$F_2$ and $F_L$

how strong are nonlinear effects?

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Can one expect nonlinear effects (saturation) in $F_2$ and $F_L$ at an EIC

- as long as have no data, answer is necessarily model-dependent
- here: use dipole models checked against HERA data ($ep$), adapted to $eA$

$$F_{2,L}(x, Q^2) = \int d^2b \, d^2r \, dz \left[ \psi^*(r, Q^2) \psi(r, Q^2) \right]_{2,L} N(x, r, b)$$

$N = \text{dipole scattering amplitude, between 0 and 1}$

- larger $N$ → expect stronger nonlinear effects to assess typical values of $N$ calculate average:

$$\langle N \rangle_{2,L} = \frac{\int d^2b \, d^2r \, dz \left[ \psi^* \psi \right]_{2,L} N^2}{\int d^2b \, d^2r \, dz \left[ \psi^* \psi \right]_{2,L} N}$$

$F_2$ and $F_L$ how strong are nonlinear effects?
Can we expect nonlinear effects (saturation) in $F_2$ and $F_L$ at an EIC

- to assess typical values of $\mathcal{N}$ calculate average:

$$
\langle \mathcal{N} \rangle_{2,L} = \frac{\int d^2b d^2r dz \left[ \psi^* \psi \right]_{2,L} \mathcal{N}^2}{\int d^2b d^2r dz \left[ \psi^* \psi \right]_{2,L} \mathcal{N}}
$$

- note: $F_2$ and $F_L$ average over all $b$
  - including dilute region of target examples:
    - Gaussian density profile $T(b) = \exp(-b^2/R^2) \Rightarrow \langle \mathcal{N} \rangle \leq 1/2$
    - hard sphere $T(b) = \sqrt{1 - b^2/R^2} \Rightarrow \langle \mathcal{N} \rangle \leq 3/4$

- following plots show $\langle \mathcal{N} \rangle_{2,L}$
  - with kinematic limits in $x, Q^2$ plane
    - for EIC with $E_e = 30$ GeV, $E_A = 130$ GeV, $y \leq 0.9$
    - for HERA ($ep$)
using bCGC dipole cross section:

\begin{align*}
\text{proton, bCGC, } &<N>_{\text{tot}} \\
\text{proton, bCGC, } &<N>_{L} \\
\text{Pb nucleus, bCGC, } &<N>_{\text{tot}} \\
\text{Pb nucleus, bCGC, } &<N>_{L}
\end{align*}

$F_2$ and $F_L$: how strong are nonlinear effects?
using IPSat dipole cross section:

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