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RESULTS ON INCLUSIVE DIFFRACTION AT ZEUS*

Marcella Capua

On behalf of the ZEUS Collaboration

INFN Cosenza and Calabria University
Arcavacata di Rende (CS), Italy
e-mail: capua@cs.infn.it

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The diffractive dissociation of virtual photons, $\gamma^* p \to Xp$, has been studied in ep interactions at HERA. The data are presented in terms of the diffractive structure function F_2^{D} and $d\sigma/dM_X$. The Pomeron intercepts, extracted from diffractive and inclusive ep interactions, are compared. The Q^2variation of the ratio of the diffractive to inclusive cross sections on W, the photon–proton center of mass energy, illuminates the transition from the perturbative, high Q^2, region to the photoproduction limit. The ranges studied in both W and Q^2 are extended with respect to previously available results.

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1. Diffraction at HERA

The diffractive dissociation of real photons, $\gamma p \to Xp$, can be treated in complete analogy with hadron–hadron diffractive interactions and therefore can be described by Regge phenomenology. By contrast, HERA allows the investigation of the partonic nature of diffraction in Deep-Inelastic Scattering (DIS) using virtual photons.

A photon of virtuality Q^2 interacts with a proton at a center of mass energy W to produce two distinct hadronic systems of masses M_X and M_Y, respectively. The system X is usually reconstructed in the central detector and is well separated in rapidity from the proton remnant system Y produced with squared four momentum transfer t. The photon dissociative processes are selected at ZEUS either by a method based on the characteristics of the distribution of M_X ("mass method") or by measuring the scattered proton

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in special downstream detector, the ZEUS Leading Proton Spectrometer (LPS). The first method yields high statistics, but contains a background of double-dissociative events, $ep \to eXY$.

1.1. Diffractive cross section and structure function

The diffractive cross section $\sigma_{ep}^{\rm diff}$ for the process $ep \to eXp$ is related to the cross section $\sigma_{\gamma^* p}^{\rm diff}$ for the diffractive dissociation of virtual photons, $\gamma^* p \to Xp$: $\frac{d\sigma_{\gamma^* p}^{\rm diff}}{dM_X} = \frac{2\pi Q^2 y}{\alpha(1+(1-y)^2)} \frac{d^3\sigma_{ep}^{\rm diff}}{dQ^2 dy dM_X}$. The diffractive cross section $\sigma_{ep}^{\rm diff}$ can also be also be expressed in terms of the diffractive structure function $F_2^{\rm D(4)}(\beta, Q^2, X_{\mathbb{P}}, t)$, where $x_{\mathbb{P}}$ may be interpreted as the fraction of the longitudinal momentum of the proton carried by the Pomeron strike and transferred to the system X, and β as the fraction of the Pomeron momentum carried by the quark that couples to the photon. The structure function $F_2^{\rm D(4)}$ is given by: $F_2^{\rm D(4)}(\beta, Q^2, x\mathbb{P}, t) = \frac{\beta Q^4}{4\pi\alpha^2(1-y+y^2/2)} \frac{d\sigma_{\gamma^* p}^{\rm diff}}{d\beta dQ^2 dx_{\mathbb{P}} dt}$. Here, α is the electromagnetic coupling constant; the contribution of the longitudinal structure function and the effect of Z^0 exchange have been neglected. With this definition, $F_2^{\rm D(4)}$ has dimension of GeV^{-2}.

2. Results

2.1. The $x_{\mathbb{P}}$ dependence of the diffractive structure function

Figure 1 shows $F_2^{\rm D(4)}$, measured using the ZEUS LPS [1], as a function of β and Q^2. The data were fit, assuming Regge factorisation, with a sum of Pomeron and Reggeon contributions. The Pomeron intercept and the values of $F_2^{\mathbb{P}}(\beta, Q^2)$ and $F_2^{\mathbb{R}}(\beta, Q^2)$ in each β and Q^2 bin were treated as free parameters. The resulting values of the Pomeron intercept was found to be $\alpha_{\mathbb{P}}(0) = 1.13 \pm 0.03({\rm stat})^{+0.03}_{-0.01}({\rm syst})$ GeV^{-2}.

2.2. W dependence of the diffractive cross section

The study of the $x_{\mathbb{P}}$ dependence of $F_2^{\rm D}$ is equivalent to that of the W dependence of $d\sigma^{\rm diff}/dM_X$. As shown, interpreting the $x_{\mathbb{P}}$ dependence of the data at fixed β and Q^2 in a Regge motivated model, one can extract the value of the effective exchanged trajectory. Equivalently, according to the Regge formalism, the W dependence of the diffractive cross section can be parametrised as $d\sigma^{\rm diff}/dM_X \propto (W^2)^{2\bar{\alpha}_{\mathbb{P}}-2}$. A compilation of values of the effective Pomeron trajectory extracted from diffractive [2–5] ep measurements are presented in Fig. 2. The line shows $\alpha_{\mathbb{P}}(0)$ as obtained from the ALLM97 parametrisation of the $\gamma^* p$ total cross section, which gives a good representation of the inclusive F_2 data for the entire Q^2 range.

