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Analysis of proton structure function at small *x*

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Abstract.

Deep Inelastic Scattering (DIS) is one of the phenomenological events in order to understand the structure of proton along with the density of partons. The HERA run had given a new understanding of the structure of hadrons. In the present work, we have plotted the graphs between four momentum transfer squared Q^2 = 8.5 GeV^2 and Q^2 = 1600 GeV^2 and found that the proton structure function $F_2(x, Q^2)$ decreases gradually with the increase in scaling factor x. This conforms well with the existing theories. The structure function rises at small Bjorken x but with the increase in x, it gradually decreases. The larger the x value, the chances of understanding the structure function seemingly become less.

Keywords: Deep Inelastic Scattering, HERA, Structure function.

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Introduction

Deep inelastic scattering (DIS) has been a basic source in understanding the substructure of proton. The DIS experiments had been carried out at HERA in the years 1992, 1993, 1994 and 1995 where the lepton-proton, like electron-proton or positron-proton, collisions took place and provided us new sets of data for analysis of the structure of proton [1-3]. The main task of HERA was the measurement of inclusive DIS lepton-proton cross section. HERA extended the previous kinematic range with large $Q^2 > 5 \times 10^4$ GeV^2 and $x < 10^{-4}$. It was observed in 1993 for the first time that the structure function rises with decreasing x. The electron was provided with an energy of 26.7 GeV and that of proton with energy 820 GeV[4]. The HERA data was analyzed to understand the variation of structure function $F_2(x, Q^2)$ with the Bjorken scaling factor x, the squared four momentum transfer Q^2 and the inelasticity y. In the present work, we briefly review some of the established literature of proton structure function and check the conformity by plotting some graphs keeping Q^2fixed, wherein its range is taken as $8.5 \leq Q^2 \leq$ 1600 GeV^2.

Methodology

The HERA experiment operated with 84 colliding electron and proton bunches. The kinematics used were basically the electron method (E), double angle method (DA) and summation method (Σ) [4-6].

The basic formulae for Q^2 and y for the E method are:

$$y_e = 1 - \frac{E_e^{'}}{E_e}\sin^2\frac{\theta_e}{2} \quad \text{and} \quad Q_e^2 = \frac{E_e^{'2}\sin^2\theta_e}{1-y_e} = 4E_e^{'}E_e\cos^2\frac{\theta_e}{2} \tag{1}$$

where E_e is the incident electron energy. $E_e^{'}$ and θ_e are the energy and polar angle of the scattered electron.

and for theΣ method are:

$$y_\Sigma = \frac{\Sigma}{\Sigma + E_e^{'}(1-\cos\theta_e)} \quad \text{and} \quad Q_\Sigma^2 = \frac{E_e^{'2}\sin^2\theta_e}{1-y_\Sigma} \tag{2}$$

$$y_\Sigma = \frac{y_h}{1+y_h-y_e} \tag{3}$$

with the standard definition

$$\Sigma = \sum_h (E_h - p_{z,h}) \quad \text{and} \quad y_h = \frac{\Sigma}{2E_e} \tag{4}$$

Here, E_h and $p_{z,h}$ are the energy and longitudinal momentum component of a particle h and the summation is over all hadronic final state particles.

For double angle (DA) method,

$$y_{DA} = \frac{\tan(\theta_{h/2})}{\tan(\theta_{e/2})+(\theta_{h/2})} \quad \text{and} \quad Q_{DA}^2 = 4E_e^2\frac{\cot(\theta_{e/2})}{\tan(\theta_{e/2})+\tan(\theta_{h/2})} \tag{5}$$

Among the above three methods, it was found that the double angle method does not contribute much to the structure function as compared to the other two methods. From Ref. [7, 8], it is clear that in QCD approach, the structure function can be understood in terms of parton distributions. It has been shown that the DGLAP evolution equation [9-13] governs the structure function $F_2(x, Q^2)$as a function of Q^2. The rise of proton structure function with x is described by the DGLAP evolution equation. Using the data given in Ref. [4], we have plotted the graphs of proton structure function versus$x$,keeping Q^2 fixed, in Figure 1.

