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THE DYNAMIC OF DIFFRACTIVE STRUCTURE FUNCTIONS AT HIGH ENERGIES

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Introduction

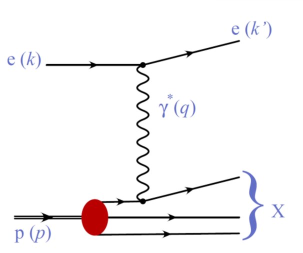
Diffraction: is mediated by diffractive exchange

- quantum numbers of vacuum
- no colour transfer
- small momentum transfer in t-channel

⇒ **Is observed as final states with large rapidity gaps (LRG)**

kinematics

Deep Inelastic Scattering



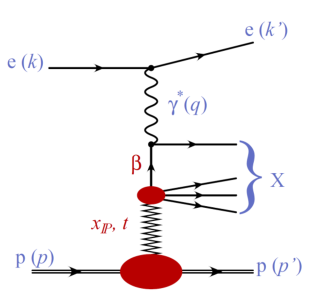
Q² = virtuality of photon

W = invariant mass of e-p system

X = Bjorken scale

Y = inelasticity

Diffractive Scattering



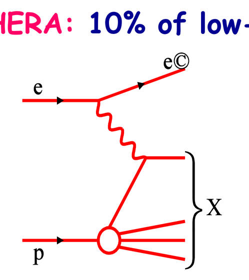
t = (4-momentum exchanged at p vertex)^2

M_X = invariant mass of photon-Pomeron system

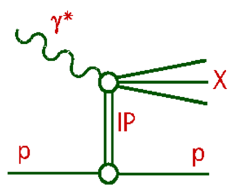
X_{IP} = fraction of proton's momentum taken by Pomeron

ß = Bjorken's variable for the Pomeron = **x/x_{IP}**

HERA: 10% of low-x DIS events are diffractive



DIS probes the partonic structure of the proton → F_2



DDIS probes the partonic structure of colour singlet exchange → F_2

Theoretical framework

Diffractive structure functions

The data are often presented in the form of a t-integrated reduced diffractive neutral current cross section, defined through

$$\frac{d\sigma^{ep\to eXp}}{d\beta dQ^2 dx_{IP}} = \frac{4\pi\alpha^2}{\beta Q^4}\left[1-y+\frac{y^2}{2}\right]\sigma_r^{D(3)}(\beta,Q^2,x_{IP}),$$

Or in terms of a diffractive structure function

$$\sigma_r^{D(3)} = F_2^{D(3)} - \frac{y^2}{1+(1-y)^2}F_L^{D(3)}.$$

The second term can be neglected anywhere but at very large y due to the presence of the $\frac{y^2}{1+(1-y)^2}$ factor.

Diffractive parton distribution functions

QCD hard scattering factorization:

$$\sigma^D(\gamma^* p \to Xp) = \sum_{parton\_i} f_i^D(x,Q^2,x_{IP},t)\cdot\sigma^{\gamma^* i}(x,Q^2)$$

diffractive parton distribution function → obey DGLAP, universal for diffractive e-p DIS

Additional assumption → Regge factorization:

$$f_i^D(x,Q^2,x_{IP},t) = f_{IP/p}(x_{IP},t)\cdot f_i^{IP}(\beta = x/x_{IP},Q^2)$$

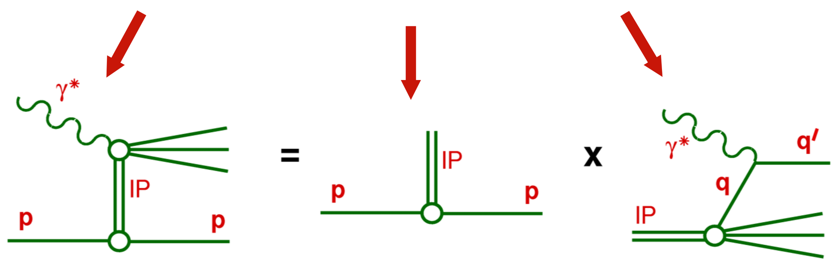
pomeron flux factor

pomeron parton distribution function

A. N. Khorramian, S. Atashbar Tehrani, S. Taheri Monfared, F. Arbabifar and F. I. Olness, Phys. Rev. D **83**, 054017 (2011) [arXiv:1011.4873 [hep-ph]].
A. N. Khorramian, H. Khanpour and S. A. Tehrani, Phys. Rev. D **81,** 014013 (2010) [arXiv:0909.2665 [hep-ph]].
A. N. Khorramian and S. A. Tehrani, Phys. Rev. D **78**, 074019 (2008) [arXiv:0805.3063 [hep-ph]].
S. Atashbar Tehrani and A. N. Khorramian, JHEP **0707**, 048 (2007) [arXiv:0705.2647 [hep-ph]].

