Deep inelastic scattering in the dipole picture at next-to-leading order

Henri Hänninen

Particle Physics Day
October 20, 2017

B. Ducloué, H. Hänninen, T. Lappi, and Y. Zhu, *Deep inelastic scattering in the dipole picture at next-to-leading order*, arXiv:1708.07328 [hep-ph].

Contents

Deep inelastic scattering and the dipole picture

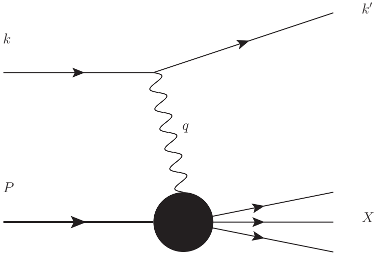

Figure: Deep inelastic scattering.

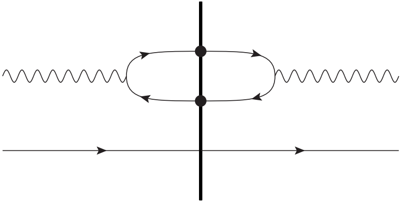

Figure: At small Bjorken-x dipole picture models the target nucleon as Color Glass Condensate, i.e. the virtual photon scatters from a semi-classical color field by fluctuating into a quark-antiquark dipole.

Leading Order DIS in the dipole picture

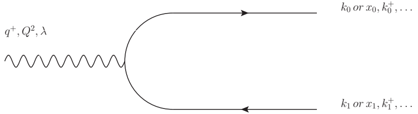

Figure: Leading order virtual photon fluctuation.

Leading Order DIS in the dipole picture

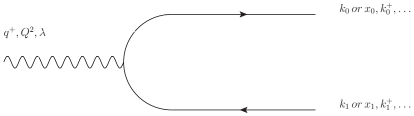

Figure: Leading order virtual photon fluctuation.

Total virtual photon-proton scattering cross section at leading order is

$$\sigma^{\gamma*}_{T,L} = \sum_f \int d^2\mathbf{r} \int_0^1 dz |\Psi^{\gamma*\to q\bar{q}}_{T,L}(\mathbf{x}, z, f)|^2 \sigma^{q\bar{q}}(\mathbf{r}). \tag{1}$$

Leading Order DIS in the dipole picture

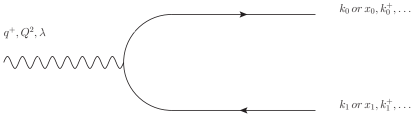

Figure: Leading order virtual photon fluctuation.

Total virtual photon-proton scattering cross section at leading order is

$$\sigma_{T,L}^{\gamma*} = \sum_f \int d^2\mathbf{r} \int_0^1 dz |\Psi_{T,L}^{\gamma* \to q\bar{q}}(\mathbf{x}, z, f)|^2 \sigma^{q\bar{q}}(\mathbf{r}). \tag{1}$$

This LO result has been fit to HERA data using LO BK target evolution with χ^2/d.o.f ~ 1.15, e.g. arXiv:1309.6963 [hep-ph].

NLO: Real diagrams

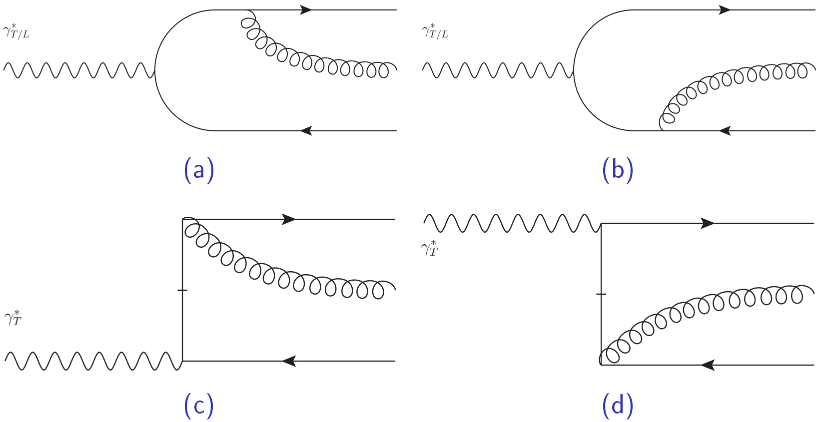

Figure: Virtual photon fluctuation diagrams relevant to the scattering at next-to-leading order where the emitted gluon takes part in the scattering off the color field. At soft limit of the longitudinal momentum of the gluon there is a logarithmic divergence in the NLO total cross section. Calculated by G. Beuf, arXiv:1708.06557 [hep-ph]

