The Transverse Nucleon Single-Spin Asymmetry for the Semi-Inclusive Production of Photons in Lepton-Nucleon Scattering

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With M. Schlegel & A. Prokudin

Introduction

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- Difficult to extract information.

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- EIC

The Process

$$l(l) + N(P) \rightarrow l(l') + \gamma\left(P_\gamma\right) + X$$

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Features of the Process

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Features of the Process

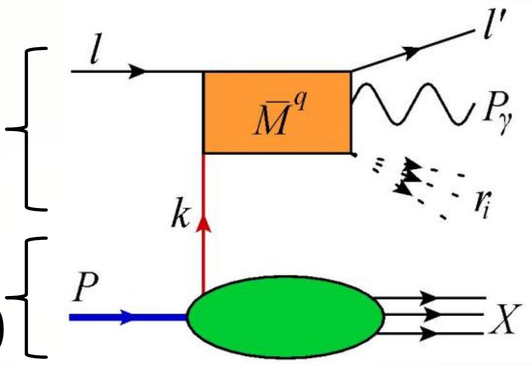
- Non-vanishing transverse SSA under time-reversal symmetry.
- The only non-perturbative objects generating the transverse SSA are the qgq correlation functions in the nucleon.

1. Unpolarized Cross Section

- Apply factorization procedure to the amplitude.

Hard Scattering
(perturbation theory)

Soft Part
(hadronic matrix element)



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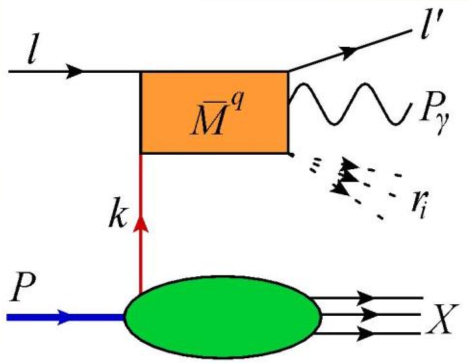
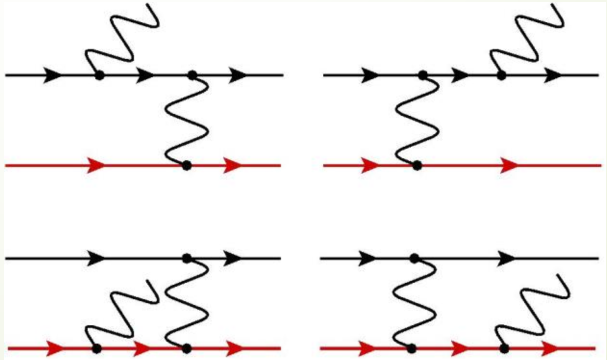


- LO diagrams for the hard scattering amplitude.

Bethe-Heitler contributions

Compton contributions



The Final Formula for the Unpolarized Differential Cross Section

$$\boldsymbol{D\sigma_U^{LO} = \frac{\alpha_{em}^3}{4\pi^2 s Q^4} \sum_{k=BH,C,I} \hat{\sigma}_U^k f_1^k(x_B)}$$

Where:

$$D\sigma = E' E_\gamma \frac{d\sigma}{d^3\vec{l}'\, d^3\vec{P}_\gamma}$$

$$s = (P + l)^2$$

$$x_B = \frac{Q^2}{2P.q}$$

$$Q^2 = -q^2$$

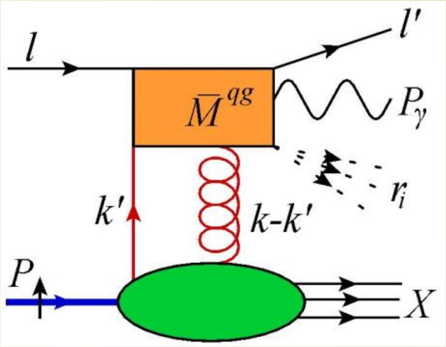
$$q = l - l' - P_\gamma$$

$$f^{BH} \equiv \sum_q e_q^2 (f^q + f^{\bar{q}})$$

$$f^C \equiv \sum_q e_q^4 (f^q + f^{\bar{q}})$$

$$f^I \equiv \sum_q e_q^3 (f^q - f^{\bar{q}})$$

2. Polarized Cross Section



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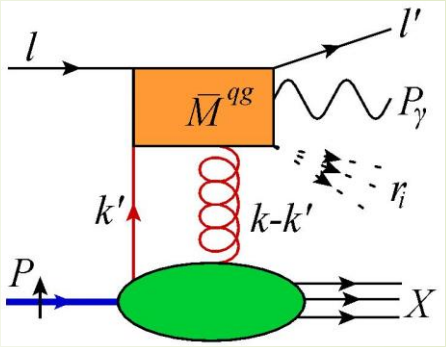