Factorization

$$f_i^D(x,Q^2,x_{IP},t) = f_{IP/P}(x_{IP},t)\cdot f_i^{IP}(\beta = x/x_{IP},Q^2)$$



MEASURMENT = FLUX(x_{IP},t) × STRUCTURE(β,Q^2)
(Regge theory) (DGLAP)

$$f_{IP}(x_{IP}) \propto \int \frac{e^{b_t t}}{x_{IP}^{2\alpha_{IP}(t)-1}}dt$$

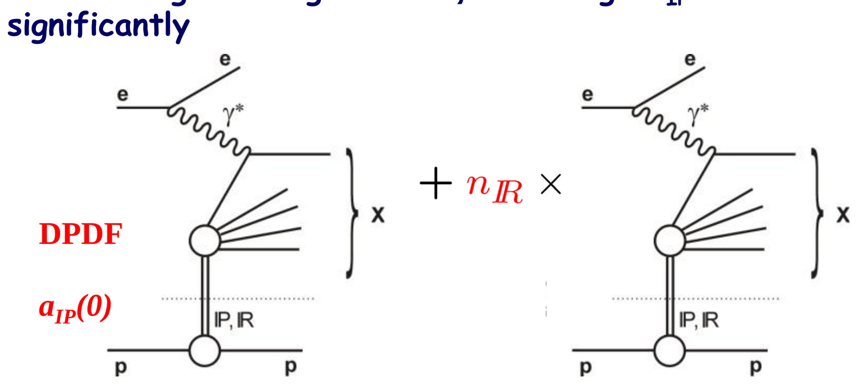
$$\alpha_{IP}(t) = \alpha_{IP}(0) + \alpha_{IP}{}'\cdot t$$

Shape of diffractive PDFs, independent on xIP and t

A. Aktas et al. [H1 Collaboration], Eur. Phys. J. C **48**, 715 (2006) [arXiv:hep-ex/0606004].
A. Aktas et al. [H1 Collaboration], Eur. Phys. J. C **48**, 749 (2006) [arXiv:hep-ex/0606003].
S. Chekanov et al. [ZEUS Collaboration], Eur. Phys. J. C **38**, 43 (2004) [arXiv:hep-ex/0408009].
S. Chekanov et al. [ZEUS Collaboration], Nucl. Phys. B **713**, 3 (2005) [arXiv:hep-ex/0501060].
S. Chekanov et al. [ZEUS Collaboration], Nucl. Phys. B **816**, 1 (2009) [arXiv:0812.2003 [hep-ex]].
S. Chekanov [ZEUS Collaboration], Nucl. Phys. B **800**, 1 (2008) [arXiv:0802.3017 [hep-ex]].

How to improve

Sub-leading exchange at low β and large x_{IP} contributes significantly



$$F_2^{D(4)} = f_{IP}(x_{IP},t)\cdot F_2^{IP}(\beta,Q^2) + n_{IR}\cdot f_{IR}(x_{IP},t)\cdot F_2^{IR}(\beta,Q^2)$$

Parameterization

We parameterized the Pomeron, a light flavor singlet distribution and a gluon distribution at an initial scale,

$$z\Sigma(z,Q_0^2) = A_\Sigma z^{B_\Sigma}(1-z)^{C_\Sigma}(1+D_\Sigma z+Ez^\Sigma),$$

$$zg = A_g e^{\frac{-0.01}{1-z}}.$$

Diffractive structure function can be described by

$$F_i(\beta,Q^2) = \sum_j c_i^j(\beta,\frac{Q^2}{\mu^2})\otimes f_j(\beta,\mu^2)$$

