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Phenomenology of the scalar PDF

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Origin and Perspective
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Scalar PDF

$$e^q(x) = \frac{1}{2M} \int \frac{d\lambda}{2\pi} e^{i\lambda x} \langle P|\bar{\psi}_q(0)\psi_q(\lambda n)|P\rangle$$

twist-3 chiral-odd PDF

Through the EOM of QCD:

$$e^q(x) = e^q_{\rm loc}(x) + e^q_{\rm gen}(x) + e^q_{\rm mass}(x)$$

"local" term

genuine qGq interaction

quark mass term

proportional to twist-2 PDFs

not quite WW-like

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$$e^q_{\rm loc}(x) = \frac{1}{2M}\int \frac{d\lambda}{2\pi}\, e^{i\lambda x}\langle P|\bar{\psi}_q(0)\psi_q(0)|P\rangle = \frac{\delta(x)}{2M}\langle P|\bar{\psi}_q(0)\psi_q(0)|P\rangle$$

related to the scalar charge through a singularity:

$$\int_{-1}^{1} dx\, e^q(x, Q^2) = \sigma_q(Q^2)$$

[Schweitzer and Efremov, JHEP08006]
[Ji, NPB 115181]
[Hatta & Zhao, PRD 102]
[Bhattacharya et al., PRD 102]

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$$\int_{-1}^{1} dx\, e^q(x, Q^2) = \sigma_q(Q^2)$$

see talks about SIGMA TERMS

$$\mathcal{M}_n[e^q_{\rm mass}] = \frac{m_q}{M_{\rm N}} \times \begin{cases} 0 & \text{for } n = 1 \\ \mathcal{M}_{n-1}[f_1^q] & \text{for } n > 1 \end{cases}$$

Accessing e(x): beam spin asymmetry in dihadron SIDIS

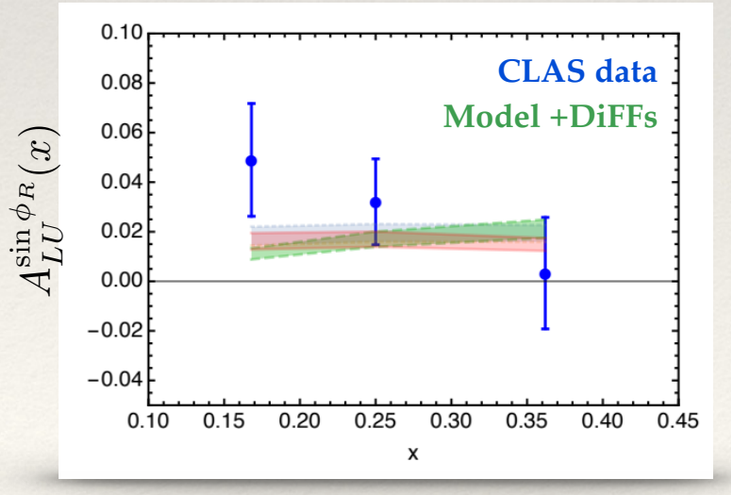
$$A_{LU}^{\sin\phi_R} \propto \frac{\text{twist-3 PDF} \times \text{twist-2 FF} + \text{twist-2 PDF} \times \text{twist-3 FF}}{\text{unpolarized}}$$

$e^q(x)$

$\tilde{G}^{\sphericalangle}$ = genuine twist-3 (unknown)

twist-2 DiFFs & PDFs known

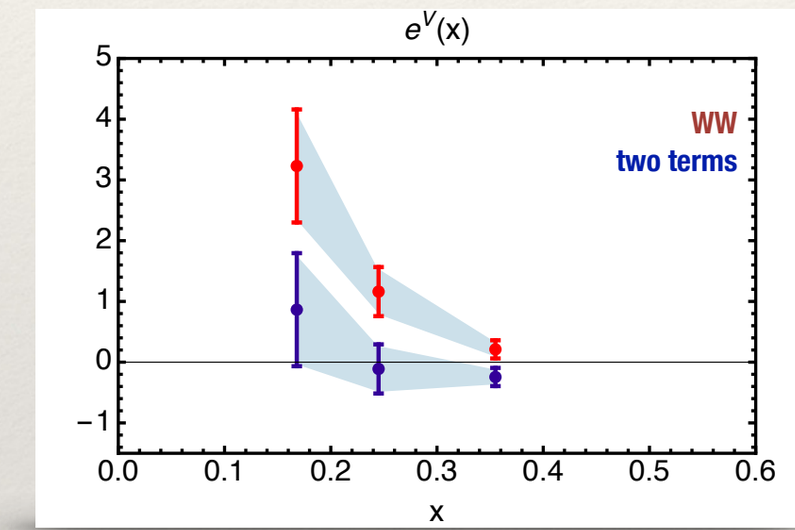
DiFFs: [Radici et al, JHEP1505]
Usual unpolarized PDFs



First available data: [CLAS Coll., 2010.09544] **New!**

Preliminary extraction: [A. Courtoy, 1405.7659]
Updated extraction: work in progress [Avakian, Courtoy, López, Miramontes, Mirazita]

Extraction of e(x)



Preliminary extraction: [A. Courtoy, 1405.7659]
TO BE UPDATED/Work in progress

$$e^V \equiv \frac{4}{9} e^{u_V}(x_i, Q_i^2) - \frac{1}{9} e^{d_V}(x_i, Q_i^2)$$

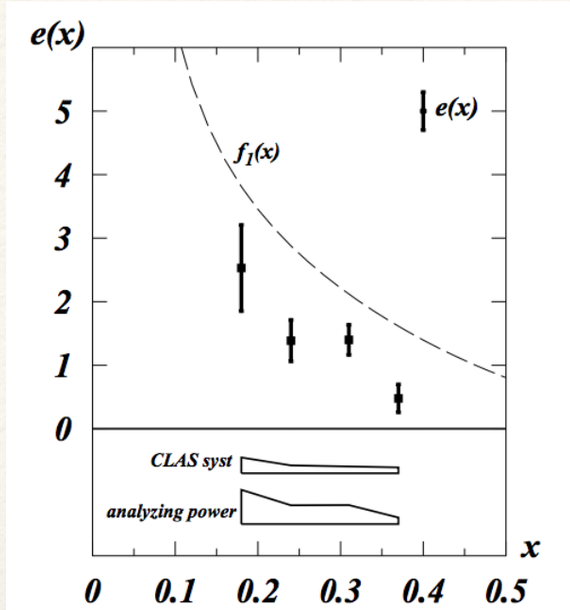


Figure 2: The $e(x) \equiv (e^u + \frac{1}{4} e^{\bar{d}})(x)$ at $\langle Q^2 \rangle = 1.5\,\mathrm{GeV}^2$ vs. x as extracted in [20] from the CLAS data [42]. For comparison is shown the corresponding flavour-combination of $f_1^a(x)$ (from [46]).

[Efremov, Goeke and Schweitzer, PRD67]

More data will lead to valuable info on the mass of the proton.

Upcoming: CLAS12

Proposed as silver measurement for multiparton correlation at **EIC**
see Yellow Report (Ch. 7.1.5)