The F_2^D Logarithmic Slope and the Saturation Phenomena

M. V. T. Machado

Instituto de Fisica, Universidade Federal do Rio Grande do Sul
Av. Bento Gonçalves, 9500. CEP 91510-970, Porto Alegre, RS. Brazil

Abstract. The logarithmic slope of the diffractive structure function, F_2^D, is a potential observable scanning the hard and soft contributions in diffraction, allowing to disentangle the QCD dynamics. We report our calculations concerning this quantity, in particular the estimates emerging from the saturation model applied to diffraction dissociation.

THE DIFFRACTIVE SLOPE

The measurements of the derivative quantity F_2-slope on Q^2 allowed a renewed interest of testing the matching of hard and soft approaches and provided constraints for the saturation formalisms.The reported turnover on the x dependence was readily associated with the transition region between the interplaying domains. The most recent determinations of the slope still deserve a better theoretical description, keeping a turnover pattern at fixed c.m.s. energy W. When we focus in diffractive DIS (DDIS), i.e. the structure function F_2^D, the situation is far from clear: initially considered as a predominantly soft process, the experimental results suggest that the diffractive cross section at HERA contains hard and soft components. Fortunately, if we consider the pQCD approach, diffraction stands a more profitable field to study saturation effects than the inclusive case. This comes from the fact that in DDIS the interaction probes larger dipole size configuration (soft content) than in the DIS reaction. We have proposed a derivative quantity, the F_2^D slope, which would help to disentangle the underlying dynamics in DDIS, settling its validity range, if such observable is measured. In Ref. [1] one perform studies of the proposed quantity for two sound models, representing the essential features in both Regge and pQCD formalisms. It was found that important deviations in the predictions between the models emerge, considering the available kinematic spectrum in diffractive DIS [2]. Here we report in particular the calculations considering the saturation pQCD model applied to diffraction dissociation and its comparison with the non-satured QCD approach, performed in details in Ref. [3].

In perturbative QCD, the $\gamma^* p$ process is described in terms of the photon splitting into a $q\bar{q}$ pair, far upstream of the nucleon, which then scatters in the proton. This reaction is mediated by the one gluon exchange which turns out into a multi-gluon one when the saturation region is approached. For transverse and longitudinally polarized photons the

CP631, *New States of Matter in Hadronic Interactions,* edited by H.-T. Elze et al.

$\gamma^* p$ cross section in the color dipole picture has the form

$$\sigma_{T,L}(x,Q^2) = \int d^2\mathbf{r} \int_0^1 d\alpha \, |\Psi_{T,L}(\alpha,\mathbf{r})|^2 \, \hat{\sigma}(x,r^2)\,, \qquad (1)$$

where $\Psi_{T,L}$ are the photon wavefunctions. The $q\bar{q}$ cross section, $\hat{\sigma}$, contains strong non-perturbative contributions which should be modeled. We choose the saturation model[4], which reproduces the experimental results at both inclusive and diffractive electroproduction. The dynamics of saturation is present in the effective dipole cross section in an eikonal way $\hat{\sigma}(x,r^2) = \sigma_0 \left[1 - \exp\left(-\frac{r^2}{4R_0^2(x)}\right)\right]$, where the x-dependent saturation scale is $R_0(x) = \frac{1}{Q_0}\left(\frac{x}{x_0}\right)^{\lambda/2}$. The parameters were determined from HERA data on F_2 and photoproduction cross section with $x < 10^{-2}$. Going to DDIS, the elastic scattering of the $q\bar{q}$ pair dominates the diffractive $\gamma^* p$ process for not too large values of the diffractive mass M_X. Instead, at large M_X the emission of a gluon becomes the leading contribution. The diffractive cross section is written in the color dipole picture, given the slope B_D, as

$$\sigma^D(x,Q^2) = \frac{1}{B_D}\frac{1}{16\pi} \int d^2\mathbf{r} \int_0^1 d\alpha \, |\Psi_{T,L}(\alpha,\mathbf{r})|^2 \, \hat{\sigma}^2(x,r^2)\,. \qquad (2)$$

