Analysis of the impact of higher-twist and absorptive corrections on the gluon distribution function

Mateus Reinke Pelicer

Supervisor: Prof. Dr. Emmanuel Gräve de Oliveira

Federal University of Santa Catarina

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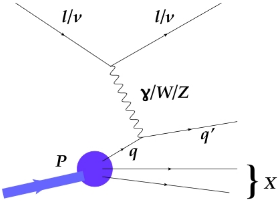
Deep Inelastic Scattering

- DIS at leading order:



- x: Fraction of momentum of the proton.
- Q^2: Boson virtuality.
- $\mu_F^2 = Q^2$.

- The proton is not an elementary particle → Cross section depends on structure functions.

$$\frac{d^2\sigma_{NC}^{e^\pm p}}{dQ^2 dx} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+ F_2(x,Q^2) \mp Y_- xF_3(x,Q^2) - y^2 F_L(x,Q^2)\right]$$

- F_2 is the dominant structure function.
- xF_3 has an impact at high $Q^2 (> M_z^2)$.
- F_L is sensitive to the gluon distribution.

Structure functions and PDFs

- According to the factorization theorem:

$$F(x,Q^2) \sim \sum_i \int_x^1 \frac{dz}{z} C_i\left(z,Q^2\right) x f_i\left(\frac{x}{z},Q^2\right)$$

- Parton Distribution Functions are of non-perturbative origin and must be parametrized and adjusted from data in pQCD.
- They are parametrized at a scale Q_0 and evolved to the data scale Q, with DGLAP[1] equation:

$$\frac{d}{d\log\mu^2} x f_i(x,\mu^2) = \frac{\alpha_s(\mu^2)}{2\pi} \sum_j x \int_x^1 \frac{dz}{z} P_{ij}(z,Q^2) f_j\left(\frac{x}{z},\mu^2\right),$$

- In this work we use the HERAPDF formalism. The parametrizatin is done at $Q_0^2 \sim 1.9$ GeV^2.

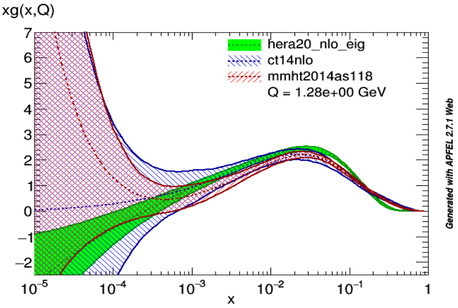
$$x f_i(x,Q^2) = A_i x^{B_i}(1-x)^{C_i} - \delta_{ig} A_i' x^{B_i'}(1-x)^{C_i'}$$

- The log-likehood variable χ^2 is minimized to obtain the PDF sets.

[1] Dokshitzer–Gribov–Lipatov–Altarelli–Parisi

Problem & Proposal

- There are several groups that work in the determination of PDFs.
- For $x \leq 10^{-3}$ there and $Q^2 \lesssim 2$ GeV^2 there is not a lot of data available, and the distributions are poorly fitted.



- The DGLAP formalism does not give a complete description of this kinemactical region. $\rightarrow$ We want to know what is the impact of some physically motivated corrections in a global analysis in this region.

Higher-Twist corrections

- Twist is used to classify the *level of divergence* of the terms in the Coefficient Functions.
- Global analysis consider leading-twist approximation, but higher-twist are propotional to $1/Q^2$, and are believed to to play an important role at low-Q^2.

$$C_{Lg}(z) = 4T_R z(1-z)\left(1 - zQ_0^2/Q^2\right),$$

$$C_{2g}^{\overline{MS}}(z) = T_R\left\{\left[(1-z)^2 + z^2\right]\log\frac{1-z}{z} + 2z(1-z) + \left[6z(1-z) - 1\right]\cdot\left(1 - zQ_0^2/Q^2\right)\right\}$$

- The quark coefficients have similar corrections.
- DGLAP never enters the low-virtuality region, so the soft contributions are embeded in the 'input' PDFs, but coefficient functions consider all available phase space. To avoid double counting, the soft contributions ($|q^2| < Q_0^2$) are excluded from C_i.

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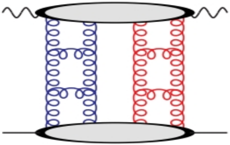
- We have found negative results.
- There were no changes in the gluon distribution or in χ^2.

Absorptive corrections

- At low-x, there is a high-density of gluons $\rightarrow$ *Gluon saturation*.
- The recombination of gluons ($g + g \rightarrow g$) becomes important. These are taken into account via parton ladders:



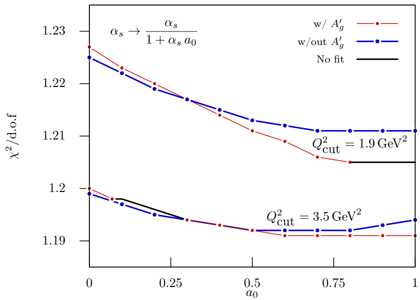
- The inclusion of one parton ladder adds a term $\sim -\int dz/z(xg)^2$ to the DGLAP.
- A second gluon ladder leads to an screening of the first by $1 - \Omega$.
- Taking into account a large number of ladders and the small-x limit:

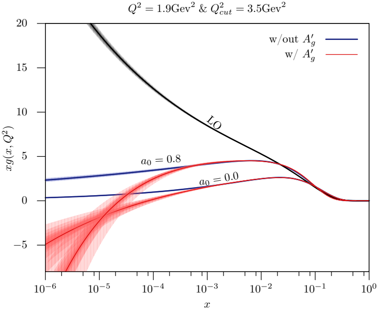
$$\frac{d}{d\log Q^2} x f_i(x, Q^2) = e^{-\Omega(x,Q^2)} \frac{\alpha_s(Q^2)}{2\pi} \sum_j x \int_x^1 \frac{dz}{z} P_{ij}(z) f_j\left(\frac{x}{z}, Q^2\right),$$

$$\Omega(x, Q^2) = \frac{3\pi}{16} \frac{\alpha_s x g(x, Q^2)}{Q^2 R^2}.$$

- The implementation of a non-linear evolution is very difficult.
- To see the effects of a suppresion to DGLAP, we have used, instead of the exponential:

$$\alpha_s \to \frac{\alpha_s}{1 + a_0\ \alpha_s}.$$





Conclusions and Perspectives

- Conclusions:
  - The implementation of higher-twist corrections to DIS have no impact on the global analysis of the distribution functions.
  - Absorptive corrections are not fully implemented, but there are indications of a considerable impact and an improvement of the fit.

- Perspectives:
  - We expect to fully implement absorptive corrections.
  - Include corrections to Drell-Yan process.
  - Implement confinement corrections, which freeze α_s at $Q^2 \sim 0.5$ GeV^2.

Acknowledgments

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