leading proton data (circle). The error band gives the value of $\alpha_{\mathbb{P}}(0)$ as obtained from a triple regge fit (see Section 3.2). The inner error bars are statistical and the outer error bars represent the sum of the statistical and systematical errors in quadrature.

2.2. Leading proton measurement

In contrast to the rapidity gap measurement where the dissociative mass was reconstructed using the different H1 detector components, the scattered proton energy is in the case of the leading proton sample measured in the forward proton spectrometer. The photon dissociative mass is then obtained from the relation $M_X^2 = W_{\gamma p}^2(1-z)$, where $z = E'_p/E_p$ is the ratio of the scattered proton to the incoming proton energy. The differential cross section shown in Fig. 1(b) is observed to be roughly independent of $W_{\gamma p}$ and z [2]. Rewriting this cross section as a differential cross section as a function of the dissociative mass, $M_X^2 d\sigma/dM_X^2$ rise with M_X^2 at fixed $W_{\gamma p}$ as can be seen in Fig. 2.

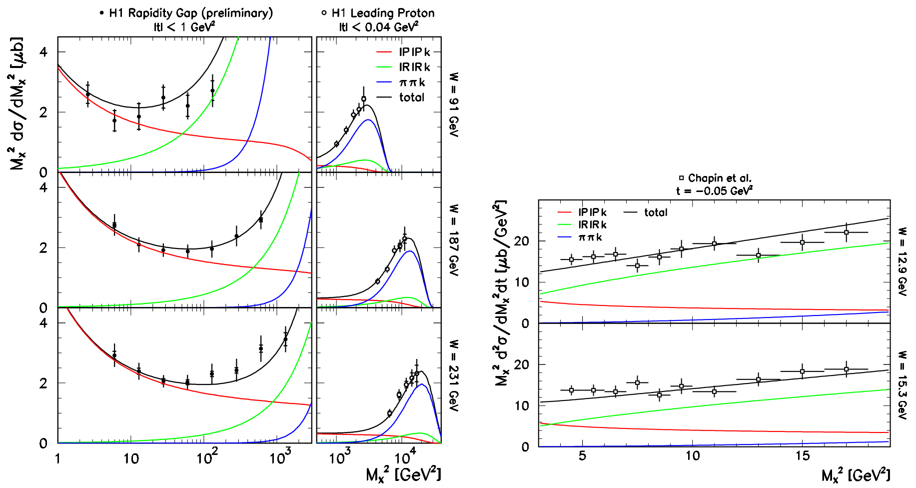

Fig. 2. The triple regge fit compared with the H1 rapidity gap data, the H1 leading proton data and fixed target data.

3. Regge analysis

3.1. Determination of an effective intercept $\alpha_{\mathrm{eff}}(0)$

In the single regge limit from the regge formalism [4–6], the differential cross section $M_X^2 d\sigma/dM_X^2$ is expressed as a sum over all contributing trajectories. Assuming that this sum can be represented by a single *effective* trajectory, the W dependence of the cross section at fixed M_X^2 can be written after integration over t as:

$$M_X^2 \frac{d\sigma}{dM_X^2} \propto \left(W^2\right)^{2\alpha_{\mathrm{eff}}(0)-2} \frac{\mathrm{e}^{-B|t_{\min}|} - \mathrm{e}^{-B|t_{\max}|}}{B}, \tag{3.1}$$

with $B = b_0 + 2\alpha' \ln\left(W^2_{\gamma p}/M^2_X\right)$, $b_0 = 4.6 \pm 0.6$ GeV^{-2}, $\alpha' = 0.26 \pm 0.02$ GeV^{-2} [7] and $\mid t_{\max} \mid = 1$ GeV^2. A value for $\alpha_{\rm eff}(0)$ at fixed M^2_X can be obtained by fitting the W-dependence of the rapidity gap data (Fig. 1(a) for each of the six M^2_X-bins to formula (3.1). The results are shown in Fig. 1(c). A similar analysis performed on the leading proton data (Fig. 1(b)) leads to an effective intercept of $\alpha_{\rm eff}(0) = 0.33 \pm 0.04({\rm stat}) \pm 0.04({\rm syst})$ and is also shown in Fig. 1(c). The result indicates that the rapidity gap data are dominated by pomeron exchange, while the leading proton data represent a mixture of reggeon and pion exchanges. The band shows the prediction of the pomeron intercept obtained from a triple regge fit (see Section 3.2).

