Wide-angle Compton scattering

P. Kroll
Universitaet Wuppertal

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As argued in [1, 2] for large Mandelstam variables $s, -t, -u$ the center-of-mass helicity amplitudes of wide-angle Compton scattering factorize in a hard subprocess, $\gamma q \to \gamma q$, and in form factors that represent $1/x$ moments of GPDs:

$$\begin{aligned} R_V(t) &= \sum e_q^2 \int_0^1 \frac{\mathrm{d}x}{x} \left[H_v^q(x,t) + 2H^{\bar{q}}(x,t)\right], \\ R_T(t) &= \sum e_q^2 \int_0^1 \frac{\mathrm{d}x}{x} \left[E_v^q(x,t) + 2E^{\bar{q}}(x,t)\right], \\ R_A(t) &= \sum e_q^2 \int_0^1 \frac{\mathrm{d}x}{x} \left[\widetilde{H}_v^q(x,t) + 2\widetilde{H}^{\bar{q}}(x,t)\right]. \end{aligned} \tag{1}$$

This factorization which is a generalization of the handbag factorization for deeply virtual exclusive processes, is achieved in a symmetric frame where skewness is zero. The form factors are mildly scale dependent as is discussed in [3]. This scale dependence may be ignored. The Compton form factors can be evaluated from the valence-quark GPDs determined in [3] in an analysis of the nucleon form factors exploiting the sum rules. The results for the form factors, including their parametric uncertainties, are shown in Fig. 1 for $-t \gtrsim 2$ GeV^2. The sea-quark contribution to these form factors can safely be since we are only interested in the large $-t$ region.

In the handbag approach the wide-angle cross section reads [2, 4]

$$\frac{d\sigma}{dt} = \frac{\pi\alpha_{\rm elm}^2}{s^2}\frac{(s-u)^2}{-us}\left[R_V^2(t) - \frac{t}{4m^2}R_T^2(t) + \frac{t^2}{(s-u)^2}R_A^2(t)\right]. \tag{2}$$

In Fig. 2 results for the Compton cross section are shown for several values of s and compared with the Hall A data [5]. The theoretical results include next-to-leading order QCD corrections [3, 6] and an estimate of the uncertainties due to the finite proton mass, see [3]. The theoretical results are only shown for $-t$ and $-u$ larger than 2.5 GeV^2. Despite the fact that the agreement with the Hall A data [5] is not perfect in particular in the forward hemisphere, one may consider these results as a remarkable success - in a parameter-free calculation the deviations between experiment and theory are less than about 30%

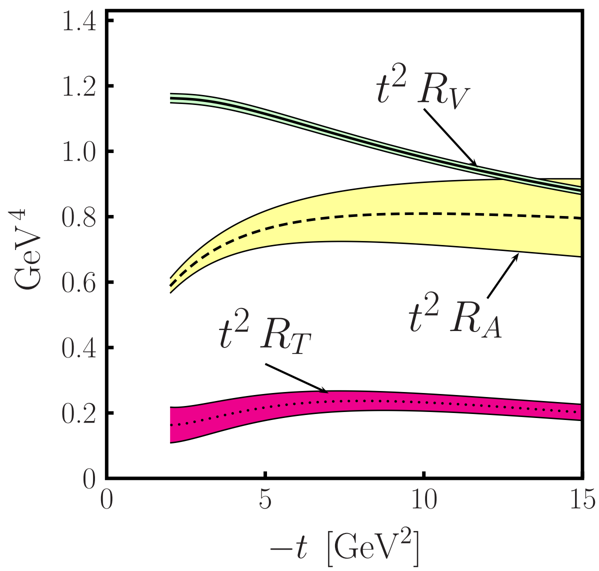

Figure 1: The Compton form factors evaluated from the default fit at the scale $\mu = 2$ GeV. The form factors are scaled by t^2; their dimension is GeV^4.