NLO: Virtual diagrams

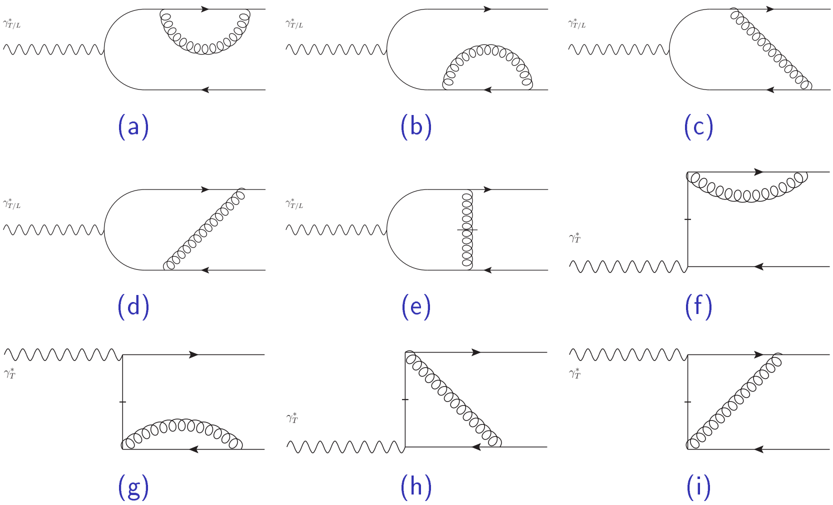

Figure: Loop diagrams relevant at next-to-leading order. These do not contribute to the soft divergence. Calculated by G. Beuf, arXiv:1606.00777 [hep-ph]

Results: Regularization schemes

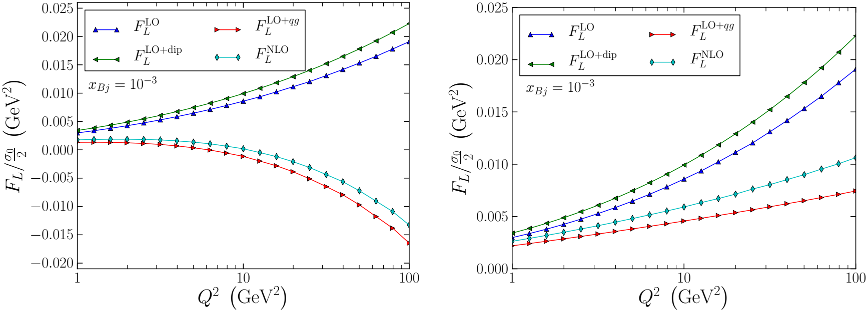

Figure: Comparison of two regularization schemes. NLO result of F_L separated into two parts, (dip) and (qg), latter of which contains the soft divergence. Left: A naive resummation scheme leads to too large (qg) contribution. Right: Results of a working resummation scheme.

Results: Magnitude of corrections

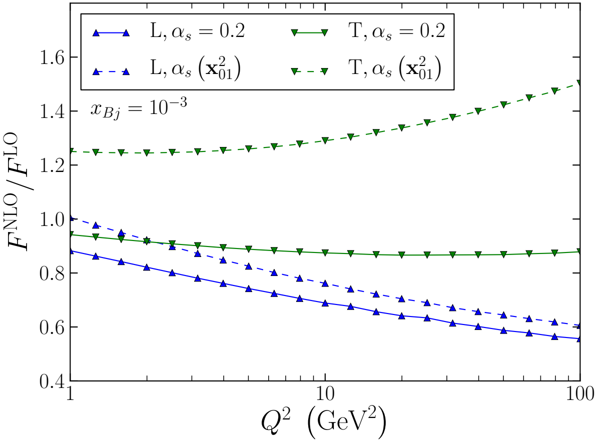

Figure: NLO/LO ratio for F_L and F_T as a function of Q^2 at $x_{\mathrm{Bj}} = 10^{-3}$ with fixed (solid) and parent dipole running (dashed) coupling.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.
- Derivation of NLO impact factors for massless quarks.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.
- Derivation of NLO impact factors for massless quarks.

What we demonstrated in our recent article:

- Factorization of high energy logarithms into BK evolution of the target leading to physical NLO corrections.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.
- Derivation of NLO impact factors for massless quarks.

What we demonstrated in our recent article:

- Factorization of high energy logarithms into BK evolution of the target leading to physical NLO corrections.

To be done:

- Combination of NLO impact factors and NLO BK evolution to get full NLO predictions $\Rightarrow$ first comparison with HERA data.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.
- Derivation of NLO impact factors for massless quarks.

What we demonstrated in our recent article:

- Factorization of high energy logarithms into BK evolution of the target leading to physical NLO corrections.

To be done:

- Combination of NLO impact factors and NLO BK evolution to get full NLO predictions $\Rightarrow$ first comparison with HERA data.
- Extension of impact factor results to heavy quarks.

Summary

What has been done previously:

- Fits to HERA data using LO impact factors and LO BK evolution.
- Numerical solution of NLO BK evolution of the target.
- Derivation of NLO impact factors for massless quarks.

What we demonstrated in our recent article:

- Factorization of high energy logarithms into BK evolution of the target leading to physical NLO corrections.

To be done:

- Combination of NLO impact factors and NLO BK evolution to get full NLO predictions $\Rightarrow$ first comparison with HERA data.
- Extension of impact factor results to heavy quarks.
- Comparison with HERA data with both massless and heavy quarks.