Structure function can be written like

$$F_i(\beta,Q^2) = F_i^{light}(\beta,Q^2) + F_i^{heavy}(\beta,Q^2)$$

Light flavor contribution

The flavor singlet contribution up to NLO is given by

$$\frac{1}{x}F_2^{light}(\beta,Q^2) = \frac{2}{9}(C_{2,q}\otimes\Sigma + C_{2,g}\otimes g)(\beta,Q^2),$$

$$\frac{1}{x}F_L^{light}(\beta,Q^2) = \frac{2}{9}(C_{L,q}\otimes\Sigma + C_{L,g}\otimes g)(\beta,Q^2),$$

Where $C_{(2,L)q}$ and $C_{(2,L)g}$ are the common NLO coefficient functions.

Heavy flavor contribution

The heavy structure functions are given through

$$F_i^h(\beta,Q^2) = \sum_k C_{i,k}^{FF,n_f} F_i^{light}(Q^2/m_h^2)\otimes f_{i,k}^{n_f}(Q^2).$$

Here, all quark flavors below m_h are treated as zero mass and one sums over all n_f flavors of light quarks.

M. Gluck, P. Jimenez-Delgado, E. Reya and C. Schuck, Phys. Lett. B **664**, 133 (2008) [arXiv:0801.3618 [hep-ph]].
M. Gluck, P. Jimenez-Delgado and E. Reya, Eur. Phys. J. C **53**, 355 (2008) [arXiv:0709.0614[hep-ph]].
S. Riemersma, J. Smith and W. L. van Neerven, Phys. Lett. B **347**, 143 (1995) [arXiv:hep-ph/9411431].

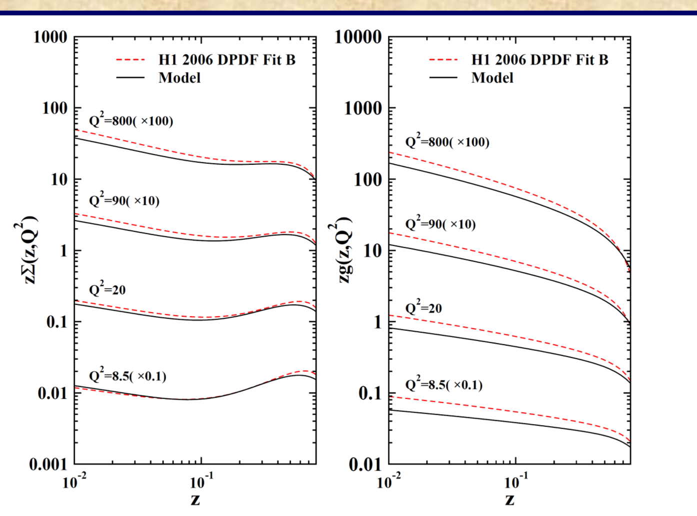
Data sets

At HERA, diffractive events were selected either by FPS/LPS method or on the basis of LRG method. They are also identified by the M_X method. We consider all three methods to achieve the best results.