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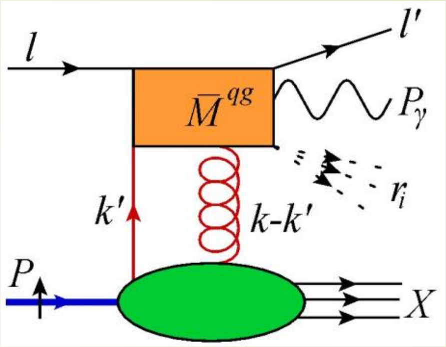

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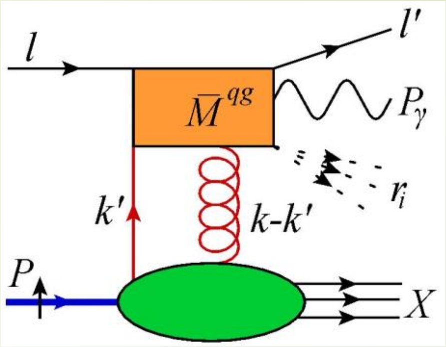

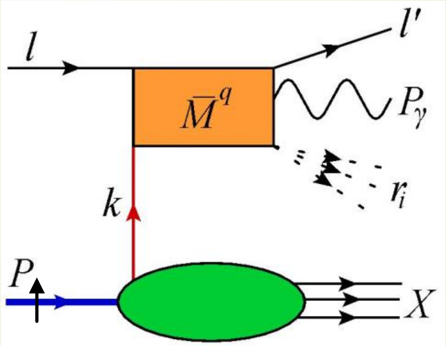

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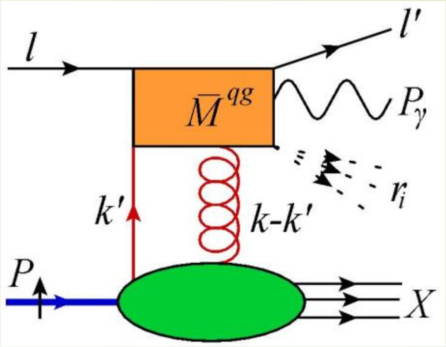
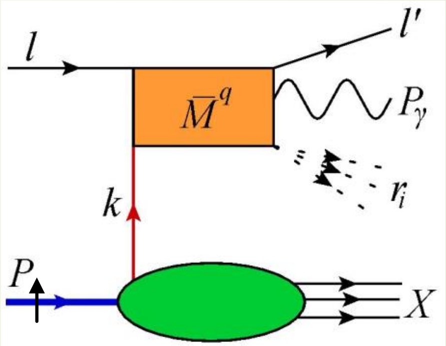
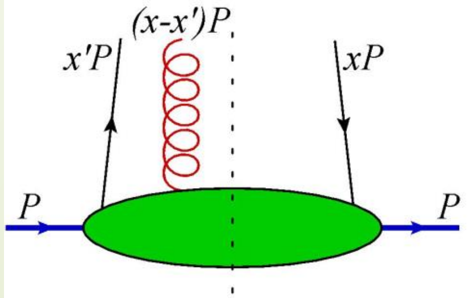
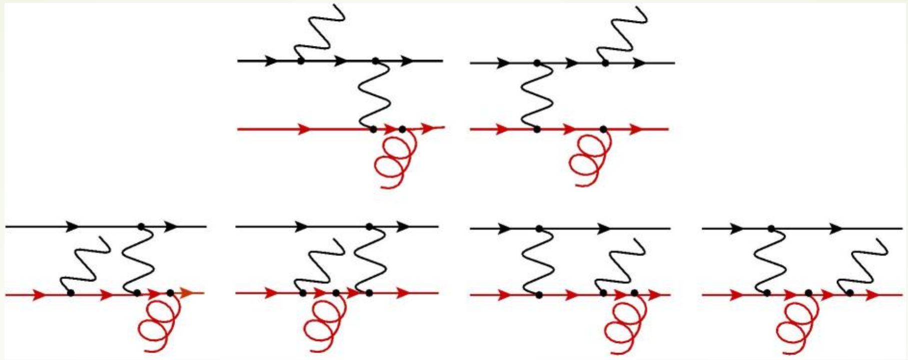
- **Dynamical contributions:** generated by qgq correlations (qgq correlation functions $F_{FT}(x,x'), G_{FT}(x,x')$).







