Diffractive processes in electron-proton and proton-proton collisions

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Abstract. In this paper we give a brief description of diffractive processes. We focus on *ep* collisions at HERA and outline key features of exclusive diffraction in hadron-hadron collision. We discuss respectively: diffractive parton distributions of the proton obtained from DGLAP fits to HERA data, including the twist–4 contribution, afterwards diffractive charm production from dipole model and at the end shortly exclusive production of a Higgs boson in pp scattering.

Keywords: pomeron, diffractive parton distributions, diffractive longitudinal structure function, survival factor, Higgs boson
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INTRODUCTION

Significant progress in understanding diffractive processes has been made at the *ep* collisions at HERA [1, 2], where the electron radiates a virtual photon, which then interacts with the proton. In these processes the incoming proton stays intact after the scattering, losing a small fraction of its initial momentum. In addition to the scattered incident particles, a diffractive system forms which is well separated in rapidity from the scattered proton is produced. In the t-channel picture, the diffractive interactions can be viewed as a vacum quantum number exchange between the diffractive system and the proton. Such a mechanism was termed a *pomeron*. There are various interpretations of this diffractive phenomenon, but very appealing one relies upon a partonic interpretation of the structure of the pomeron [3]. It is possible to describe well the diffractive cross section data from HERA [1, 2], by the QCD DGLAP evolution of parton distribution in the pomeron combined with a Regge parametrisation of flux factor [4].

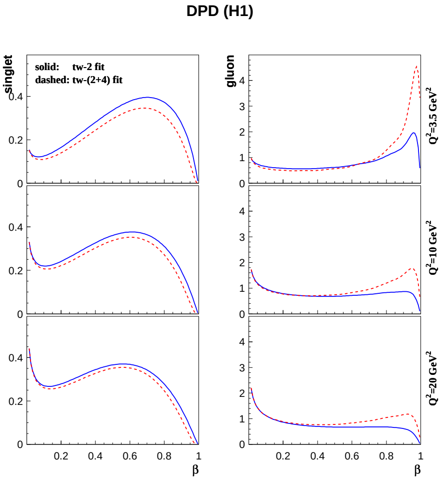
DIFFRACTIVE PARTON DISTRIBUTIONS FROM FITS TO H1 DATA

The DPDs which we obtained recently [4] from fits to H1 data in the two scenarios: with and without higher twist component, are shown in Fig. 1. We plot the distributions $\beta\Sigma_{I\!P}(\beta,Q^2)$ and $\beta g_{I\!P}(\beta,Q^2)$ for several values of Q^2. We see that the quark distributions are practically the same while the gluon distribution from the fit with higher twist is strongly peaked near $\beta = 1$.

This somewhat surprising result can be understood by analyzing the logarithmic slope of F_2^D for fixed β. From the DGLAP equations, we schematically have

$$\frac{\partial F_2^D}{\partial \ln Q^2} \sim P_{qq}\otimes \Sigma_{I\!P} + P_{qG}\otimes G_{I\!P} - \Sigma_{I\!P}\int P_{qq} \qquad (1)$$

where the negative term sums virtual corrections. For large β, the measured slope is negative which means that the negative term in eq. (1) must dominate over the positive ones. The addition of the higher twist contribution to F_2^D, proportional to powers of $1/Q^2$, contributes negative value to the slope. This has to be compensated by a larger gluon distribution near $\beta = 1$ in the second term on the r.h.s. of eq. (1) in order to describe the same data.

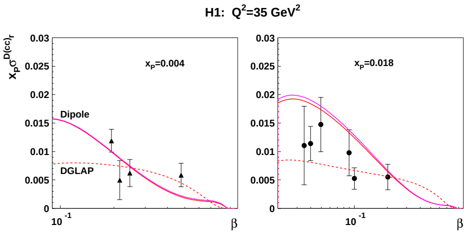


1: DPDs from fits to H1 data.

The main result of our analysis in paper [4] is a new prediction for the diffractive longitudinal structure function F_L^D. The twist–4 term in F_L^D makes this prediction significantly different in the region of large β from that found in the pure DGLAP analysis. A measurement of F_L^D at HERA in this region of β should confirm the presented expectations which are based on the perturbative QCD calculations.

Diffractive Charm production

Regarding the diffractive processes at HERA we considered recently two most popular parametrizations of the interaction between the diffractive system and the proton in the dipole models- the GBW [5] and CGC [6, 7] parametrizations which are based on the idea of parton saturation in dense gluon systems. We extracted diffractive parton distributions from the dipole model formule and compare them with those obtained from the DGLAP fits to the HERA data.The gluon distributions from the two approaches were used to make predictions for the diffractive charm production which is shown in Fig. 2.We found that this contribution to F_2^D is significant in both approaches, especially for large values of β (up to 30%). We also found good agreement with the open charm production data from HERA.



2: Predictions for diffractive charm production.

DIFFRACTION AT TEVATRON AND LHC

The difference between diffraction at HERA and the Tevatron is that diffraction can occur not only on either p or $\overline{p}$ side as at HERA, but also on both sides. It has been shown that the dPDFs of HERA can not be used directly to make predictions at the Tevatron. In fact, diffractive hard-scattering factorization does not apply to hadron-hadron collision because of soft interactions between spectator partons(often referred as multiple scatterings). They can produce additional final-state particles which fill the would-be rapidity gap (hence the often -used term "rapidity gap survival") [8]. A main challenge in the description of exclusive diffraction in hadron-hadron collisions for example exclusive production of a Higgs bosons is to account for secondary interactions between incident partons. It is very important that in particular, a Tevatron or LHC diffractive gluon denisity could be extracted including $defacto$ the survival gap probability.

CONCLUSIONS

The theoretical description of diffractive processes is a real challenge since it must combine perturbative QCD effect of hard scattering with nonperturbative phenomenon of rapidity gap formation. Many aspects of these processes in ep collisions can be successfully described in QCD if a hard scale is present. The obtained diffractive parton distributions in our last analysis can also be used in the analysis of diffractive processes at the LHC, in particular, to the estimation of the bacground to the diffractive Higgs production, see [9] for a recent discussion. Open diffractive charm production which we shortly discuss in this paper is very sensitive to the form of a diffractive gluon distribution, which are central input in description exclusive diffraction. Diffractive processes may provide a clean environment to study or even discover the Higgs boson at the LHC.

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