Diffractive Deep Inelastic Scattering to Lepton-Proton DIS: Implications for QCD Momentum Sum Rules and Parton Distributions

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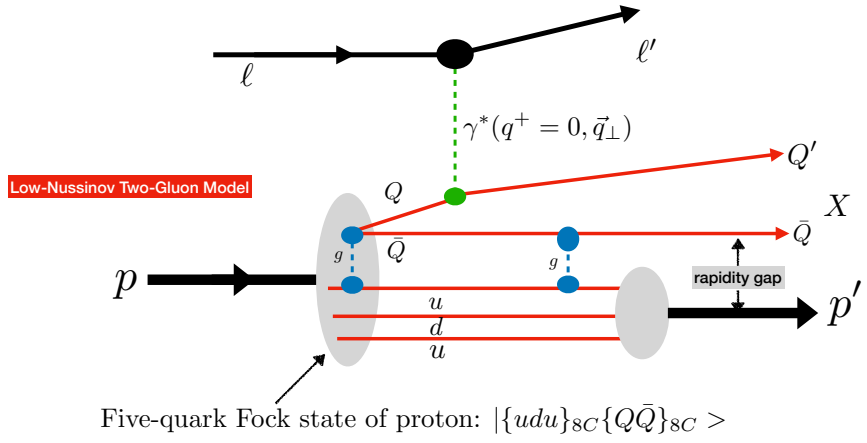
DDIS contribution to Lepton-Proton DIS

- The inclusive cross section for lepton-proton scattering (DIS) $\ell p \to \ell' X$ includes a diffractive deep inelastic (DDIS) contribution $\ell p \to \ell' p' X$, in which the proton remains intact with a large longitudinal momentum fraction x_F greater than 0.9 and small transverse momentum.
- The DDIS events, which can be identified with Pomeron exchange in the t-channel, account for approximately 10% of all of the DIS events.
- In Figure we show a simplified description of the DDIS event $\gamma^* + p_{|uduQ\bar{Q}\rangle} \to p' + X + \text{rapgap}$ based on the two-gluon Low-Nussinov model (PRL34, 1286, PRD12, 164) of Pomeron exchange in the LF framework. Multiple gluons can also propagate between the initial and final gluons. The five-quark Fock state of proton $|\{udu\}_{8C}\{Q\bar{Q}\}_{8C}\rangle$ produces the rapidity gap.



DDIS contribution to Lepton-Proton DIS

- When one measures DIS, one automatically includes the leading-twist DDIS events as a contribution to the DIS cross section, whether or not the final-state proton p' is detected.
- In such events, the missing momentum fraction $x_{p'} \sim 0.9$ carried by the final-state proton p' in the DDIS events could be misidentified with the light-front momentum fraction carried by sea quarks or gluons in the protons' Fock structure.
- The QCD Pomeron-exchange amplitude which produces DDIS events does not obey the operator product expansion (OPE) nor satisfy momentum sum rules (MSR).
- Our framework is supported by the paper Pelicer et al, Eur. Phys. J. C79 (2019) 9.
- Conclusion:

  The quark and gluon distributions measured in a DIS experiment will be misidentified, unless the measurements explicitly exclude the DDIS events, and thus the correct determination of PDFs derived from the DIS data requires the explicit subtraction of the DDIS contribution from full DIS cross section:

$$\boxed{\frac{d\sigma_{\mathrm{DIS_{true}}}}{dxdQ^2} = \frac{d\sigma_{\mathrm{DIS}}}{dxdQ^2} - \frac{d\sigma_{\mathrm{DDIS}}}{dxdQ^2}}$$