Mellin Moments of Heavy Flavor Contributions to $F_2(x, Q^2)$ at NNLO

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Abstract

The main part of this thesis is concerned with the calculation of the $O(\alpha_s^3)$ heavy flavor contributions to the Wilson coefficients of the structure function $F_2(x, Q^2)$ and to the operator matrix elements(OMEs) for the twist–2 operators of unpolarized deeply inelastic scattering. The massive Wilson coefficients are obtained in the region $Q^2 \gg m^2$ as convolutions of the massive OMEs and the known light flavor Wilson coefficients. We also compute the massive OMEs which are needed to evaluate heavy flavor parton distributions in the variable flavor number scheme to 3–loop order. The renormalization of the massive OMEs is discussed in great detail. All contributions to the Wilson coefficients and operator matrix elements but the genuine constant terms at $O(\alpha_s^3)$ of the OMEs are derived in terms of quantities, which are known for general values in the Mellin variable N. For the operator matrix elements $A_{Qg}^{(3)}, A_{qg,Q}^{(3)}$ and $A_{gg,Q}^{(3)}$ the moments $N = 2$ to 10, for $A_{Qq}^{(3),\rm PS}$ to $N = 12$, and for $A_{qq,Q}^{(3),\rm NS}$, $A_{qq,Q}^{(3),\rm PS}$, $A_{gq,Q}^{(3)}$ to $N = 14$ are computed. These terms contribute to the light flavor +-combinations. For the flavor non-singlet terms, we calculate as well the odd moments $N = 1$ to 13, corresponding to the light flavor −-combinations. We also obtain the moments of the 3–loop anomalous dimensions, their color projections for the present processes respectively, in an independent calculation, which agree with the results given in the literature.
Additionally we study applications of the same techniques to the polarized and transversity case at the NLO and NNLO level, for which results only for the respective massive OMEs are presented.
The mathematical structure of the occurring momentum integrals and of the final results in terms of harmonic sums is discussed in detail.