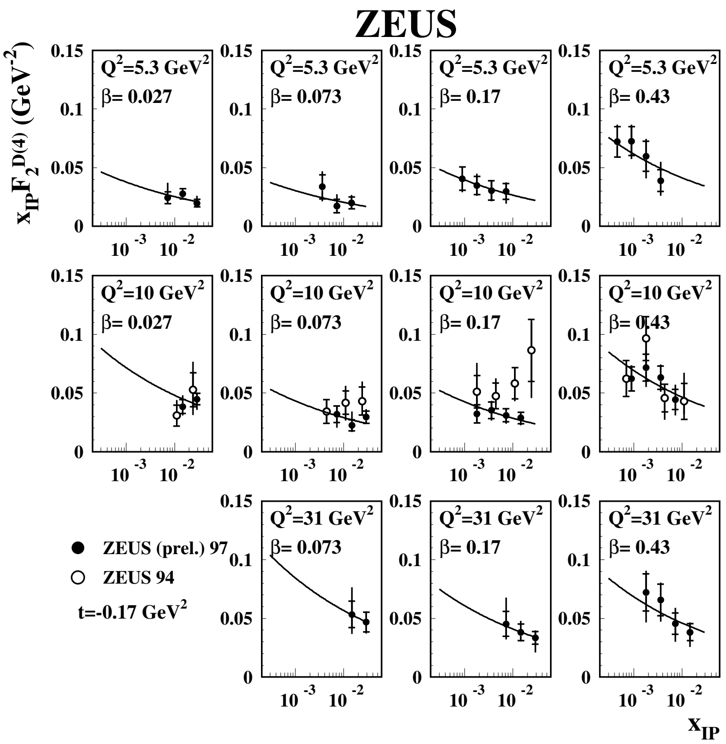

Fig. 1. The diffractive structure function $x_{\mathbb{P}}F_2^{\mathrm{D}(4)}$ measured with the LPS is plotted as a function of $x_{\mathbb{P}}$ in bins of β and Q^2. The solid lines are the results of the fit described in the text.

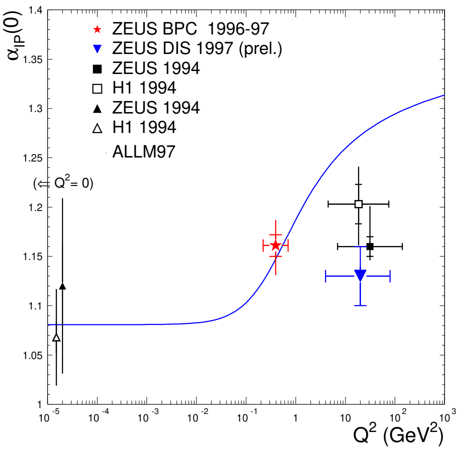

Fig. 2. $\alpha_{\mathbb{P}}(0)$ extracted from the energy dependence of selected inclusive and diffractive HERA data.

At high Q^2, the curve describing the Pomeron intercept for the inclusive data is higher than the diffractive data, while in photoproduction and low Q^2 electroproduction the effective intercept in the diffractive and inclusive case are compatible [6]. This is illustrated in Fig. 3 which shows the ratio of the diffractive to the total cross section is plotted for Q^2 and M_X bins as a function of W. The energy dependences of the inclusive and diffractive cross sections are rather similar at high Q^2, in contrast to the expectation from Regge theory. However, the data for $Q^2 < 1$ GeV^2 show a rise in W, consistent with Regge theory.

