Information Content of the DVCS amplitude

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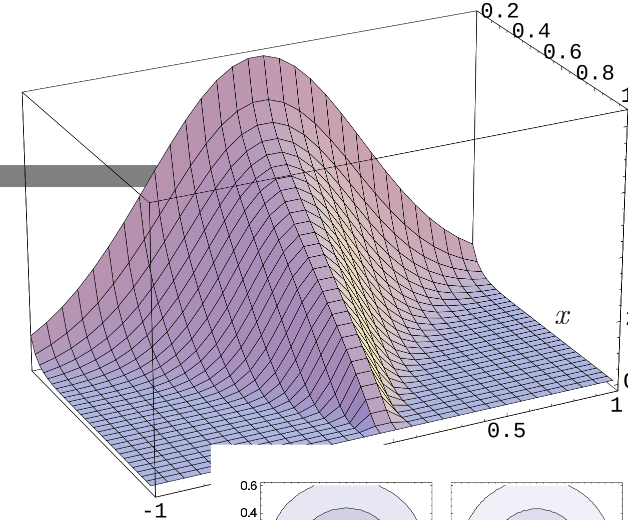
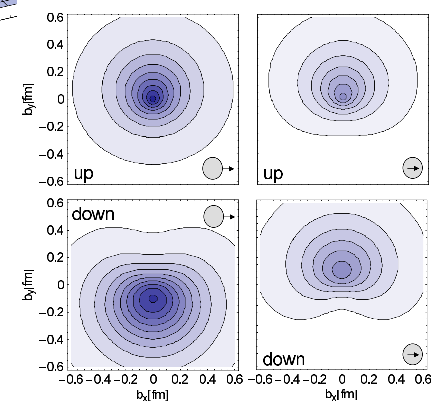
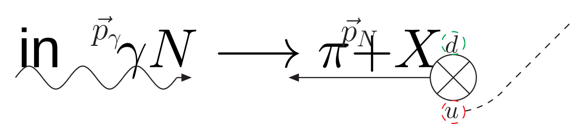
GPDs are cool





- $J_q = \frac{1}{2}\int dx\, x\, [H(x,\xi,0) + E(x,\xi,0)]$
- Transverse imaging:
  - $H(x,0,-\mathbf{\Delta}_\perp^2) \longrightarrow q(x,\mathbf{b}_\perp)$
  - $\tilde{H}(x,0,-\mathbf{\Delta}_\perp^2) \longrightarrow \Delta q(x,\mathbf{b}_\perp)$
  - $E(x,0,-\mathbf{\Delta}_\perp^2) \longrightarrow \perp$ distortion of PDFs when the target is $\perp$ polarized
- Chromodynamik lensing and $\perp$ single-spin asymmetries (SSA)

  transverse distortion of PDFs $+$ final state interactions $\Big\} \Rightarrow \perp$ SSA in $\gamma N \longrightarrow \pi + X$



  - Sivers/Boer-Mulders asymmetry
- Quark Gluon Correlations ($g_2(x)$) $\longrightarrow \perp$ force on quarks in DIS
- But: DVCS $\overset{?}{\rightsquigarrow}$ GPDs

$\mathcal{A}_{DVCS} \overset{?}{\rightsquigarrow} GPDs$

- Ji relation $J_q = \int_0^1 dx x \left[H(x,\xi,0) + E(x,\xi,0)\right]$ requires $GPDs(x,\xi,0)$ for (common) fixed ξ for all x
- transverse imaging requires GPDs for $\xi = 0$
- $\mathcal{A}_{DVCS}(\xi,t) \longrightarrow \int_{-1}^1 dx \frac{GPD^{(+)}(x,\xi,t)}{x-\xi+i\varepsilon}$
  - ξ longitudinal mometum transfer on the target $\xi = \frac{p^{+\prime}-p^+}{p^{+\prime}+p^+}$
  - x (average) momentum fraction of the active quark $x = \frac{k^{+\prime}+p^+}{p^{+\prime}+p^+}$
- $\Im \mathcal{A}_{DVCS}(\xi,t) \longrightarrow GPD^{(+)}(\xi,\xi,t)$
  - only sensitive to 'diagonal' $x = \xi$
  - limited ξ range, e.g. $-t = \frac{4\xi^2 M^2 + \mathbf{\Delta}_\perp^2}{1-\xi^2}$ implies $\xi > \xi_{min}$ for fixed t
- $\Re \mathcal{A}_{DVCS}(\xi,t) \longrightarrow \int_{-1}^1 dx \frac{GPD^{(+)}(x,\xi,t)}{x-\xi}$ probes GPDs off the diagonal, but ...