The diffractive structure function is derived from Eq. (2) in the momentum space. We numerically calculated the F_2^D slope, using the same parameters values from Ref.[4]. In Fig. (1), one shows the $x_{I\!P}$ behavior for the approaches with (GW)[4] and without saturation (BW)[5], at typical β values. We analyze in particular the transition region between hard and soft dynamics ($Q^2 \sim 1.5 - 9$ GeV^2). The saturation model produces a transition between positive and negative slope values at low $\beta = 0.04$, while presents a positive slope for medium and large β. The pQCD approach without saturation[5], shows a positive slope for the whole Q^2 and $x_{I\!P}$ range. In the pQCD models without saturation, an ad hoc cutoff in the transverse momentum loop integration is inserted, as well as the energy dependence of the unintegrated gluon distribution. In the saturation model, instead, the saturation radius $R_0(x)$ gives the infrared cutoff (the saturation momentum scale) and determines the energy dependence. If this scale is large (1-2 GeV^2), then the resulting process is not soft and can be completely calculated using pQCD methods. Therefore, the saturation model extends the pQCD approach towards lower Q^2 values. We conclude that, the difference between the behaviors predicted by these two models for the $x_{I\!P}$ spectrum, mainly in the region of small β and medium Q^2, is large and which should allow to discriminate the dynamics in future experimental analyzes.

ACKNOWLEDGMENTS

The author thanks the Organizers of this lively meeting and the enjoyable discussions with J. Raufeisen, J. Osborne, E. Luna and M.A. Betemps. I am grateful to V.P. Gonçalves who collaborated in a joint way to obtain the results presented here.

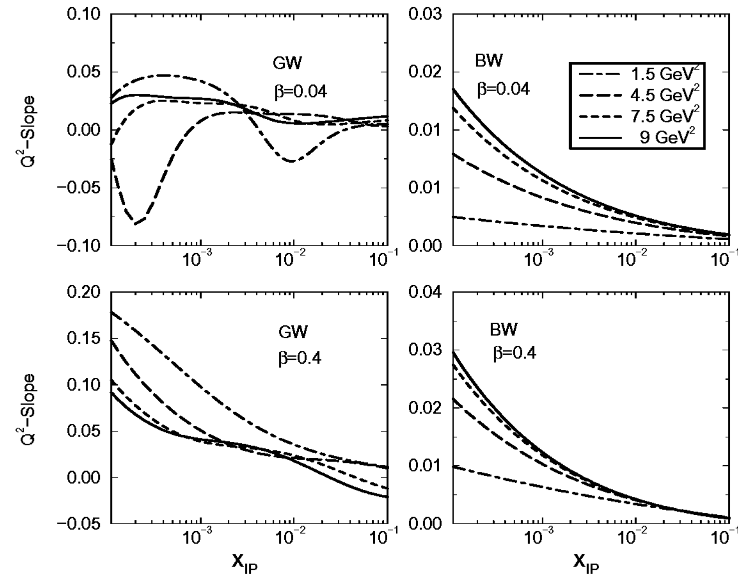

FIGURE 1. The $x_{I\!P}$ dependence on the logarithmic slope for the pQCD model (BW) and the the saturation model (GW) presented at typical β values.

REFERENCES

1. M.B. Gay Ducati, V.P. Gonçalves, M.V.T. Machado, *Phys. Lett.* **B506**, 52 (2001).
2. M.B. Gay Ducati, V.P. Gonçalves, M.V.T. Machado, in Proc. IXth Blois Workshop, Pruhonice near Prage, June 9-15 (2001) [hep-ph/0110025]; in Proc. XXXIth ISMD, Datong, China, Sep. 1-7 (2001) [hep-ph/0111444].
3. M.B. Gay Ducati, V.P. Gonçalves, M.V.T. Machado, *Nucl. Phys.* **A697**, 767 (2002).
4. K. Golec-Biernat, M. Wüsthoff, *Phys. Rev.* **D59**, 014017 (1999); *Phys. Rev.* **D60**, 114023 (1999).
5. J. Bartels, M. Wüsthoff, *J. Phys. G: Nucl. Part. Phys.* **22**, 929 (1996); J. Bartels, C. Royon, *Mod. Phys. Lett.* **A14**, 1583 (1999).