IL NUOVO CIMENTO Vol. 36 C, N. 5 Settembre-Ottobre 2013
DOI 10.1393/ncc/i2013-11597-y

Colloquia: QCDN12

A first universality check of Generalized Parton Distributions

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ricevuto il 18 Aprile 2013

Summary. — Using the so-called Goloskokov-Kroll Generalized Parton Distribution model, based on fits to Deeply Virtual Meson Production data, nucleon form factors and parton distributions, we have performed a systematic evaluation of Deeply Virtual Compton Scattering observables measured at H1, ZEUS, HERMES, as well as Hall A and CLAS at Jefferson Lab. We observe a good agreement, especially in the low to mid-x_B region, justifiying the use of the same GPDs for different processes and thus, their universality property.

PACS 13.60.Le – Meson production.
PACS 13.60.Fz – Elastic and Compton scattering.
PACS 12.39.St – Factorization.

1. – Introduction

The analysis of hard exclusive processes through the use of Generalized Parton Distributions (GPDs) is one of the main interests of modern hadronic physics. It is based on the factorization of these processes into a short-distance (hard) partonic process and long-distance (soft) hadronic matrix elements, parametrized as GPDs. The GPDs contain both the information on longitudinal momentum distributions of the partons inside the nucleon and their transverse localization, allowing for the first time to perform 3D images of the nucleon. The GPDs also give access to the famous Ji's sum rule, relating them to the total angular momenta of the partons inside the nucleon [1]. One of the important properties of GPDs is their universality: indeed, the same GPDs occur for instance in Deeply Virtual Compton Scattering (DVCS), Timelike Compton Scattering (TCS) and Deeply Virtual Meson Production (DVMP). A comprehensive review of Generalized Parton Distributions can be found in ref. [2].

In this talk presented at the Bilbao QCD'N12 workshop, I have shown recent work [3] demonstrating that a GPD model [4] based on fits to Deeply Virtual Meson Production data, nucleon form factors and parton distributions can be used to give a good description of DVCS data in an equivalent kinematical range. These proceedings will give a short summary of the article this talk was based on, and I advise to refer to the original work for more complete information [3].

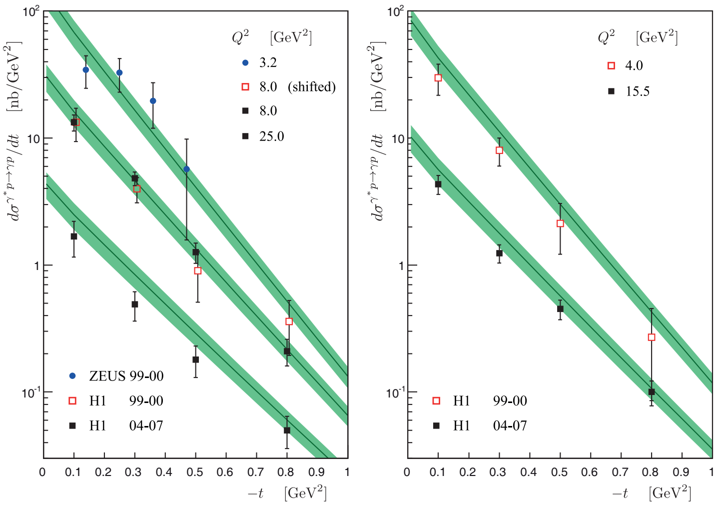

Fig. 1. – Differential DVCS cross section *versus* $-t$ for a set of Q^2 values and large W values ranging from 71 GeV at low Q^2 to 104 GeV at the highest Q^2. Data are taken from refs. [5], where statistical and systematical errors are added in quadrature and normalization uncertainties were ignored. Our predictions are shown as solid lines with errors represented by shadowed bands.

2. – The Goloskokov-Kroll GPD model

The so-called GK model of GPDs is based on the double distribution ansatz [6]: each GPD is the product of a zero-skewness GPD times a profile function which generates its skewness dependence. The zero-skewness GPD contains the GPD forward limit times a Reggeized t-dependence. For GPDs H and $\widetilde{H}$, the forward limit is given by the usual parton distribution, whereas in the other cases, the forward limits are parametrized in a similar manner, but with their parameters adjusted to DVMP data from HERMES, COMPASS, E665, H1 and ZEUS [4]. More details may be found in P. Kroll's talk and proceedings of the QCD'N12 workshop. Note that this model satisfies all known theoretical constraints for GPDs, especially positivity and polynomiality([1]).

3. – Deeply Virtual Compton Scattering observables

The Goloskokov-Kroll GPD model whose parameters were adjusted using DVMP data, was then used to make predictions at leading-order and leading-twist for a large number of DVCS observables from H1, ZEUS, HERMES, Hall A and CLAS [3]. The agreement is very good for almost all the H1, ZEUS and HERMES data which represent the low to mid-x_B region (up to $x_B \sim 0.1$) and only fair for the Jefferson Lab data which are all in the valence x_B region. A selection of three plots are shown on figs. 1–3: the DVCS cross section from H1 and ZEUS, the DVCS beam charge asymmetry from HERMES and the unpolarized and polarized DVCS cross sections from Hall A. In all three cases, the observables are compared to our prediction. As stated before, the agreement is remarkable for H1, ZEUS and HERMES data, as well as the polarized cross sections from Hall A, it is however not as good for the unpolarized cross sections from Hall A,

([1]) The so-called D-term is set to zero however.