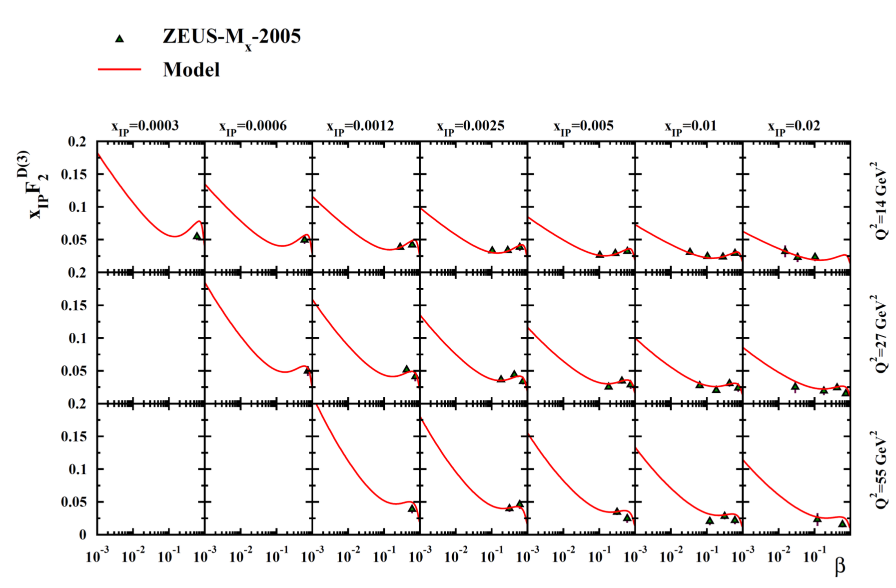
Lable	Data set	β-range	x_{IP}-range	Q^2-range	Data points
H1-LRG-06	$\sigma_r^{D(3)}$	0.0043-0.8	0.001-0.03	8.5-1600	190
H1-FPS-06	$\sigma_r^{D(3)}$	0.02-0.7	0.0011-0.08	10.7-24	40
ZEUS-M_X-05	$F_2^{D(3)}$	0.0153-0.75	0.00048-0.02126	14-55	56
ZEUS-LPS-04	$F_2^{D(3)}$	0.007-0.48	0.0005-0.06	13.5-39	27
ZEUS-M_X-08	$F_2^{D(3)}$	0.021-0.799	0.0006-0.03345	14-320	244
ZEUS-LRG-09	$\sigma_r^{D(3)}$	0.025-0.7955	0.0005-0.014	8.5-225	155
ZEUS-LPS-09	$\sigma_r^{D(3)}$	0.013-0.609	0.0009-0.09	14-40	42
H1-FPS-10	$\sigma_r^{D(3)}$	0.0056-0.562	0.0025-0.075	8.8-200	100
Total					854

Table 1: Overview of the published data points.

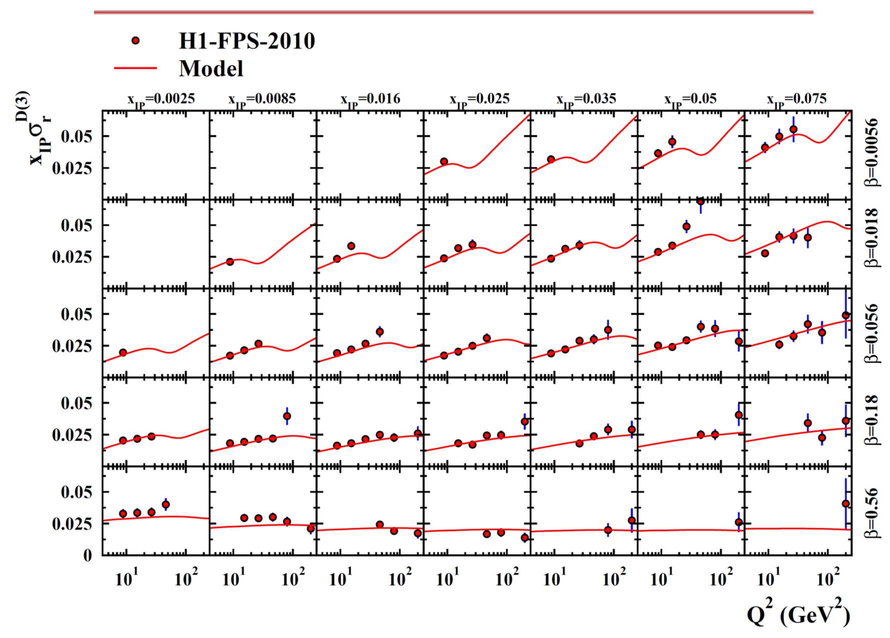
Results



Comparison between the total quark singlet and gluon distributions obtained from our model and H1 2006 DPDF Fit B.



The reduced diffractive cross sections, as a function of β for different regions of Q^2 and x_{IP} are compared with ZEUS-M_x-2005 data.



The reduced diffractive cross sections, as a function of Q^2 for different regions of β and x_{IP} are compared with H1-FPS-2010 data.

Conclusion

We have shown that the diffractive observables measured in the H1 and ZEUS experiments at HERA can be well described by a perturbative QCD analysis which fundamental quark and gluon distributions, evolving according to the NLO DGLAP equations, are assigned to the Pomeron and Reggeon exchanges. In particular, a global analysis of all available data has been performed with a proper description of these measurements. Although these data obtained by various methods with very different systematics, they are broadly consistent in the shapes of the distribution throughout most of the phase space. Our fit implements a fixed flavor treatment of heavy quark threshold effects.