QCD ANALYSIS OF THE DIFFRACTIVE STRUCTURE FUNCTION $F_2^{D(3)}$

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The proton diffractive structure function $F_2^{D(3)}$ measured in the H1 and ZEUS experiments at HERA is analyzed in terms of perturbative QCD evolution. The data are well described by a QCD analysis in which point-like parton distributions, evolving according to the DGLAP equations, are assigned to the leading and sub-leading Regge exchanges. The gluon distributions are found to be quite different for H1 and ZEUS. A global fit analysis, where a higher twist component is taken from models, allows us to use data in the whole available range in diffractive mass and gives a stable answer for the leading twist contribution. An extrapolation to the Tevatron range is compared with CDF data on single diffraction.

1 Introduction

It is now experimentally well established at HERA [1,2] that a substantial fraction of ep events is contributable to diffraction, i.e. color singlet exchange, initiated by a highly virtual photon. The idea of a point-like structure of the Pomeron exchange [3] opens the way to the determination of its parton (quark and gluon) distributions, where the Pomeron point-like structure can be treated in a similar way as the proton one [4].

2 Extraction of parton distributions in the Pomeron

As indicated in the following equation :

$$F_2^{D(3)}(Q^2,\beta,x_{\mathbb{P}}) = f_{\mathbb{P}/\mathrm{p}}(x_{\mathbb{P}})F_2^{\mathbb{P}}(Q^2,\beta) + f_{\mathbb{R}/\mathrm{p}}(x_{\mathbb{P}})F_2^{\mathbb{R}}(Q^2,\beta) \qquad (1)$$

the diffractive structure function $F_2^{D(3)}$ can be investigated in the framework of Regge phenomenology. In this parameterisation, $F_2^{\mathbb{P}}$ can be interpreted as the Pomeron structure function and $F_2^{\mathbb{R}}$ as an effective Reggeon structure function, with the restriction that it takes into account various secondary Regge contributions which can hardly be separated. Moreover, it has been suggested that the Q^2 evolution of these structure functions may be understood in terms of parton dynamics [3], i.e. as coming from leading twist, perturbative QCD contributions where parton densities are evolved according to DGLAP equations.

A simple prescription is adopted in which the parton distributions of both the Pomeron and the Reggeon are parameterised in terms of non-perturbative input distributions at some low scale $Q_0^2 = 3$ GeV^2.

The pion structure function [5] is assumed for the sub-leading Reggeon trajectory with a free global normalization to be determined by the data.

For the Pomeron, a quark flavour singlet distribution ($zS_q(z,Q^2) = u + \bar{u} + d + \bar{d} + s + \bar{s}$) and a gluon distribution ($zG(z,Q^2)$) are parameterized in terms of coefficients $C_j^{(S)}$ and $C_j^{(G)}$ at $Q_0^2 = 3$ GeV^2.

$$zS(z, Q^2 = Q_0^2) = \left[\sum_{j=1}^{3} C_j^{(S)} \cdot P_j(2z-1)\right]^2 \cdot e^{\frac{0.01}{z-1}} \quad (2)$$

$$zG(z, Q^2 = Q_0^2) = \left[\sum_{j=1}^{3} C_j^{(G)} \cdot P_j(2z-1)\right]^2 \cdot e^{\frac{0.01}{z-1}} \quad (3)$$

where $z = x_{i/\mathbb{P}}$ is the fractional momentum of the Pomeron carried by the struck parton, $P_j(\zeta)$ is the j^{th} member in a set of Chebyshev polynomials, which are chosen such that $P_1 = 1$, $P_2 = \zeta$ and $P_{j+1}(\zeta) = 2\zeta P_j(\zeta) - P_{j-1}(\zeta)$.

The trajectory intercepts are fixed to $\alpha_{\mathbb{P}} = 1.20$, $\alpha_{\mathbb{R}} = 0.62$ for H1 and $\alpha_{\mathbb{P}} = 1.13$ for ZEUS. No sub-leading trajectory is needed to fit ZEUS data [4]. Only data points with $Q^2 \geq 3$ GeV^2, $\beta \leq 0.65$, $M_X > 2$ GeV and $y \leq 0.45$ are included in the fit in order to avoid large higher twist effects and the region that may be most strongly affected by a non-zero value of R. The resulting parton densities of the Pomeron are presented in figure 1 with the values of χ^2/dof.