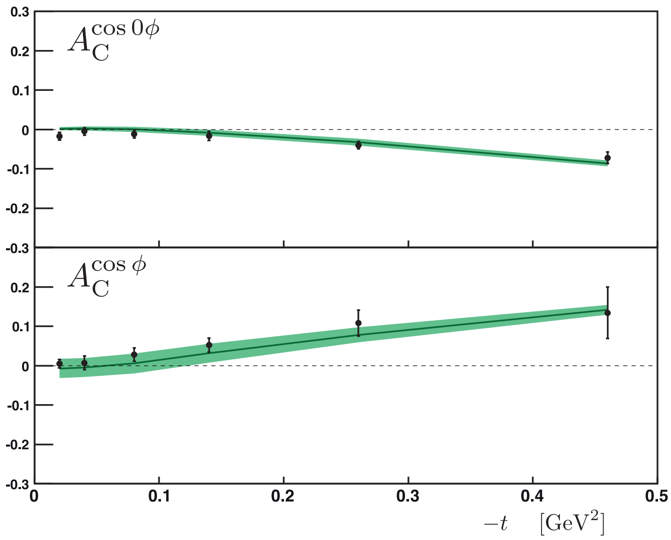

Fig. 2. – The $\cos 0\phi$ and $\cos\phi$ harmonics of the beam charge asymmetry at the kinematical setting $x_B \simeq 0.097$ and $Q^2 \simeq 2.51\,\text{GeV}^2$. Data are taken from HERMES [7], table 6. Our results are shown as solid lines with the shaded areas as the error bands.

potentially pointing to a lack of strength in the real part of GPD H at high x_B. This may be due to the absence of a D-term in the GK model, but may also point to more subtle effects (higher-twist or higher-α_S order). It is however not a surprise considering the parameters of the model were not fit in this x_B region. Note that this feature is confirmed by beam spin asymmetry data from CLAS in a similar x_B domain [8].

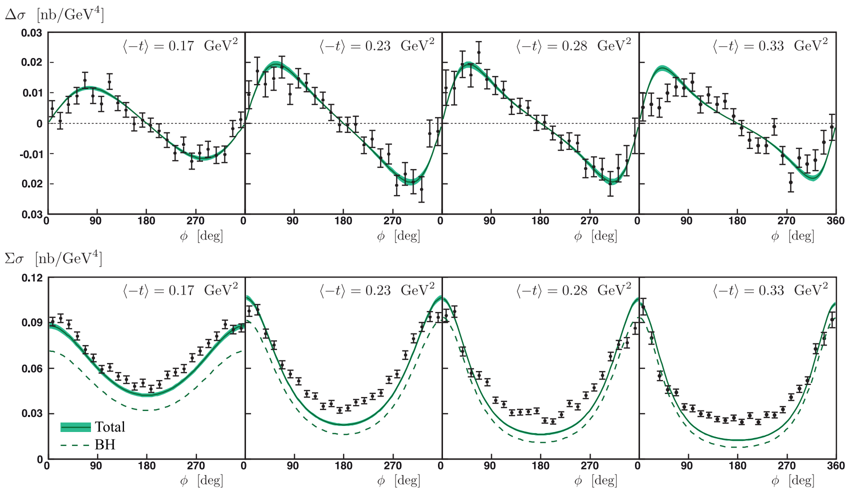

Fig. 3. – Jefferson Lab Hall A helicity-dependent cross section data at and different t bins for $x_B = 0.36$ and $Q^2 = 2.3\,\text{GeV}^2$. The top plots show the differences of cross sections for opposite electron helicities *versus* ϕ whereas the bottom plots show the unpolarized cross section. Data are taken from [9].The Bethe-Heitler contribution to the unpolarized cross section is represented by dashed lines whereas our full results are shown as solid lines with the errors as shadowed bands.

4. – Conclusion

As a necessary and important first step, the universality of a GPD model was tested, using a parametrization extracted from the analysis of DVMP data in a then parameter-free evaluation of DVCS data. The various observables were computed at leading-order of α_S and leading-twist using the so-called Goloskokov-Kroll GPD set. The agreement we observe is remarkable at low and mid-x_B (H1, ZEUS and HERME data) but could be improved at high x_B (Jefferson Lab data). This could be explained by the fact that the model parameters were adjusted against low to mid-x_B DVMP data. Also, no additional D-term has been added, which might change the real part of GPD H at large-x_B. Although improvements of the GPD parametrization is definitely needed to describe the Jefferson Lab data, one should also be wary of higher-order corrections in α_S as well as higher-twist effects, both of which received a lot of attention lately [10, 11].

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I would like to thank the organizers of QCD-N'12 for the invitation to this interesting workshop and I am looking forward to the next edition.

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