Working Group on Diffraction: Executive Summary

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Abstract
We give a brief overview of the topics covered in the working group on diffraction.

1 Introduction

From 2006 to 2008, the working group on diffraction had 74 individual presentations, documenting the considerable activity and progress in the field. This program covered a variety of topics: the presentation and assessment of new data from HERA and the Tevatron [1–5], developments in the theory of diffraction in ep and in pp or $p\bar{p}$ collisions [6–15], and the ongoing preparatory studies for measuring diffractive processes at the LHC [16–20]. Many presentations were related in one way or another to the prospect of seeing central exclusive production of the Higgs boson, $p + p \to p + H + p$, or of other new particles. Important progress has been made in this field since the first proceedings of the HERA/LHC workshop [21] appeared, both on the side of instrumentation at LHC and in the understanding of the relevant theory, with crucial input provided by new measurements from the H1, ZEUS, and CDF Collaborations. In the following we give a brief overview of the different topics presented in these proceedings and of their interrelation.

2 Diffraction from electron-proton to hadron-hadron collisions

A key result of the numerous studies of diffraction at HERA is that in the presence of a hard scale several diffractive channels can be understood in terms of a partonic description, which allows us to calculate important features of the process in perturbation theory. This concerns the inclusive cross section for diffractive deep inelastic scattering [1] as well as diffractive jet or heavy flavor production from a highly virtual photon [2, 9]. The increasingly precise HERA results for these channels are well described in terms of perturbatively calculated hard-scattering coefficients and of diffractive parton densities. The latter are a special case of fracture functions [6] and, just as the usual parton densities, have been fitted to data.

It has long been anticipated from theory and seen in data that such a simple factorized description is not valid in diffractive hadron-hadron collisions, and recent results from HERA and the Tevatron have corroborated this finding. Secondary interactions between partons of the colliding hadrons significantly decrease the fraction of events with large rapidity gaps, and it remains a challenge to quantitatively understand the dynamics of these interactions [7, 8] at the LHC. Let us recall that the associated physics is closely related to that of multiple parton interactions and hence of importance far beyond the context of diffractive final states [21]. Similar rescattering effects are also expected in ep collisions when the exchanged photon becomes quasi real, not only for diffraction but also for events with an observed leading baryon [3]. The situation here seems, however, to be more complicated than initially thought due to the double nature of a real photon as a pointlike and a hadronic object. Based on the same data, the two contributions [2] and [9] to these proceedings draw conflicting conclusions about the magnitude of rescattering effects in diffractive photoproduction. The study of additional experimental observables, such as double differential distributions or certain ratios should help clarify the situation.

A wealth of information about high-energy dynamics can be gained from the detailed experimental studies of exclusive diffraction at HERA, notably of exclusive production of a vector meson or a real photon [4]. Precise data for such channels in particular provide good constraints on the generalized gluon distribution [10], which not only carries valuable information about proton structure at small momentum fractions but is also a key ingredient for calculating central exclusive production in pp or $p\bar{p}$ collisions. Ultraperipheral collisions at LHC offer the prospect to study exclusive diffraction initiated by a real photon at energies well beyond the HERA regime [11]. Suitable exclusive channels may also provide clear signals for odderon exchange, which, although naturally arising within the QCD picture of high-energy collisions, have been conspicuously absent from data so far [12].

Finally, the combined consideration of ep data for both inclusive and exclusive diffraction and for non-diffractive events remains maybe the best strategy for clarifying the importance of parton saturation at HERA, i.e., of non-linear dynamical effects due to high parton densities [13]. To understand such dynamics at the quantitative level remains one of the great challenges in high-energy QCD, and there is hope that the huge phase space available in pp collisions at LHC can be harnessed to shed further light on this physics. This remains an ambitious enterprise, requiring measurements at forward rapidities at the LHC [16] and further development of the theory [14].

3 Preparing for diffraction and forward physics at LHC

The opportunities for diffractive and forward measurements at LHC cover a wide area of physics, ranging from the determination of the elastic and total pp cross section at the highest energies yet achieved in the laboratory [17, 18] to the study of both electroweak and strong interactions in $\gamma\gamma$ and γp collisions [11, 16, 19, 20]. High hopes are put into the possibility to observe central exclusive production of new particles such as a light Higgs boson, with the prospect of the precise measurement of their mass, width, and quantum numbers in a very clean environment [20]. The theoretical description of the central exclusive production mechanism involves many difficult issues, and a milestone in testing our understanding of this mechanism has been the observation of exclusive dijet production by CDF [5]. Despite this success, one must keep in mind the uncertainties inherent in extrapolating dynamics from Tevatron to LHC energies, and a number of diffractive measurements have been proposed to validate the theory at an early stage of LHC running [15].

The forward instrumentation currently available at ATLAS, CMS and ALICE will allow a rich program to be carried out in forward and diffractive physics from the very beginning of the data taking. Feasibility studies performed by CMS [16] indicate that measurements of forward jets sensitive to the low-x PDFs of the proton are possible with the first 10 pb^{-1} of integrated luminosity. "Rediscovery" of hard diffraction at the LHC is possible within the first 10–100 pb^{-1}, via single-diffractive production of dijets and W bosons, as well as Υ photoproduction [16]. In addition, exclusive dilepton production can be used for the calibration of the forward detectors and for luminosity determination [16]. TOTEM [17] plans to measure central and single diffractive cross sections, as well as high-t elastic scattering and forward charged particle multiplicities with the first data. A more ambitious joint CMS-TOTEM physics program is foreseen [17] as soon as common CMS and TOTEM data taking is possible. TOTEM [17] and ATLAS [18] will also measure the total and elastic pp cross sections in dedicated runs with special beam optics. A diffractive physics program is also taking shape at ALICE [19], thanks to the particle-identification capability and good acceptance for low-p_T particles of the ALICE detector, along with the lack of pile-up at the ALICE interaction point.

ATLAS and CMS will also be able to carry out a forward and diffractive physics program at the highest LHC instantaneous luminosities if the AFP and FP420 programs are approved [20]. AFP aims at instrumenting with near-beam proton detectors the regions at ± 220 and ± 420 m from the ATLAS interaction point, while FP420 at CMS aims at instrumenting the ± 420 m region to complement existing proton detectors at TOTEM. These additions to ATLAS and CMS will permit the measurement of forward protons down to values of the fractional momentum loss of the proton of $\xi \simeq 0.002$.

In summary, the diffractive community is looking forward to the next years, when the final analysis of HERA data and a variety of measurements at LHC will hopefully teach us valuable lessons on the physics of the strong interaction and beyond.

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