- The LO diagrams for the quark-gluon hard amplitude:



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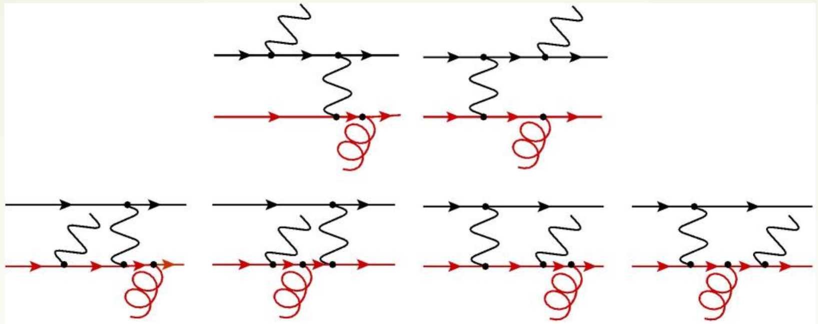

- We encounter three types of propagators:

$$\frac{1}{(k'+q)^2+i\epsilon}=\frac{x_B}{Q^2}(\frac{\mathcal{P}}{x'-x_B}-i\pi\delta(x'-x_B))$$ → **Soft-gluonic pole (SGP)**

$$\frac{1}{(k'+\tilde{q})^2+i\epsilon}=\frac{\tilde{x}_B}{\tilde{Q}^2}(\frac{\mathcal{P}}{x'-\tilde{x}_B}-i\pi\delta(x'-\tilde{x}_B))$$ → **Hard pole (HP)**

$$\frac{1}{(k'-P_\gamma)^2+i\epsilon}=-\frac{1}{\gamma Q^2}(\frac{\mathcal{P}}{x'}+i\pi\delta(x'))$$ → **Soft-fermionic pole (SFP)**

Where $\tilde{q}=l-l'$, $\tilde{Q}^2=-\tilde{q}^2$, $\tilde{x}_B=\frac{\tilde{Q}^2}{2P.\tilde{q}}$

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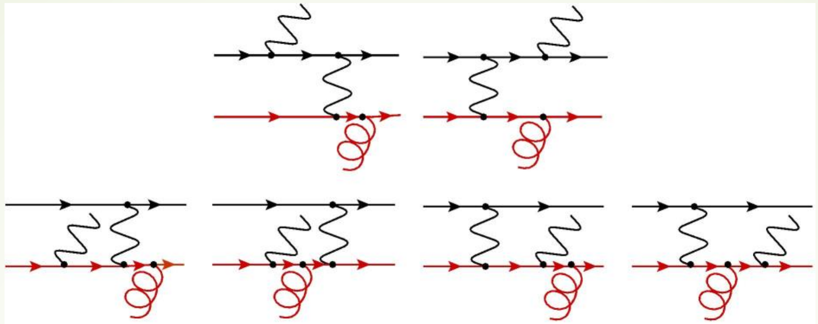

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$$\frac{1}{(k'-P_\gamma)^2+i\epsilon} = -\frac{1}{\gamma Q^2}\left(\frac{\mathcal{P}}{x'} + i\pi\delta(x')\right)$$ ➡ **Soft-fermionic pole (SFP)**

Where $\tilde{q} = l - l'$, $\tilde{Q}^2 = -\tilde{q}^2$, $\tilde{x}_B = \frac{\tilde{Q}^2}{2P.\tilde{q}}$

- The SGP cancel when added to the twist-3 kinematical contributions.

$$\pi F_{FT}^{q}(x,x) = f_{1T}^{\perp(1),q}(x)$$

The Formula for the Spin-dependent Cross Section

$$D\sigma_T^{LO}(S) \propto [\sin(\phi_s - \phi')\sigma_{UT}^1 + \sin(\phi_s - \phi^\gamma)\sigma_{UT}^2 + \sin(\phi' - \phi^\gamma)\cos(\phi_s - \phi')\sigma_{UT}^3 + \sin(\phi' - \phi^\gamma)\cos(\phi_s - \phi^\gamma)\sigma_{UT}^4]$$

$$\sigma_{UT}^{i=1,2} = \sum_{k=C,I} [\hat{\sigma}_{HP,F}^{i,k} F_{FT}^k(x_B, \tilde{x}_B) + \hat{\sigma}_{SFP,F}^{i,k} F_{FT}^k(x_B, 0) + \hat{\sigma}_{HP,G}^{i,k} G_{FT}^k(x_B, \tilde{x}_B) + \hat{\sigma}_{SFP,G}^{i,k} G_{FT}^k(x_B, 0)]$$

$$\sigma_{UT}^{i=3,4} = \sum_{k=C,I} [\hat{\sigma}_{HP,G}^{i,k} G_{FT}^k(x_B, \tilde{x}_B) + \hat{\sigma}_{SFP,G}^{i,k} G_{FT}^k(x_B, 0)]$$

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- The transverse SSA is generated by twist-3 dynamical qgq correlations in the nucleon through SFP and HP contributions.
- A point-by-point scan of $F_{FT}(x, x')$ and $G_{FT}(x, x')$.

Thank you for listening