QCD ANALYSIS OF NEUTRINO CHARGED CURRENT STRUCTURE FUNCTION $F_2$
IN DEEP INELASTIC SCATTERING

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ABSTRACT

An analytic expression for the neutrino charged current structure function $F_2(x,Q^2)$ in deep inelastic scattering, consistent with quantum chromodynamics, is proposed. The calculated results are in good agreement with experiment.

1. Introduction. Recently, the CCFRR group[1] has measured the neutrino charged current structure functions. The data were obtained using the Fermilab narrow band beam and the Laboratory E neutrino detector[2-4]. The structure function $F_2(x,Q^2)$ extracted from the neutrino and antineutrino event samples is plotted versus $Q^2$ in Fig.1.

A number of attempts have been made to fit the data for lepton-nucleon deep inelastic scattering by using QCD. The analyses are based on fitting of Altarelli-Parisi (A-P) equations. For a fixed $Q^2=Q_0^2$, the structure function $F_2$ is assumed to be of a particular form, so as to give $x$ dependence consistent with experimental data at $Q_0^2$. The A-P equations are then solved numerically to yield results which are consistent with experiment. The arbitrariness of $Q^2$ is, however, restricted to sufficiently large values of $Q_0^2$ for which perturbative calculations can be trusted. In this paper, an analytic expression for $F_2(x,Q^2)$, consistent with QCD, is proposed.

2. Calculations and Discussion. According to QCD, the singlet structure function $F_2(x,Q^2)$ and its momenta are related to each other[5] by the equation

$$\int_0^1 x^{-2} F_2(x,Q^2) dx = \delta^2 A_s [\ln(Q^2/\Lambda^2)]^{-dn}$$

The function $F_2(x,Q^2)$ can not be expressed as a product of
two functions, one depending upon \( x \) only and the other depending upon \( Q^2 \) alone, because then the function of \( Q^2 \) alone as evaluated by using left hand side of equation (1) would be independent of \( n \). This is not valid because right hand side of equation (1) depends upon \( n \). To incorporate this \( n \) dependence, we assume that

\[
F_2(x, Q^2) = A(1-x)e^{-ax}
\]

where

\[
a = \left[ \ln \left( \frac{Q^2}{\Lambda^2} \right) \right]^{0.747}
\]

For large value of \( Q^2 \), this expression when substituted in equation (1) gives results which are consistent with QCD.

A very good agreement with experimental data for \( Q^2 > 5 \) \((\text{GeV}/c)^2\) is obtained by using \( A = 2, \Lambda = 0.5\text{GeV}/c \).

Fig. 1 shows experimental data as well as theoretical predictions for \( F_2(x, Q^2) \) plotted against \( Q^2 \) at fixed values of \( x \). The agreement is quite satisfactory and confirms our assumption about the form of \( F_2(x, Q^2) \).

3. Conclusion. Quantum chromodynamics is now believed to be the promising theory of strong interactions. The perturbative calculations of cross sections for deep inelastic scattering based on QCD are confirmed experimentally. However, numerical integration has to be performed to obtain various results. We have proposed a simple analytic expression for the structure function \( F_2(x, Q^2) \). This expression yields results which are consistent with experiment.

4. Acknowledgement. The financial assistance from the Pakistan Science Foundation under contract No. P-PU/Phys(11/2) is gratefully acknowledged.
References


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