Analytic Properties of DPE Amplitudes *or* Collinear Factorisation for Central Exclusive Production

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Analytic and crossing properties of amplitudes of the central exclusive production (CEP) are considered using the formalism of collinear Generalised Parton Distributions (GPDs). The analytic continuation from unphysical region is considered which leads to the finite expression. The natural interpretation of the emerging cuts corresponds to double spectral density in overlapping channel due to the instability of produced particle and inapplicability of Steinmann relations. The relations of CEP amplitudes to the exclusive decay rates are discussed. The direct calculation in physical region results in violation of factorisation similar to the discussed recently for pion transition and electromagnetic form-factors. The similarity between Feynman mechanism for form-factor and Durham model is pointed out.

1 Introduction

Currently the standard QCD mechanism for the diffractive production of heavy central system is provided by the model of Kaidalov, Khoze, Martin and Ryskin (Durham group, KKMR) developed for Higgs production at the LHC (see Refs. [1, 2, 3]). It is nevertheless interesting whether collinear QCD factorisation may be also applied here. This opportunity was discussed earlier [4] at the Blois workshop of 2005 (which marked the 20th anniversary of these meetings).

2 Collinear QCD Factorisation and "Standard" Durham Model

The basic idea is the generation of new hard processes by the "substitution" of Distribution Amplitudes (DA's) by Generalised Parton Distributions (GPD's), which may be considered as a generalised crossing: here not only the momenta of initial and final particles may be interchanged, but their number increased.

The first stage is just the pion form-factor, and the hard meson electroproduction may be considered as a substitution of one of DA's by GPD's. The next stage would be the substitution by another GPD of the remaining DA, so that one gets the amplitude for Central Exclusive Drell-Yan (CEDY) process $p_1p_2 \to p_1'p_2'Q$ (the Abelian counterpart of Higgs production, requiring to change quark GPDs to gluon ones). The explicit calculation of the cross-section in the *physical* region, however, results in the violation of factorisation. However, now this possibility does not seem so dangerous as four years ago. Indeed, the BABAR data (discussed at this meeting by S. Eidelman) may imply the violation of factorisation [5] for pion transition and electromagnetic form-factors. Note that the Feynman mechanism for the pion electromagnetic form-factor, which is supposed to dominate in the case of violation of collinear factorisation,

directly correspond to the KKMR approach, as in both cases the parton with almost zero longitudinal momentum fraction (soft quark or screening gluon with $x' \ll x$) appears. Still,

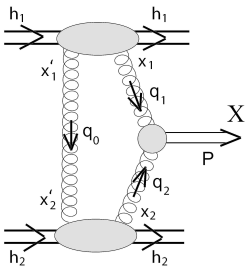

Figure 1: The KKMR mechanism of central exclusive production is similar to Feynman mechanism for form-factors: screening gluon with soft momentum q_0 corresponds to soft quark for form-factor

the direct fit of the collinear factorisation expression regularised by the finite width of gluon propagator may be of interest.

At the same time, the consideration of the unphysical region $|\xi_{1,2}| > 1$, where $\xi_{1,2} = s_{2,1}/s$ and $s_i = (p_i' + Q)^2$, results in the factorised amplitude

$$\mathcal{H}(\xi) = \int_{-1}^{1} dx\, dy \frac{H(x,\xi_1)}{x-\xi_1} \frac{H(y,\xi_2)}{y-\xi_2}. \tag{1}$$

Let us stress that the dimension parameter appearing in CEP amplitude in front of this expression is just the dilepton (or Higgs) mass squared, in complete similarity to momentum transfer Q^2 for pion form-factor. One may [4] recast it in the form of (double and single) subtracted spectral representations. However, the analytic continuation to the physical region is now more subtle, as the cuts in s and s_i provide the different signs for the $\imath\varepsilon$ addition to $\xi_{1,2}$. The symmetric contribution of the combinations of the cuts in s, s_1 and s, s_2 would lead to the pure real amplitude.

At the same time, the double cut in s_1, s_2 is not forbidden by Steinmann relations, as the produced particle (virtual photon or Higgs) is unstable[1]. It is therefore quite natural to perform analytic continuation in a symmetric way: $\xi_{1,2} \to \xi_{1,2} + \imath\varepsilon$. In this case both imaginary and real parts of CEP amplitudes are controlled.

Moreover, the crossing from GPDs to Generalised Distribution Amplitudes (GDA), describing the hard production of hadron pairs, relates the CEP amplitudes to that of exclusive decay of Higgs to two $p\bar{p}$ pairs. For the latter amplitude the region $|\xi_{1,2}| > 1$ (being unphysical for CEP) is a physical one and (1) is applicable. Let us stress, that it is the factorised expression which make this continuation possible, connecting the processes with the very different invariant masses of final state.

3 Conclusions

The possible violation of collinear QCD factorisation in the simplest lepton-pion processes makes the applicability of the (regularised) collinear factorisation to CEP amplitudes less dramatic. At

[1] I am indebted to V.S. Fadin and L.N. Lipatov for the illuminating discussion of this problem.

the same time, the analytic continuation form unphysical region may be performed by relating the cuts in scaling variables $\xi_{1,2}$ to the cuts in overlapping variables which are not forbidden by Steinmann relations. This also allows to obtain a crossing relations between CEP and exclusive decay amplitudes. The similarity between various exclusive amplitudes appearing when non-perturbative inputs are changes provides a new insight for standard KKMR mechanism relating it to Feynman mechanism for pion form-factor.

Acknowledgements

Useful discussions with V.S. Fadin, A.B. Kaidalov, V.A. Khoze and L.N. Lipatov are gratefully acknowledged. This study was partially supported by the Russian Foundation for Fundamental Research, grants No. 09-02-01149, 09-02-00732-, 08-02-00896-.

References

[1] V.A. Khoze, A.D. Martin and M.G. Ryskin, Phys. Lett. B **401**, 330 (1997);
V.A. Khoze, A.D. Martin and M.G. Ryskin, Eur. Phys. J. C **23**, 311 (2002).

[2] A.B. Kaidalov, V.A. Khoze, A.D. Martin and M.G. Ryskin, Eur. Phys. J. C **33**, 261 (2004).

[3] A.B. Kaidalov, V.A. Khoze, A.D. Martin and M.G. Ryskin, Eur. Phys. J. C **31**, 387 (2003) [arXiv:hep-ph/0307064].

[4] O. V. Teryaev, arXiv:hep-ph/0510031.

[5] A. V. Radyushkin, arXiv:0906.0323 [hep-ph].