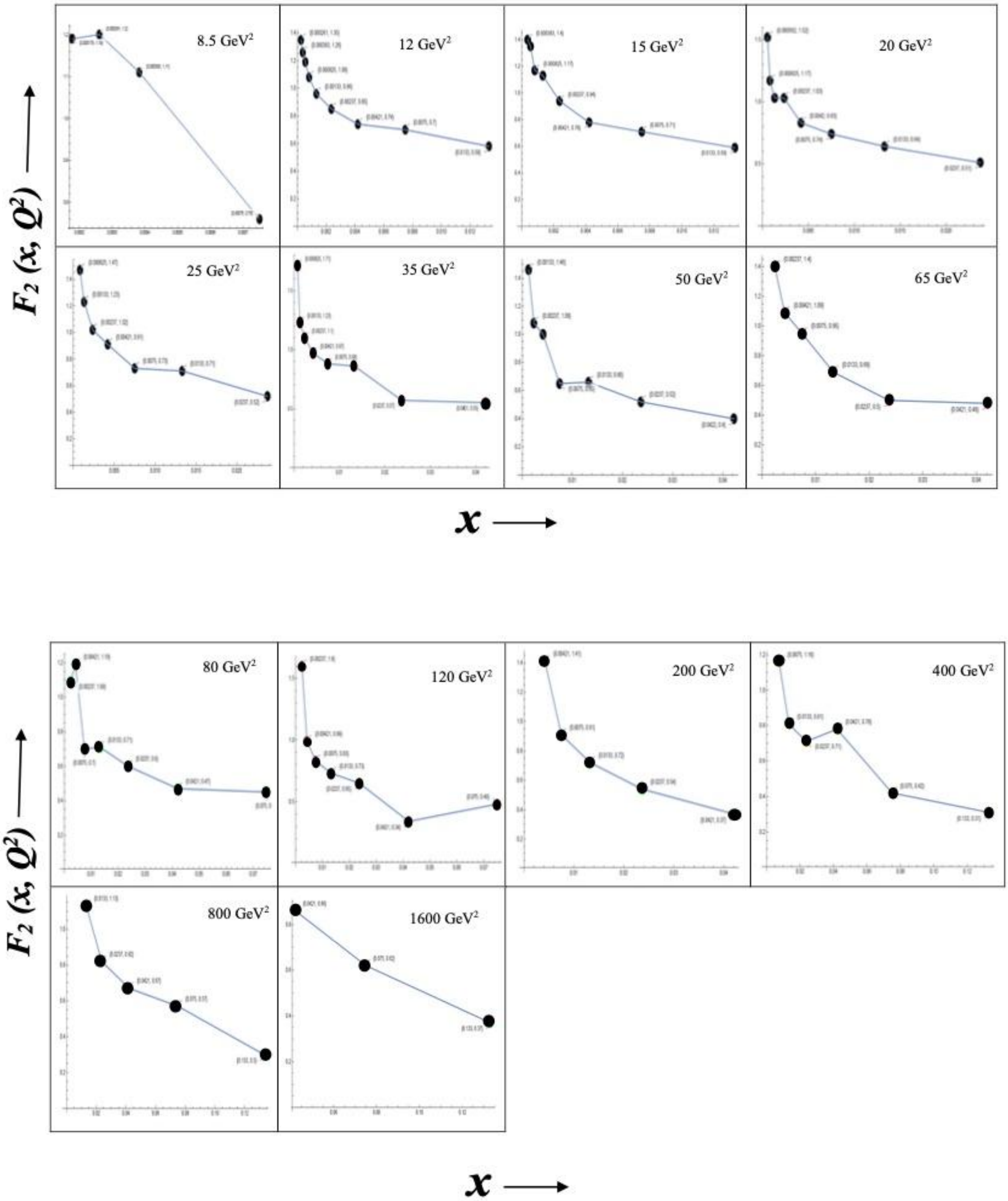

Figure 1: Plot between $F_2(x, Q^2)$ and x where $8.5 \leq Q^2 \leq 1600$ GeV^2.

Conclusion

From the plotted graphs, we observe that at very small values of Q^2 the structure functions do not increase with decrease in x, implying that when x decreases beyond a certain limit the regular behaviour of gradual rise of structure function is not shown. The Q^2 and x dependence of the structure function in the small x region, as measured at HERA, has been clearly observed. For certain range of Q^2, the structure function rises steeply and thus helps researchers to understand the substructure of proton.

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