

LETTER TO THE EDITOR

A COMMENT ON DEEP INELASTIC NEUTRINO SCATTERING IN THE QUARK-CONFINING POTENTIAL MODELS*

SVJETLANA FAJFER and KENAN SURULIZ

Institut za fiziku, University of Sarajevo, 71000 Sarajevo, Yugoslavia

Received 17 March 1986

UDK 539.12

Original scientific paper

We calculate structure functions for ν - N deep inelastic scattering using quark-confining potential models.

In addition to the electromagnetic lepton-nucleon scattering, an important source of information about nucleon structure is the study of neutrino-nucleon scattering.

In the previous note¹⁾ we presented a calculation of nucleon structure functions for e - N deep inelastic scattering using quark-confining potential models. Here we apply the same method to the investigation of ν - N deep inelastic scattering.

The main features of the model are exposed in Ref. 1. For neutrino scattering the virtual photon is replaced by the W boson, and corresponding changes are made in the interaction Lagrangian. We denote the polarization vectors of the W boson going in the z -direction by

$$\begin{aligned}\varepsilon_{\mu}^{(R)} &= \frac{-1}{2} (1, i, 0, 0) \\ \varepsilon_{\mu}^{(L)} &= \frac{1}{2} (1, -i, 0, 0) \\ \varepsilon_{\mu}^{(S)} &= \frac{1}{\sqrt{q^2}} (0, 0, \nu, iq_z),\end{aligned}\tag{1}$$

* Supported in part by grants from the NSF and SIZ-nauke BiH.

otherwise the conventions are the same as in Ref. 1. The cross-section for the basic process $Wq \rightarrow q'$ is

$$d\sigma = C \bar{\varepsilon}_\mu \varepsilon_\nu (L_{\mu\nu} + L_{\mu\nu}^s) \tag{2}$$

with

$$L_{\mu\nu} + L_{\mu\nu}^s = \int \frac{d^2k_T}{\bar{k}_z + q_z} (l_{\mu\nu} + l_{\mu\nu}^s). \tag{3}$$

The $l_{\mu\nu}$ are of the same form as for the electromagnetic scattering, and $l_{\mu\nu}^s$ have additional γ_5 terms (we take only the dominant transition and set the K - M matrix equal to 1).

The integration over quark transverse momentum k_T is easily performed in the Bjorken limit. The $L_{\mu\nu}$ are essentially the same as before, and $L_{\mu\nu}^s$ are

$$L_{ij}^s = ie_{ij3} N^2 \exp \left\{ -\frac{k_z^2}{\xi^2} \right\} \left\{ \left(\frac{m_N x + m}{E + m} \right)^2 \pi \xi^2 + \frac{\pi \xi^4}{(E + m)^2} \right\}, \text{ other } L_{\mu\nu}^s = 0. \tag{4}$$

Now it is easy to find the cross-sections for different polarizations of W bosons:

$$\begin{aligned} \sigma^{(L)} &= 2\pi C \xi^2 N^2 \exp \left\{ -\frac{(E - m_N x)^2}{\xi^2} \right\} \left\{ \left(\frac{m_N x + m}{E + m} \right)^2 + \frac{\xi^2}{(E - m)^2} \right\} \\ \sigma^{(R)} &= 0 \end{aligned} \tag{5}$$

$$\sigma^{(S)} = \pi C \xi^2 \frac{m_N^2 x^2}{q^2} N^2 \exp \left\{ -\frac{k^2}{\xi^2} \right\} \left\{ \left(1 + \frac{E - m_N x}{E + m} \right)^2 + \frac{\xi^2}{(E + m)^2} \right\}.$$

If the q^2 dependence of the W propagator is neglected (which is justified in this case), the structure functions F_i are simply expressed in terms of $\sigma^{(L)}$, $\sigma^{(R)}$, $\sigma^{(S)}$ and then calculated explicitly:

$$\begin{aligned} F_1(x) &= \frac{2m_N K}{|\pi \xi} \frac{(m_N x + m)^2 + \xi^2}{(E + m)^2 + \xi^2} \exp \left\{ -\frac{\xi^2}{(E - m_N x)^2} \right\} \\ F_2(x) &= xF_1(x) \\ F_3(x) &= F_1(x), \end{aligned} \tag{6}$$

in the Bjorken limit.

Besides the Callan-Gross relation here we also have the connection of the third structure function F_3 with the first two. This is a manifestation of the chiral symmetry (which emerges in the Bjorken limit).

The structure function $F_3(x)$ (or rather $x F_3(x)$) is plotted in Fig. 1, for three potential model wave functions described in Ref. 1. The general shape of the $x F_3$ vs. x curve is in agreement with experimental results²⁾ in the case of the HOS model³⁾.

