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PHOTO NUCLEAR ENERGY LOSS TERM FOR MUON-NUCLEUS INTERACTIONS BASED ON ξ SCALING MODEL OF QCD

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1. **Introduction.** EMC collaboration experiments[1] discovered a significant deviation of the ratio of structure functions of iron and deuteron from unity (see Fig. 1).

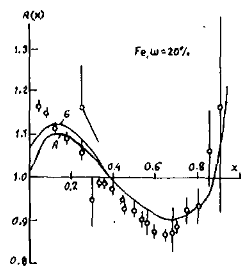

Fig.1: Ratio of the structure functions of iron and deuteron Data from the EMC[1].

This result was later verified by a SLAC group[2]. These results have established the fact that the quark parton distribution in nuclei are different from the corresponding distribution in the nucleous. In the present paper we examine whether these results have any effect on the calculation of photo nucleous energy loss term for muon-nucleus nuclear interaction. All the previous[3-7] calculations were based on the data of ep scattering in which the deviation discussed above was neglected. Though the EMC and SLAC data were restricted to rather large q^2 region it is expected that the deviation would persist even in the low q^2 domain[8]. The model used by us is a modified version of ξ scaling model of Georgi and Politzer[9]. For the ratio of iron and deuteron structure function we took a rather naive least square fit of the form $R(x) = a + bx^9$ and assume the formula to be valid for the whole q^2 region in the absence of any knowledge of $R(x)$ for small q^2.

2. **ξ scaling model and Kinematics.** If a massless quark carries a fraction ξ of the proton momentum and is kicked onto its mass shell by the collision, then

$$(\xi p + q)^2 = \xi^2 m_p^2 + 2\xi p\cdot q + q^2 = 0 \qquad (1)$$

from which we get

$$= \frac{2x}{1 + (1 + 4x^2 m_p^2/q^2)^{1/2}} \qquad (2)$$

where x is the usual Bjorken scaling variable defined by $x = q^2/2m_p$ being the energy transfer. Taking into account of scale breaking phenomena, nucleon structure function has been constructed after the scaling model of Georgi and Politzer[10] for large q^2 in the following way

$$\nu W_2 = \frac{a(1-\xi)^{3.5}}{\xi}\,\frac{x^2\,[1 + m_p\nu/(q^2 + \bar{a}^2)]}{(1 + 4m_p^2x^2/q^2)^{1.5}} \qquad (3)$$

For low q^2 ($< .1$ (Gev/c)^2) the structure formation can be approximated by $\nu W_2 \simeq (aq^2 + bq^2/\nu)$ (4)

and we take

$$w_1 \simeq \nu w_2/2m_p x \quad (5)$$

A good fit[11] to the structure function for low and high q^2 values is obtained with a = ·655, $\bar{a}$ = ·3. The x dependance of the ratio R(x)

$\nu w_2^{Fe} / \nu w_2^{D}$ is taken to be

$$R(x) \simeq 1{\cdot}2 - {\cdot}5x \quad (6)$$

the energy loss term b_N is given by

$$b_N = \frac{N}{E} \int_{\nu_{min}}^{\nu_{max}} \int_{q^2_{min}}^{q^2_{max}} A^{n-1} \frac{d^2\sigma}{dq^2 d\nu} dq^2 d\nu \quad (7)$$

where q^2, E, ν are respectively the 4 dimensional momentum transfer squared, the muon energy and the energy transfer E - E'. N is the Avogadro number, A the atomic mass n mber and n is the power index describing the A dependance of the cross section and m_p is the proton mass. The limits of integrations are given by

$$\nu_{min} \simeq m_\pi , \quad \nu_{max} = E\left[1 - \frac{m_p}{2E}\left(1 + m_{\mu^2}/m_{p^2}\right)\right] \quad (8)$$

$$q^2_{min} = \frac{m_{\mu^2}\nu^2}{E(E-\nu)} , \quad q^2_{max} = 2 m_p \nu \quad (9)$$

m_π, m_μ being the pion and muon mass respectively. The double differential cross section for inelastic muon nucleus scattering is given by Drell and Walecka[12]

$$\frac{d^2\sigma}{dq^2 d\nu} = \frac{2\pi\alpha^2}{|\vec{p}|^2 q^4}\left[(q^2 - 2 m_{\mu^2}) W_1 + (2E(E-\nu) - q^2/2) W_2 \right] \quad (10)$$

In principle b_N can be evaluated from (7) and (10) but the calculation is cumbersome and lengthy. However if we neglect terms of order 1/E then b_N can be expressed in a closed form.

$$b_N^1 = \frac{2\pi\alpha^2 A_{eff}}{A} N\bar{A}\left[1{\cdot}45 \ln (m_{\mu^2} E + \bar{a}^2 m_p/2) + 8{\cdot}858\right] \quad (11)$$

where A for atmosphere is 14·75 and $A_{eff}/A \simeq$ ·8. the suffix 1 in b_N means that b_N has been calculated without taking into account of EMC effect. If we take into consideration of EMC effect and calculate b_N (call it b^2_N) then to the leading order

$$b^2_N \simeq 1{\cdot}2\, b^1_N \quad (12)$$

3. <u>Results and Discussions</u>. Fig.2 shows the energy dependance of b_N found from the present calculation. Though the EMC data is mainly confined in the region of $q^2 > 1$ Gev/c we assumed the result to be valid in the whole q^2 region. The result b^2_N would be modified in future when further data for heavy nucleus like Al would be available in $q^2 < 1$ (Gev/c) region.

If it is found that R(x) does not differ from that in the low q^2 region then b_N^1 will represent the muon energy loss, which is still higher than that estimated by Dau et al.

Conclusion Assuming EMC results for R(x) to be valid in the low q^2 region, b_N value calculated using the structure function for deep inelastic muon scattering off a nucleon bound in a nucleus found to be higher than that obtained using the structure function for deep inelastic muon scattering off a free nucleon. Also both b_N^1 and b_N^2 rise with energy.

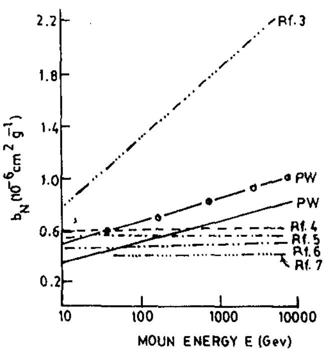

Fig.2: The energy loss parameter b_N ploted as a function of muon energy E —— present calculation for $F_2^D(x)$ -o-o-o- Present calculation for $F_2^{Fe}(x)$ and others taken from the references (3-7).

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