3.2. Triple Regge fit

A combined triple regge fit was performed on the rapidity gap, the leading proton and fixed target data samples. The data were fitted to the expression:

$$\frac{d\sigma}{dM^2_X} = \int\limits_{t_{\min}}^{t_{\max}} dt \, \frac{s_0}{W^4} \sum_{i,k} G_{iik}(t) \left(\frac{W^2}{M^2_X}\right)^{2\alpha_i(t)} \left(\frac{M^2_X}{s_0}\right)^{\alpha_k(0)}$$

in which i can be a pomeron, reggeon or pion and k a pomeron or reggeon. Possible interference terms have not been considered. The trajectories are assumed to take the linear form $\alpha_i(t) = \alpha_i(0) + \alpha' t$. The functions $G_{iik}(t)$ may be factored into products of terms $\beta(t)$ describing the couplings of the reggeons to external particles and $g_{iik}(t)$ the three-reggeon coupling. The t dependence of these terms are parametrized here as $\beta_{pi}(t) = \beta_{pi}(0){\rm e}^{b_{pi} \cdot t}$ and $g_{iik}(t) = g_{iik}(0){\rm e}^{b_{iik} \cdot t}$. In the present fit (see Fig. 2) the 6 couplings $G_{iik}(0)$ with $i = \mathbb{P}$, π, $\mathbb{R}$ ($= \rho$, ω, f or a) and $k = \mathbb{P}$, $\mathbb{R}$ and $\alpha_{\mathbb{P}}(0)$ are left free. The remaining parameters are fixed to values found in the literature, *i.e.* $\alpha'_{\mathbb{P}} = 0.26 \pm 0.02$, $\alpha_{\mathbb{R}}(0) = 0.55 \pm 0.10$, $\alpha'_{\mathbb{R}} = 0.90 \pm 0.10$, $b_{p\mathbb{P}} = 2.3 \pm 0.3$, $b_{p\mathbb{R}} = 1.0 \pm 1.0$ and $b_{iik} = 0.0 \pm 1.0$ [4,7–10].

Additional isospin exchanges may contribute in the rapidity gap data with respect to the proton tagged data sample, leading to *e.g.* $Y = n$ or Δ's. To account for these additional exchanges the ratio for the pion exchange contribution in the rapidity gap data to the tagged proton data is set to 3, according to the relevant Clebsch–Gordan coefficient, whereas to account for the unknown mix of isovector and isoscalar contributions in the reggeon exchanges, a parameter $\mathcal{R}$ was introduced defined as the ratio of the $\mathbb{R}\mathbb{R}k$ couplings in the rapidity gap data to that in the proton tagged data.

From the result of the fit shown in Fig. 2 one deduces that the rapidity gap sample is dominated by pomeron exchange, the leading proton by pion exchange while the fixed target data are dominated by $\mathbb{R}$ exchanges.

The extracted value of the pomeron intercept is found to be $\alpha_{\mathbb{P}}(0)$ =1.127 $\pm$0.004(stat)$\pm$0.025(syst)$\pm$0.046(mod) and the isospin parameter to be $\mathcal{R}$= 11.4$\pm$0.2$\pm$6.8. The rather large value of $\mathcal{R}$ may indicate that a significant contribution from the proton resonances are present and that refinements in the model used are required. However, the result for $\alpha_{\mathbb{P}}(0)$ is relatively insensitive to these model assumptions.

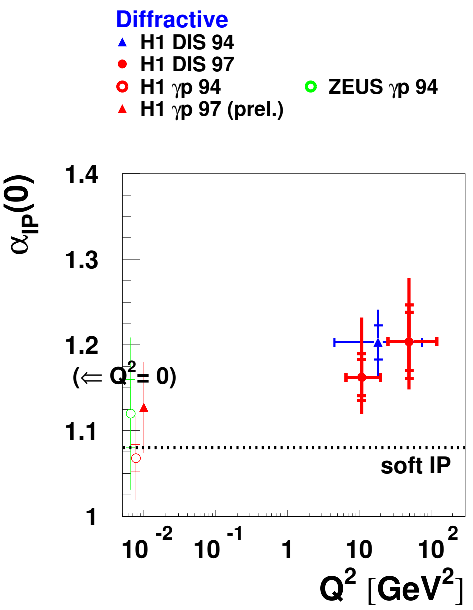

Fig. 3. The evolution of $\alpha_{\mathbb{P}}(0)$ in function of Q^2 updated with this new measurement at Q^2= 0 GeV^2.

In Fig. 3 the intercept of the pomeron is shown as a function of Q^2 updated with this new measurement. The new extracted value of the pomeron intercept is in good agreement with previous measurements from H1 and Zeus. A possible rise for the pomeron intercept is seen as a function of Q^2.

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