Extraction of GPDs observables

ANN meeting

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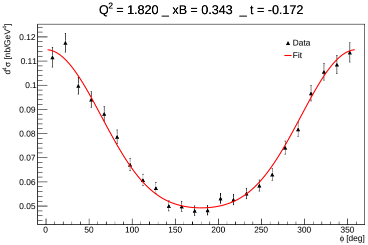
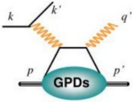
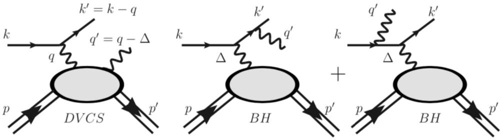
General Problem

$$F = f(\underbrace{k, Q^2, x_B, t}_{kinematics}, \phi)$$





$$ep \longrightarrow e' p' \gamma$$

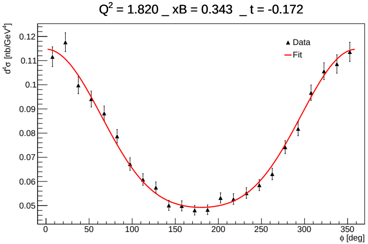


$$\frac{d^5\sigma}{dx_{Bj}dQ^2d|t|d\phi d\phi_S} = \frac{\alpha^3 x_B y^2}{16\pi^2 Q^4\sqrt{1+\epsilon^2}}\frac{1}{e^6}\left[|\mathcal{T}^{BH}|^2 + |\mathcal{T}^{DVCS}|^2 + \mathcal{I}\right] .$$

General Problem

$$F = f(\underbrace{k, Q^2, x_B, t}_{kinematics}, \phi)$$

- Unknown parameters (CFFs)
- Model dependent
  - VA formulation (Pseudo-data 1, 2)
    - Written in terms of helicity amplitudes.
    - Covariant description.
  - BKM (2002) formulation (Pseudo-data 3)
    - Previous formulation widely adopted.
    - Written in terms of harmonics of the azimuthal angle, ϕ, and in kinematic powers of 1/Q



Extraction Methods

Least Squared Fits and Neural Networks:

- Locally: Take each kinematic bin independently of the others.
- Globally: Take all kinematic bins at the same time.

BH cross section

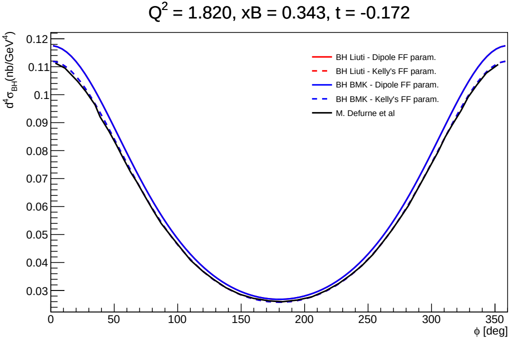
VA

$$\left|\mathcal{T}^{BH}\right|^2 = \frac{1}{t}\left[A(y,x_{Bj},t,Q^2,\phi)\left(F_1^2+\tau F_2^2\right) + B(y,x_{Bj},t,Q^2,\phi)\tau G_M^2(t)\right]$$

BKM

$$\left|\mathcal{T}_{BH}\right|^2 = \frac{e^6}{x_B^2 y^2 (1+\epsilon^2)^2 t \mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left\{ c_0^{BH} + c_1^{BH}\cos(\phi) + c_2^{BH}\cos(2\phi)\right\}$$

$\left|\mathcal{T}^{BH}\right|^2$ is exactly known



Pure DVCS cross section

BKM

$$
\begin{aligned}
\left|\mathcal{T}_{DVCS}\right|^2 &= \tfrac{e^6}{y^2Q^2} c_0^{DVCS} \\
&= \frac{e^6}{y^2Q^2}\left\{2(2-2y-y^2)\right\} C_{unp}^{DVCS}(\mathcal{F},\mathcal{F}^*)
\end{aligned}
$$

$$
\begin{aligned}
C_{unp}^{DVCS}(\mathcal{F},\mathcal{F}^*) = \frac{1}{(2-x_B)^2}\Bigg\{ & 4(1-x_B)\left[(\Re e\mathcal{H})^2 + (\Im m\mathcal{H})^2 + (\Re e\widetilde{\mathcal{H}})^2 + (\Im m\widetilde{\mathcal{H}})^2\right] \\
& - x_B^2 \frac{t}{4M^2}\left[\left(\frac{4M^2}{t} + \frac{(2-x_B)^2}{x_B^2}\right)\left[(\Re e\mathcal{E})^2 + (\Im m\mathcal{E})^2\right] + (\Re e\widetilde{\mathcal{E}})^2 + (\Im m\widetilde{\mathcal{E}})^2\right]\Bigg\} \\
& - 2x_B^2\left(\Re e\mathcal{H}\Re e\mathcal{E} + \Im m\mathcal{H}\Im m\mathcal{E} + \Re e\widetilde{\mathcal{H}}\Re e\widetilde{\mathcal{E}} + \Im m\widetilde{\mathcal{H}}\Im m\widetilde{\mathcal{E}}\right)
\end{aligned}
$$

