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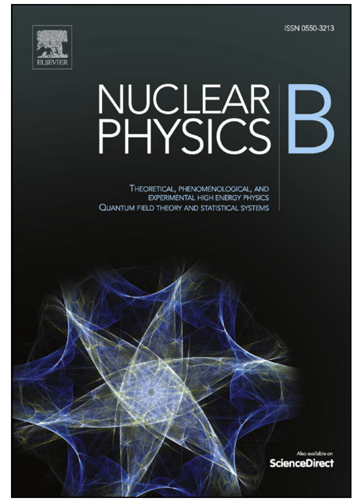

Solution of QCD⊗QED coupled DGLAP equations at NLO

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Abstract

In this work, we present an analytical solution for QCD⊗QED coupled Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) evolution equations at the leading order (LO) accuracy in QED and next-to-leading order (NLO) accuracy in perturbative QCD using double Laplace transform. This technique is applied to obtain the singlet, gluon and photon distribution functions and also the proton structure function. We also obtain contribution of photon in proton at LO and NLO at high energy and successfully compare the proton structure function with HERA data [1] and APFEL results [2]. Some comparisons also have been done for the singlet and gluon distribution functions with the MSTW results[3]. In addition, the contribution of photon distribution function inside the proton has been compared with results of MRST [4] and with the contribution of sea quark distribution functions which obtained by MSTW [3] and CTEQ6M [5].

I. Introduction

In quantum electrodynamic (QED), interactions of photon can be regarded as a structureless object since QED is an abelian gauge theory and photon has no self-interaction. The photon in an interaction can be fluctuate into a charged fermion and anti-fermion, because of Heisenberg uncertainty principle, and if one of fermions interacts with a gauge boson the photon reveals its parton structure. Fig. (1) shows scheme of deep inelastic scattering a photon with a gauge boson. In the deep inelastic scattering of electron-positron collider LEP and the electron-proton collider HERA are reported the main results on the structure of photon. Recent studies on the effect of Drell-Yan with high-mass in ATLAS have shown which the structure of photon or corrections of QED have effects on parton distribution functions [6, 7]. These results and discoveries improve our understanding about the internal structure of the proton and it can approximate theoretical activity to experimental data.

In Ref. [4], Martin and et al. showed that the photon distribution is larger than the b quark distribution at $Q^2 = 20GeV^2$ and also larger than the sea quarks at the highest values of x inside the proton and neutron. So, it is interesting to study the photon distribution of the proton and neutron, to obtain these contributions at different scales can be used QCD⊗QED coupled DGLAP evolution equations. Recently, several methods have been proposed to solve the coupled DGLAP evolution equations as Laplace transform [8-12] and Mellin transform methods [13] and etc. The most appropriate and simplest of these methods is the laplace transfom, because it simplifies the equations to simplest form. Block et al. in Ref. [8] showed that the NLO coupled DGLAP evolution equations, by using the double Laplace transform, can be solved and arrived to decoupled NLO evolved solutions.