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Gluon evolution for the Berger–Block–Tan form of the structure function F_2

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In the snall-x regime, nonperturbative effects were expected to play an important role. However, as it has been observed up to very low $Q^2 \sim 1$ GeV^2 values, considered processes are described reasonably well by perturbative OCD (pQCD) methods (see, for example, [1, 2]). It should be noted, nonetheless, that at extremely low x, $x \to 0$, the pQCD evolution provides a rather singular behavior of the parton distribution functions (PDFs) (see, e.g., [3–8] and references therein), which strongly violates the Froissard boundary [9].

In [10, 11] a new form of the deep inelastic lepton-hadron scattering (DIS) structure function (SF) $F_2(x, Q^2)$ was proposed. It will be called below as the Berger–Block–Tan (BBT) structure function. The SF $F_2^{\rm BBT}(x, Q^2)$ leads to the low x asymptotics of the (reducted) DIS cross-sections $\sim \ln^2 1/x$, which is in turn in an agreement with the Froissard predictions [9]. This parametrization is relevant in investigations of ultrahigh energy processes, such as scattering of cosmic neutrino off hadrons (see [12–16]).

Following to our previous studies in [17, 18] and [19–21], recently the gluon density $f_g(x, Q^2)$ and the longitudinal DIS SF $F_L(x, Q^2)$ in the BBT form have been obtained in [22, 23] and [24, 25] at small values of x, using the SF $F_2^{\rm BBT}(x, Q^2)$. To do it, we proposed a violation of twist-two evolution of gluon density by a nonlinear term. The purpose of the present Letter to show the exact form of the violation. All the results will be done at the leading order (LO) of perturbation theory.

We show that the nonlinear term is negative at low x values and is suppressed as $1/\ln^2(1/x)$, that is in a full agreement with earlier studies in [26]. However, the Q^2-dependence is different: at large Q^2 values our nonlinear term $\sim 1/ln(Q^2)$ but the corresponding one in [26] $\sim 1/Q^2$.

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