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CC DIS at α_s^3 in Mellin-N and Bjorken-x spaces

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Third-order results for the structure functions of charged-current deep-inelastic scattering are discussed. New results for 11'th Mellin moment for $F_{2,L}^{\nu p-\bar{\nu}p}$ structure functions and 12'th moment for $F_3^{\nu p-\bar{\nu}p}$ are presented as well as corresponding higher Mellin moments of differences between the respective crossing-even and -odd coefficient functions. Approximations in Bjorken-x space for these differences obtained with lowest five moments as well as consistency of new results with these approximations are discussed. The $1/N_c$ suppression of the differences is shown and the correction to the Paschos-Wolfenstein relation is discussed.

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1. Introduction

Structure functions in deep-inelastic scattering (DIS) are among the most extensively measured observables. Today the combined data from fixed-target experiments and the HERA collider spans about four orders of magnitude in both Bjorken-x and the scale $Q^2 = -q^2$ given by the momentum q of the exchanged electroweak gauge boson [1]. In this report I focus on the W-exchange charged-current (CC) case, see Refs. [2, 3, 4] for recent measurements in neutrino DIS and at HERA. I present new Mellin moments for coefficient functions in combination $\nu p - \bar{\nu} p$ and discuss the results for differences between the corresponding crossing-even and -odd coefficient functions. I show suppression of such differences in large $1/N_c$ limit and discuss α_s^3 correction to the Paschos-Wolfenstein relation [5].

2. Results for the CC coefficient functions and their applications

Recently the first five odd-integer moments have been computed of the third-order coefficient functions for $F_{2,L}^{\nu p - \bar{\nu} p}$ in charged-current DIS, together with the corresponding moments $N = 2, \ldots, 10$ for $F_3^{\nu p - \bar{\nu} p}$ [6]. Meanwhile calculation of new results for 11'th moment for the first and 12'th moment for the latter case has been finished. We use scale choice $\mu_r = \mu_f = Q$ and standard QCD colour factors $C_A = 3$ and $C_F = 4/3$ throughout this paper and denote the Mellin-N moments of corresponding coefficient functions as $C_{a,N}^{\rm ns}$, $a = 2, 3, L$. Following the formalism outlined in [6] we find the following numerical results

$$
\begin{aligned}
C_{2,11}^{\rm ns} \;&=\; 1 + 21.01295976\, a_s + a_s^2\,(722.3767644 - 51.01867375\, n_f) \\
&\quad + a_s^3\,(29020.51723 - 4259.717409\, n_f + 89.53420655\, n_f{}^2)\,, \\
C_{L,11}^{\rm ns} \;&=\; 0.4444444444\, a_s + a_s^2\,(30.42631299 - 1.781422693\, n_f) \\
&\quad + a_s^3\,(2021.685213 - 266.3750306\, n_f + 7.082458684\, n_f{}^2)\,, \\
C_{3,12}^{\rm ns} \;&=\; 1 + 22.20106054 a_s + a_s^2\,(774.6238566 - 53.26617873\, n_f) \\
&\quad + a_s^3\,(31152.95983 - 4483.444700\, n_f + 91.41515482\, n_f{}^2)\,,
\end{aligned}
\qquad (2.1)
$$

where the normalized coupling constant $a_s = \alpha_s/(4\pi)$ and n_f denotes the number of effectively massless quark flavours. The results in analytical form can be found in App. A.

Unlike fixed-N calculations for the combination $\nu p - \bar{\nu} p$, the complete three-loop results for $F_{2,L}^{\nu p + \bar{\nu} p}$ [7, 8] (the α_s^3 coefficient functions for this process are those of photon-exchange DIS, but without the contributions of the fl_{11} flavour classes) and $F_3^{\nu P + \bar{\nu} P}$ [9] facilitate analytic continuations to these values of N. This continuation has been performed using the x-space expressions and the Mellin transformation package provided with version 3 of FORM [10]. Thus we are in a position to derive the respective moments of the hitherto unknown third-order contributions to the even-odd differences which are defined as

$$
\delta C_{2,L} \;=\; C_{2,L}^{\nu p + \bar{\nu} p} - C_{2,L}^{\nu p - \bar{\nu} p}\,, \qquad \delta C_3 \;=\; C_3^{\nu p - \bar{\nu} p} - C_3^{\nu p + \bar{\nu} p}\,. \qquad (2.2)
$$

The signs are chosen such that the differences are always 'even – odd' in the moments N accessible by the OPE, and it is understood that the $d^{abc}d_{abc}$ part of $C_3^{\nu p + \bar{\nu} p}$ [11, 9] is removed before the