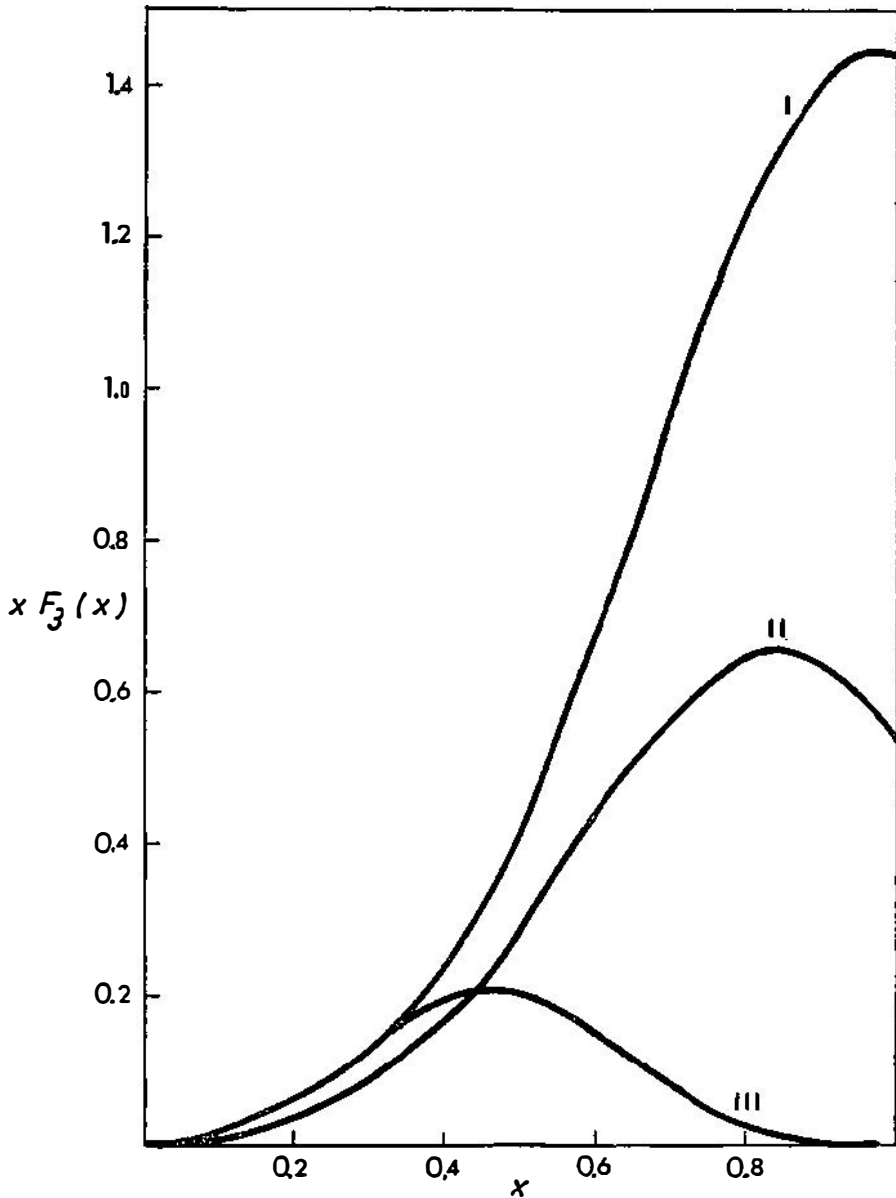


Fig. 1. The structure function $x F_3(x)$ is shown as a function of x . The normalization is arbitrary. The curve I corresponds to the model described in Ref. 1, the curve II is drawn for the same set of confining parameters with zero quark mass and the curve III describes the structure function behaviour in the HOS model³⁾.

In conclusion we can say that there are no additional terms coming from the use of quark-confining potential model which means that in the leading term approximation F_i give typical parton-like behaviour.

This approach suffers from several drawbacks, e. g. the oversimplification of the basic picture of the nucleon: we neglect a part of sea quark contributions which are dominant in the $x \rightarrow 1$ region. Still, the study of deep inelastic scattering in this sense completes the investigation of the use of the quark-confinement models in hadronic processes.

References

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KOMENTAR O DUBOKO-NEELASTIČNOM RASPRŠENJU NEUTRINA
U POTENCIJALNIM MODELIMA KVARKOVSKOG KONFAJNMENTA

SVJETLANA FAJFER i KENAN SURULIZ

Institut za fiziku, 71000 Sarajevo

UDK 539.12

Originalni znanstveni rad

Strukturne funkcije za ν - N duboko-neelastično raspršenje proračunate su u potencijalnim modelima kvarkovskog konfajnmenta.