at values of the Mandelstam variable which are not much larger than typical hadronic scales (here 2 times the nucleon mass squared). Another remarkable result is obtained for the correlation parameter A_{LL} (K_{LL}) between the helicities of the incoming photon and the incoming (outgoing) proton [4, 6]. As a consequence of the neglect of quark masses one has $A_{LL} = K_{LL}$ in the handbag approach. To a good approximation the correlation parameters are given by the ratio of R_A and R_V times a known kinematical factor which approximately is the corrsponding correlation parameter ($\hat{A}_{LL}$) for the subprocess $\gamma q \to \gamma q$. Also this prediction is in fair agreement with a measurement [7] at the rather low energy of $s = 6.9$ GeV^2. Particularly noteworthy is the sign of the correlation parameter. In most other hard physics approaches to wide-angle Compton scattering (e.g. [8]) A_{LL} comes out almost mirror-symmetric to the handbag result.

Measurements of wide-angle Compton scattering at high energies are interesting. One may compare with predictions and probe factorization. This process is complementary to DVCS in so far as in the first process GPDs are probed at large t while the second one probes the small $-t$ behavior. For studying the transverse localization of partons for which a Fourier transform from the momentum transfer Δ ($\Delta^2 = t$) to the impact parameter is required, knowledge of the GPDs over a large range of t is essential.

References

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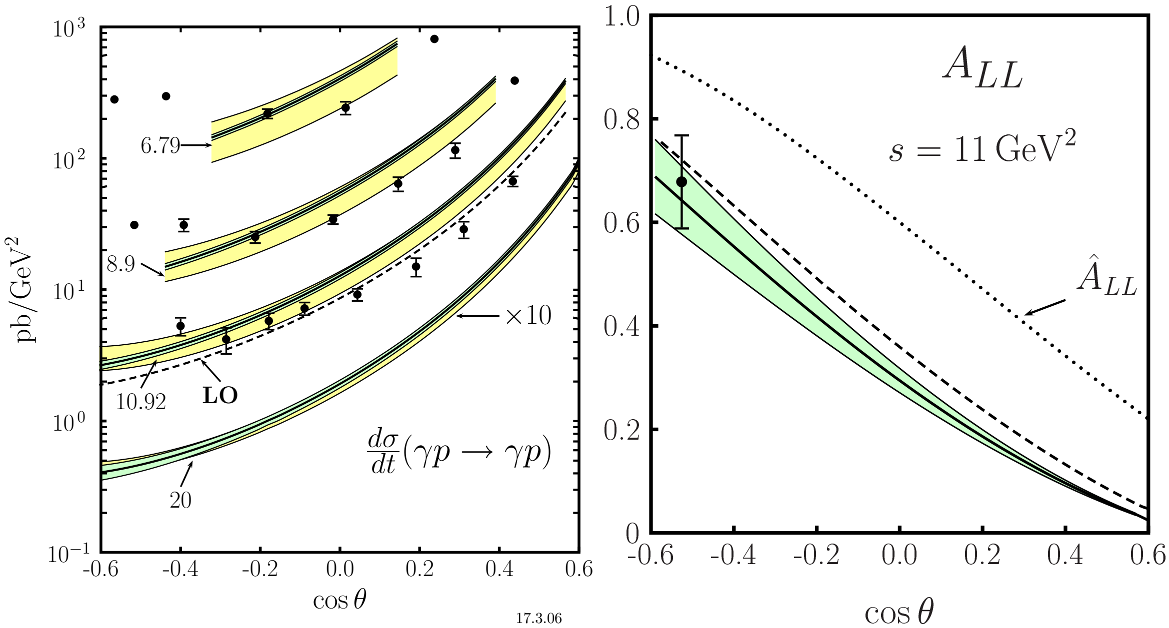

Figure 2: Left: The Compton cross section at several values of s evaluated from the Compton form factors shown in Fig. 1. Data taken from [5]. The green error bands represent the parametric uncertainties of the form factors while the yellow bands include uncertainties due to target mass corrections. Right: The A_{LL} parameter. Data (on K_{LL}) taken from [7] measured at $s = 6.9$ GeV^2.

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