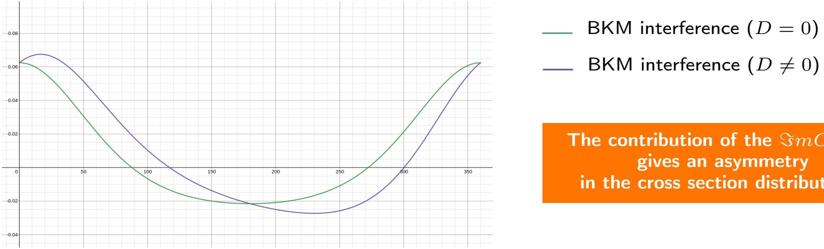
VA

$$
\begin{aligned}
\left|\mathcal{T}_{DVCS}\right|^2 = \frac{1}{Q^2(1-\epsilon)} 4\Bigg[& (1-\xi^2)\left[(\Re e\mathcal{H})^2 + (\Im m\mathcal{H})^2 + (\Re e\widetilde{\mathcal{H}})^2 + (\Im m\widetilde{\mathcal{H}})^2\right] \\
& + \frac{t_o - t}{2M^2}\left[(\Re e\mathcal{E})^2 + (\Im m\mathcal{E})^2 + \xi^2(\Re e\widetilde{\mathcal{E}})^2 + \xi^2(\Im m\widetilde{\mathcal{E}})^2\right] \\
& - \frac{2\xi^2}{1-\xi^2}\left(\Re e\mathcal{H}\,\Re e\mathcal{E} + \Im m\mathcal{H}\Im m\mathcal{E} + \Re e\widetilde{\mathcal{H}}\,\Re e\widetilde{\mathcal{E}} + \Im m\widetilde{\mathcal{H}}\Im m\widetilde{\mathcal{E}}\right)\Bigg]
\end{aligned}
$$

- Pure DVCS is constant at this approximation.

Substituting the Fourier harmonics, the squared amplitude can be written in a similar way to Liuti's formulation:

$$\frac{x_B y^3 t \mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}{e^6}\mathcal{I}^{BMK} = A\,(x_B, t, Q^2, \phi)\big(F_1 \Re e\mathcal{H} - \frac{t}{4M^2}F_2 \Re e\mathcal{E}\big)$$
$$+ B\,(x_B, Q^2) G_M \big(\Re e\mathcal{H} + \Re e\mathcal{E}\big) + C\,(x_B, t, Q^2, \phi) G_M \Re e\widetilde{\mathcal{H}}$$
$$+ D\,(x_B, t, Q^2, \phi)\big(F_1 \Im m\mathcal{H} - \frac{t}{4M^2}F_2 \Im m\mathcal{E} + \frac{x_B}{(2-x_B)}\Im m\widetilde{\mathcal{H}}\big)$$



The contribution of the $\Im m CFFs$ gives an asymmetry in the cross section distribution.

$$Q^2|t|\mathcal{I}^{Liuti} = A_{UU}^{\mathcal{I}}\,(F_1 \Re e\mathcal{H} + \tau F_2 \Re e\mathcal{E}) + B_{UU}^{\mathcal{I}}\,G_M\,(\Re e\mathcal{H} + \Re e\mathcal{E}) + C_{UU}^{\mathcal{I}}\,G_M \Re e\widetilde{\mathcal{H}}$$

BH-DVCS interference cross section

Substituting the Fourier harmonics, the squared amplitude can be written in a similar way to Liuti's formulation:

$$\frac{x_B y^3 t \mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}{e^6}\mathcal{I}^{BMK} = A\,(x_B, t, Q^2, \phi)\Big(F_1 \Re e\mathcal{H} - \frac{t}{4M^2}F_2 \Re e\mathcal{E}\Big)$$

$$+\ B\,(x_B, Q^2) G_M \big(\Re e\mathcal{H} + \Re e\mathcal{E}\big) +\ C\,(x_B, t, Q^2, \phi) G_M \Re e\widetilde{\mathcal{H}}$$

$$A\,(x_B, t, Q^2, \phi) = -8\frac{K^2(2-y)^3}{(1-y)} - 8(2-y)(1-y)(2-x_B)\frac{t}{Q^2} - 8K(2-2y+y^2)\cos\phi$$

$$B\,(x_B, t, Q^2) = 8(2-y)(1-y)\frac{x_B^2}{(2-x_B)}\frac{t}{Q^2}$$

$$C\,(x_B, t, Q^2, \phi) = \frac{x_B}{(2-x_B)}\left[A(x_B, t, Q^2, \phi) + \frac{(2-x_B)^2}{x_B^2}B(x_B, t, Q^2)\right]$$

$$Q^2|t|\mathcal{I}^{Liuti} = A^{\mathcal{I}}_{UU}\,(F_1\Re e\mathcal{H} + \tau F_2 \Re e\mathcal{E}) + B^{\mathcal{I}}_{UU}\,G_M\,(\Re e\mathcal{H} + \Re e\mathcal{E}) + C^{\mathcal{I}}_{UU}\,G_M \Re e\widetilde{\mathcal{H}}$$