$\mathcal{A}(\xi,t) \longleftrightarrow GPD^{(+)}(\xi,\xi,t),\ \Delta(t)$

- (Anikin, Teryaev, Diehl, Ivanov, ...): dispersion relation for DVCS amplitude

$$\Re\mathcal{A}(\nu,t,Q^2) = \frac{\nu^2}{\pi}\int_0^\infty \frac{d\nu'^2}{\nu'^2}\frac{\Im\mathcal{A}(\nu',t,Q^2)}{\nu'^2-\nu^2} + \Delta(t,Q^2)$$

- In combination with LO factorization ($\mathcal{A} = \int_{-1}^{1} dx \frac{H(x,\xi,t,Q^2)}{x-\xi+i\varepsilon}$)

$$\Re\mathcal{A}(\xi,t,Q^2) = \int_{-1}^{1} dx \frac{H(x,\xi,t,Q^2)}{x-\xi} = \int_{-1}^{1} dx \frac{H(x,x,t,Q^2)}{x-\xi} + \Delta(t,Q^2)$$

- Earlier derived from polynomiality (Goeke,Polyakov,Vanderhaeghen)

$\hookrightarrow$ ‘Condense’ information contained in $\mathcal{A}_{DVCS}$ (fixed Q^2) into $GPD(x,x,t,Q^2)$ & $\Delta(t,Q^2)$

$$\mathcal{A}(\xi,t,Q^2) \leftrightarrow \begin{cases} GPD(\xi,\xi,t,Q^2) \\ \Delta(t,Q^2) \end{cases}$$

$\mathcal{A}(\xi,t) \longleftrightarrow GPD(\xi,\xi,t)$, $\Delta(t)$

- $\Re\mathcal{A}(\xi,t) = \int_{-1}^{1} dx \frac{H(x,\xi,t)}{x-\xi}$ probes GPDs for $x \neq \xi$, but new information can be 'projected back' onto diagonal plus D-term!
- remaining 'new' (not in $\Im\mathcal{A}$) info on GPDs after 'projecting back' onto diagonal:
  - D-form factor
  - constraints from $\int dx \frac{GPD(x,x,t)}{x-\xi}$ on $GPD(\xi,\xi,t)$ in kinematically inaccessible range $\xi < \xi_{min}$ & $\xi > \xi_{max}$
- Information away from diagonal ($x = \xi$): Q^2 evolution: changes x distribution in a known way for fixed ξ

DVCS $\rightsquigarrow GPD(x,\xi,t)$ (a mathematical exercise)

$$GPD(x,\xi,t,Q^2) = (1-x^2)\sum_{n=0}^{\infty} C_n^{3/2}(x) \sum_{m=0(even)}^{n} a_{nm}(\xi)\mathcal{C}_{n-m}(\xi,t,Q^2)$$

- $C_n^{3/2}(x)$ Gegenbauer polynomials; $a_{nm}(\xi)$ known polynomial
- $\mathcal{C}_k(\xi,t,Q^2)$ unknown, but evolve with known power $\sim \gamma_k$ of $\alpha_s(Q^2)$
- consider $x=\xi$ (relabel: $k=n-m$)

$$GPD(\xi,\xi,t,Q^2) = (1-\xi^2)\sum_{k=0}^{\infty} \mathcal{C}_k(\xi,t,Q^2) f_k(\xi) \tag{1}$$

with $f_k(\xi) = \sum_{m=0(even)}^{\infty} a_{m+k,m}(\xi) C_{m+k}^{3/2}(\xi)$ known function.

- for fixed ξ, each term in (1) evolves with different γ_k

$\hookrightarrow$ from Q^2-dependence of $GPD(\xi,\xi,t,Q^2)$ (fixed ξ and t) over 'wide' range of Q^2, in principle possible to determine $\mathcal{C}_k(\xi,t,Q^2)$

$\hookrightarrow$ $GPD(x,\xi,t,Q^2)$ for $x \neq \xi$ model-independently!

Application of $\int_{-1}^{1} dx \frac{H(x,\xi,t)}{x-\xi} = \int_{-1}^{1} dx \frac{H(x,x,t)}{x-\xi} + \Delta(t)$

- take $\xi \to 0$ (should exist for $-t$ sufficiently large)

$$\int_{-1}^{1} dx \frac{H^{(+)}(x,0,t)}{x} = \int_{-1}^{1} dx \frac{H^{(+)}(x,x,t)}{x} + \Delta(t)$$

$\hookrightarrow$ DVCS allows access to same generalized form factor $\int_{-1}^{1} dx \frac{H^{(+)}(x,0,t)}{x}$ also available in WACS (wide angle Compton scattering), but t does not have to be of order Q^2

$\hookrightarrow$ after flavor separation, $\frac{1}{F_1(t)} \int_{-1}^{1} dx \frac{H^{(+)}(x,0,t)}{x}$ at large t provides information about the 'typical x' that dominates large t form factor

Discussion

- DVCS at fixed Q^2 insufficient to fix GPDs off the diagnal $x = \xi$
- in principle, Q^2-evolution provides access off the diagonal, but
  - need to be sure that higher twist is negligible...
  - polynomial expansion poorly convergent at small x, i.e. in applcations need expansion that converges better (dual?)
  - noise?