PRAMANA
—journal of
physics

Vol. 50, No. 4,
April 1998
pp. 315–321

Approximate fixed-ρ solution of 'sea-quark' evolution equation at small-x and HERA

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MS received 24 April 1997; revised 18 March 1998

Abstract. We found an approximate simple solution of sea-quark evolution equation in terms of $\rho(=\sqrt{\ln(x_0/x)/\ln[\ln(Q^2/\Lambda^2)/\ln(Q_0^2/\Lambda^2)]})$ and $\zeta(\equiv \ln[\ln(Q^2\Lambda^2)/\ln(Q_0^2/\Lambda^2)])$ in the small-x region when ρ is fixed and compared with HERA data. Agreement with data is found for large Q^2 and small ρ. Comparison with double asymptotic scaling prediction is made. We found a critical value of ρ. More data are needed to confirm this point.

Keywords. DGLAP evolution equations; soft and hard pomeron.

PACS No. 12.35

In the small-x limit, the coupled DGLAP [1,2] sea-quark and gluon evolution equations for leading order can be written as sea-quark and gluon evolution equations in decoupled forms. The gluon evolution equation is of the form of wave equation in terms of the variables $\xi(\equiv \ln(x_0/x))$ and $\zeta(\equiv \ln[\ln(Q^2/\Lambda^2)/\ln(Q_0^2/\Lambda^2)])$ (x_0 and Q_0^2 being the starting scales of perturbative evolution) [3]. In the asymptotic limit of $\sigma(\equiv \sqrt{\xi\zeta})$, the solution of this wave equation gives rise to scaling in terms of σ and $\rho(\equiv \sqrt{\xi/\zeta})$, which is termed as 'double asymptotic scaling' (DAS) [3]. From the gluon momentum distribution function we can find the sea-quark momentum distribution function using DGLAP sea-quark evolution equation for small-x. Thus, we can obtain the structure function. The prediction for proton structure function from DAS, when compared with the data from HERA [7], has good agreement [3–5] for large values of σ and ρ. In the case of gluon, prediction from DAS agrees well with the fit obtained by Glück *et al* [6] above a certain value of $\rho(\equiv \delta/\gamma)$, which can be found analytically [8]. Hence, we found a simple solution [9] of gluon wave equation at fixed ρ which agrees well with the fit [6] below $\rho = \delta/\gamma$. Here, we extend the solution [9] in approximate form to proton structure function for large value of ζ (that is, Q^2) which can be used to analyse the data below the critical value of $\rho(\equiv \delta/\gamma)$, because, the complete expression for structure function from DAS has a discontinuity at $\rho = \delta/\gamma$ and is negative below this value. To compare our prediction with that from DAS, we separated the HERA data [11] into two sets one set having $\rho > \delta/\gamma$ and another one having $\rho < \delta/\gamma$. The DAS predictions, without inclusion of complete splitting kernel of the process $g \to q\bar{q}$, for proton structure function is found to be in good agreement with data, but our predictions fall far below the data for $\rho > \delta/\gamma$. But for $\rho < \delta/\gamma$ our prediction is good. If we include the complete splitting kernel in DAS, then we cannot use