1 Introduction

This work is mainly based on the paper "Complete $O(\alpha_S)$ corrections to heavy-flavour structure functions in electroproduction" by Laenen et. al.[1] - that is, it recalculates all properties and formulas. It extends then the application to the equivalent *polarized* processes. The treating of the polarized processes can for example be found in [2] and we will use many ideas and technices from there. **FiXme Error: more** FiXme Error!

1.1 Motivation

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1.2 Notation

To collect all soft and collinear poles we have to calculate in $n = 4 + \epsilon$ dimension. Unfortunaly the extension for *polarized* processes is nontrivial, because the occuring Levi-Civita tensors $\varepsilon_{\mu\nu\rho\sigma}$ and γ_5. A common choice to deal with these objects is the HVBM prescription[3] that keeps those two objects four dimensional at the price for splitting the full n dimensional space into a $n-4$ dimensional space, called "hat-space", and a four dimensional space (that is actually never used).

In leading order (LO) we have to consider the following processes

$$\gamma^*(q;\sigma_q) + \mathrm{g}(k_1;\sigma_{k_1}) \to Q(p_1) + \overline{Q}(p_2) \tag{1}$$

The corresponding parton structure tensor $W^{(0)}_{\mu\mu'}$ can then be written as **FiXme Error: avoid all order expr?** FiXme Error!

$$\begin{aligned}
&W^{(0)}_{\mu\mu'}(k_1,q;s,t_1,u_1,q^2;\sigma_{k_1}\sigma_q)\\
&= \frac{1}{2}E_\epsilon K_{\gamma\mathrm{g}} \int \frac{d^{n-1}p_1}{2E_1(2\pi)^{n-1}} \int \frac{d^{n-1}p_2}{2E_2(2\pi)^{n-1}} \delta(p_1^2-m^2)\delta(p_2^2-m^2)\\
&\quad (2\pi)^n \delta^{(n)}(k_1+q-p_1-p_2)\,\mathcal{M}^{(0)}_{\mu}(\sigma_{k_1})\,\mathcal{M}^{(0)}_{\mu'}(\sigma_q)
\end{aligned} \tag{2}$$

where the initial 1/2 is the initial state spin average, $K_{\gamma\mathrm{g}}$ is the color average,

$$E_\epsilon := \begin{cases} 1/(1+\epsilon/2) & \text{unpolarized} \\ 1 & \text{polarized} \end{cases} \tag{3}$$

accounts for initial freedom in n dimensions for bosons and we defined the following Mandelstam variables:

$$s = (q+k_1)^2, \quad t_1 = t - m^2 = (k_1-p_2)^2 - m^2, \quad u_1 = u - m^2 = (q-p_2)^2 - m^2 \tag{4}$$

$$s' = s - q^2, \quad u_1' = u_1 - q^2 \tag{5}$$

FiXme Error: move to LO? The Lorentz indices μ and μ' refer to the virtual photon that is exchanged with the scattering lepton. FiXme Error!

By using Lorentz covariance, hermiticity, parity invariance and current conservation the parton structure tensor can be decomposed into several parts:

$$\begin{aligned} W^{(0)}_{\mu\mu'}(k_1, q; s, t_1, u_1, q^2; \sigma_{k_1}, \sigma_q) = &\left(-g_{\mu\mu'} + \frac{q_\mu q_{\mu'}}{q^2}\right) \frac{d^2\sigma_T(s,t_1,u_1,q^2)}{dt_1 du_1} \\ &+ \left(k_{1,\mu} - \frac{k_1 \cdot q}{q^2} q_\mu\right)\left(k_{1,\mu'} - \frac{k_1 \cdot q}{q^2} q_{\mu'}\right)\left(\frac{-4q^2}{s'^2}\right) \\ &\cdot \left(\frac{d^2\sigma_T(s,t_1,u_1,q^2)}{dt_1 du_1} + \frac{d^2\sigma_L(s,t_1,u_1,q^2)}{dt_1 du_1}\right) \end{aligned} \tag{6}$$

FiXme Error: extend We can then define appropiate projection operators[4]: FiXme Error!

$$\mathcal{P}_{G,\mu\mu'} = -g_{\mu\mu'} \qquad b_G(\epsilon) = \frac{1}{2(1+\epsilon/2)} \tag{7}$$

$$\mathcal{P}_{L,\mu\mu'} = -\frac{4q^2}{s'^2} k_{1,\mu} k_{1,\mu'} \qquad b_L(\epsilon) = 1 \tag{8}$$

$$\mathcal{P}_{P,\mu\mu'} = i\varepsilon_{\mu\mu'\rho\rho'} \frac{q^\rho k_1^{\rho'}}{s'} \qquad b_P(\epsilon) = 1 \tag{9}$$

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$$\frac{d^2\sigma_k(s,t_1,u_1,q^2)}{dt_1 tu_1} = b_k(\epsilon)\mathcal{P}_{k,\mu\mu'} W^{\mu\mu'} \tag{10}$$

with $k \in \{G, L, P\}$ denoting (here and mostly ever after) the projection type. The transverse partonic cross section $d\sigma_T$ can be reconstructed from the above definitions by using

$$\frac{d^2\sigma_T}{dt_1 du_1} = \frac{d^2\sigma_G}{dt_1 du_1} + b_G(\epsilon)\frac{d^2\sigma_L}{dt_1 du_1} \tag{11}$$

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2 Leading Order Calculations

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3 Next-To-Leading Order Calculations

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4 Mass Factorization

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FiXme Error: do

5 Partonic Results

FiXme Error!

FiXme Error: do

6 Hadronic Results

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FiXme Error: do

7 Summary

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FiXme Error: do

A References

[1] E. Laenen, S. Riemersma, J. Smith, and W. van Neerven, "Complete $O(\alpha_S)$ corrections to heavy-flavour structure functions in electroproduction," Nuclear Physics B **392** no. 1, (1993) 162 – 228. http://www.sciencedirect.com/science/article/pii/055032139390201Y.

[2] I. Bojak, NLO QCD corrections to the polarized photoproduction and hadroproduction of heavy quarks. PhD thesis, Dortmund U., 2000. arXiv:hep-ph/0005120 [hep-ph].

[3] P. Breitenlohner and D. Maison, "Dimensional renormalization and the action principle," Comm. Math. Phys. **52** no. 1, (1977) 11–38. http://projecteuclid.org/euclid.cmp/1103900439.

[4] W. Vogelsang, Tests and signatures of spin dependent parton distributions in leading and next-to-leading order of PhD thesis, Dortmund U., 1993. http://alice.cern.ch/format/showfull?sysnb=0171841.

List of Corrections