3 Global fits

Then, we have tried to refine these QCD fits by extending the number of data points included into the procedure. The problem is that the cuts described above are essential to avoid the experimental domain where non-perturbative power contributions could be large and we cannot suppress these cuts without subtracting in another way these power contributions (or higher-twist terms). However, some parametrizations for higher-twist contributions have been proposed [6,7] after a dedicated analysis of H1 data.

We use these parametrizations to subtract the higher twist component from the $F_2^{D(3)}$ measurements at high β and we redo the QCD analysis with all data points included. The resulting parton densities of the Pomeron are in

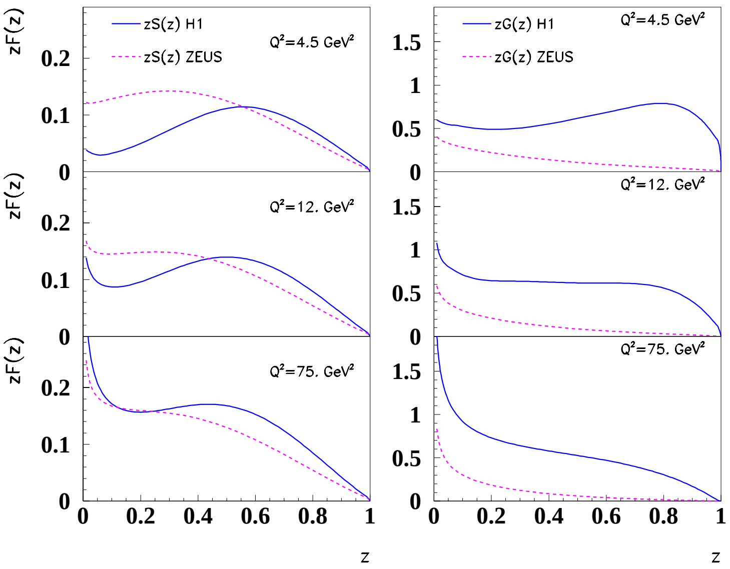

Figure 1. Quark flavour singlet (zS, left) and gluon (zG, right) distributions of the Pomeron derived from H1 diffractive data ($\chi^2/dof = 177.1/154 = 1.15$, full lines) and ZEUS diffractive data ($\chi^2/dof = 29.3/(30-6) = 1.22$, dashed lines).

perfect agreement with those presented in figure 1. Moreover, the statistical significance of the global QCD fits is increased.

4 Extrapolation to Tevatron and comparison with CDF data

The QCD fits we have obtained from HERA data allow us to make direct comparisons for measurements at the Tevatron. It is quite interesting to be able to directly test factorization breaking between HERA and the Tevatron using the measurements performed at both accelerators. We thus compare the extrapolations of the H1 and ZEUS QCD fits to the recent CDF diffractive jet cross-section measurement [8]. We note a large discrepancy both in shape and normalization between H1 predictions and CDF data, clearly showing factorization breaking. However, the ZEUS fits are more compatible in normalization with the CDF measurement even if the shape is not described properly. More precise data from HERA and more detailed comparisons with Tevatron are thus needed to study precisely factorization breaking between both experiments.

5 Conclusions

We have proposed of a new NLO DGLAP fit to the diffractive structure functions. We have obtained parton distributions for the Pomeron using H1 and ZEUS data. They both require a large gluon component inside the Pomeron but the gluon densities are quite different. Using a parametrisation for the higher twist contribution to F_2^D allows us to get a description of the full set of data using the NLO DGLAP evolution equations, and leads to the same parton distributions as before. The same difference leads to diverging extrapolations for single diffraction at the Tevatron. The ZEUS-based extrapolation leads to a possible compatibility with factorization at least in the small β (large diffractive mass) range.

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