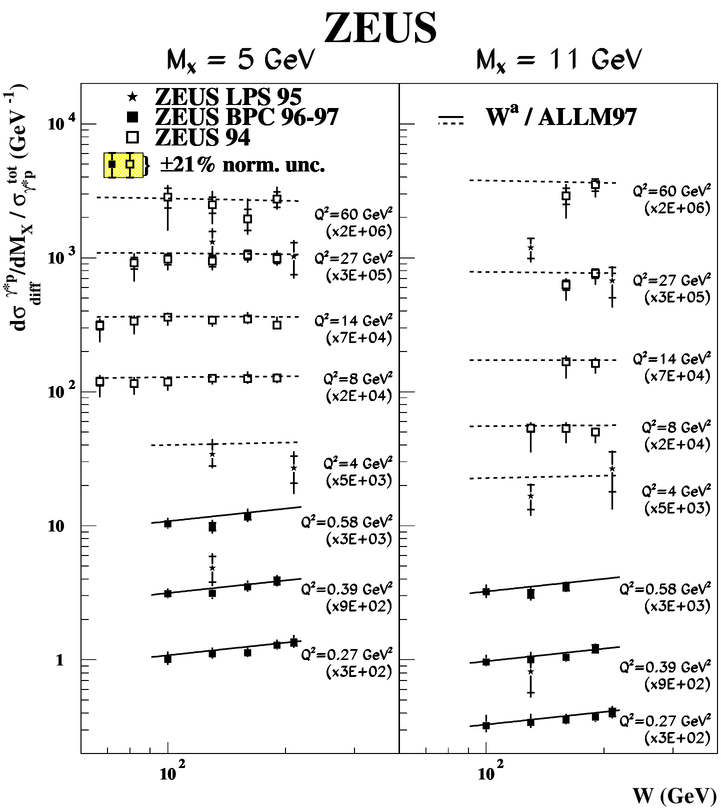

Fig. 3. The values of the ratio $d\sigma^{\rm diff}/dM_X/\sigma^{\rm tot}_{\gamma^* p}$ for different W and M_X bins as a function of Q^2.

2.3. Q^2 dependence of the diffractive cross section

Figure 4 shows the diffractive cross section, $d\sigma^{\rm diff}_{\gamma^* p}/dM_X$, as a function of Q^2 for different M_X and W selections. The recent ZEUS measurement [6] at low Q^2 is shown together with previous ZEUS [5] and H1 [2] measurements.

A change of the Q^2 dependence of $d\sigma^{\rm diff}/dM_X$ is apparent with decreasing Q^2, reminiscent of the behaviour of the photon–proton cross section, $\sigma_{\rm tot}^{\gamma^* p}$, which also exhibits [7] a flattening for $Q^2 \lesssim 1$ GeV^2. This is consistent with the expectation, based on the conservation of the electromagnetic current, that $\sigma_{\gamma^* p}^{\rm tot} \to$ constant as $Q^2 \to 0$, although the Q^2 value of the transition is not predicted. Moreover Fig. 4 shows that the main features of the data are reproduced by a parametrisation based on the model of Bartels *et al.* (BEKW) [8], in which the dominant contributions to the diffractive structure function come from the fluctuations of the photon into either a $q\bar{q}$ pair or a $q\bar{q}g$ pair, with the first component dominant at large β and the second dominant at small β. As Q^2 decreases, for a fixed value of M_X, β also decreases: the data indicate the increasing importance of the $q\bar{q}g$ contribution at low Q^2.

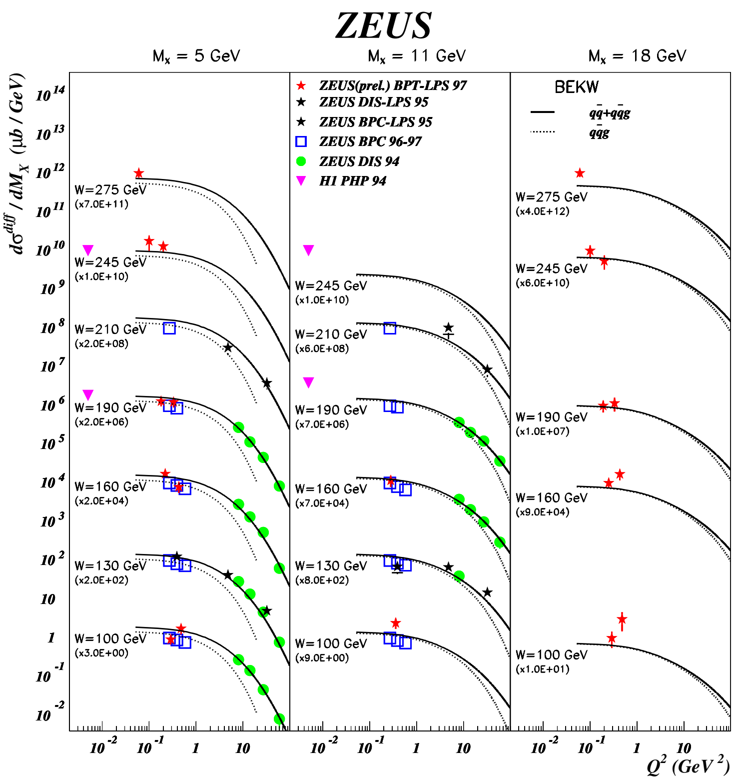

Fig. 4. The values of $d\sigma_{\gamma^* p}^{\rm diff}/dM_X$ for different W and M_X bins as a function of Q^2. The lines are the result of the BEKW parametrisation described in the text.

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