

PHOTONUCLEAR CROSS SECTION OF HIGH ENERGY MUONS

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The photonuclear cross section of high energy muons has been estimated using modified ξ -scaling model after Georgi and Politzer for lepton-hadron scattering. The ν_0/E scaling has been found in the present derivation of the integral cross section $\sigma_{tot}(\nu > \nu_0)$ versus ν_0/E . The similar results were obtained by Dau et al. recently who used *Generalised Vector Dominance Model*.

1. Introduction

The investigation on photonuclear cross section of high energy muon is necessary for the estimation of energy loss of muons in the recent experiments of MUTRON¹⁾ and DUMAND²⁾. Most of the cosmic ray phenomenology is concerned with low q^2 values in case of nuclear interactions. Moreover, the lepton-nucleon scattering in accelerator experiments on deep inelastic scattering gives precise results for $q^2 > 1$ (GeV/c)².

The theoretical investigation on integral photonuclear cross section has been recently made by Constandt et al.³⁾, Dau et al.⁴⁾ and Minorikawa et al.⁵⁾. However, the result of Constandt et al.³⁾ has been by the accelerator data after Jain et al.⁶⁾. More recently Dau et al.⁴⁾ have used the generalised vector dominance model of Devenish and Schildknecht⁷⁾. However the calculated results of Minorikawa et al.⁵⁾ based on Brasse et al.⁸⁾ scaling show a strong disagreement with Dau et al.⁴⁾.

This fact reminds us that more investigation should be made on photonuclear cross section.

In the present paper we used ξ -scaling model of Georgi and Politzer⁹⁾ to estimate the photo-nuclear cross section. Our results have been compared with those found by Constandt et al.³⁾, Minorikawa et al.⁵⁾ and Jain et al.⁶⁾.

2. Nuclear physics and kinematics

If a massless quark carries a fraction ξ of the proton momentum and is kicked onto its mass shell by the collision,

$$(\xi p + q)^2 = 0 = \xi^2 m_p^2 + 2 \xi p q + q^2 \tag{1}$$

the positive part solution of (1) gives

$$\xi = 2x [1 + (1 + 4x^2 m_p^2/q^2)^{1/2}]^{-1}. \tag{2}$$

The scale breaking phenomena on nucleon structure function has been constructed following Georgi and Politzer⁹⁾

$$\nu W_2 \simeq \frac{0.655}{\xi} \frac{(1 - \xi)^{3.5} [1 + m_p \nu / (q^2 + \bar{a}^2)]}{(1 + 3.5194 x^2/q^2)^{1.5}} \tag{3}$$

where $x = q^2/2m_p \nu$. For low q^2 viz., $q^2 < 0.1$ (GeV/c)², follows

$$\nu W_2 \simeq 0.655 x [1 + m_p \nu / (q^2 + \bar{a}^2)] \simeq 0.655 q^2/2\bar{a}^2. \tag{4}$$

The one-photon exchange approach on the inclusive cross section for muon-nucleon scattering has been considered following Drell and Walecka¹⁰⁾

$$\frac{d^2\sigma}{dq^2 d\nu} = \frac{2\pi a^2}{E^2 q^4} \{ (q^2 - 2m_\mu^2) W_1 + [2E(E - \nu) - q^2/2] W_2 \} \tag{5}$$

where

$$W_1 \simeq \nu W_2/2x. \tag{6}$$

Thus

$$\begin{aligned} \sigma(\nu > \nu_0) &= \int_{\nu_0}^{\nu_{max}} \int_{q_{min}^2}^{q_{max}^2} \frac{d^2\sigma}{dq^2 d\nu} \simeq \\ &\simeq 2\pi a^2 a [3 \ln (E/\nu_0)^2 + (4 + 1.5 m_p \ln (E/\nu_0))] \cdot 0.389 \cdot 10^{-27} \text{ cm}^2. \end{aligned} \tag{7}$$

3. Results and discussion

The nucleon structure function νW_2 for low and high q^2 values expected from ξ -scaling model have been displayed in Figs. 1 and 2 along with the accelerator data of Jain et al.⁶⁾, Anderson et al.¹¹⁾ and Eickmeyer et al.¹²⁾. The calculated

shapes of νW_2 fairly agrees with the experimental result for large q^2 rather than low q^2 values. Fig. 3 shows the calculated cross section for nuclear interactions of muons with an energy transfer ν_0 as a function of the scaling variable ν_0/E . The figure contains the following results:

- i) calculated cross section from $\nu W_2 = 0.761 (q^2/m_p^2)^{0.915}$ (8) after Constandt et al.³⁾ marked by curve 1,
- ii) the same phenomena from $GVDM$ with $\bar{m} = 0.6$ GeV, $R = 0.18$ and $\sigma_{\gamma N} = 0.0125$ fm² by Constandt et al.³⁾ marked by 2,
- iii) the same phenomena by Minorikawa et al.⁵⁾ with $\nu W_2 = q^2/\nu^2$ marked by 3,
- iv) accelerator data after Jain et al.⁶⁾.

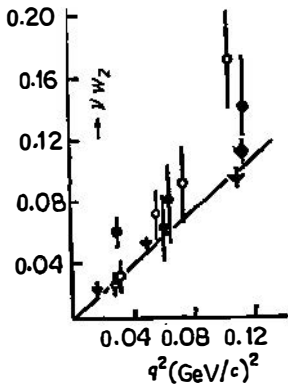


Fig. 1. The nucleon structure function νW_2 plotted as a function of $q^2 < 0.12$ (GeV/c)². Full line is the present result. Accelerator data: \blacktriangle — $\nu > 2$ GeV, \blacksquare — $\nu > 2$ GeV Eickmeyer et al.¹²⁾; \circ — 15.8 GeV/c μ^- ; \bullet — 10.1 GeV/c μ^+ Jain et al. ⁶⁾.

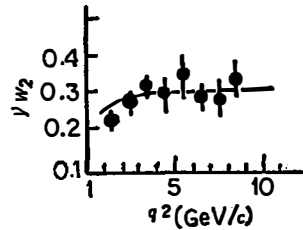
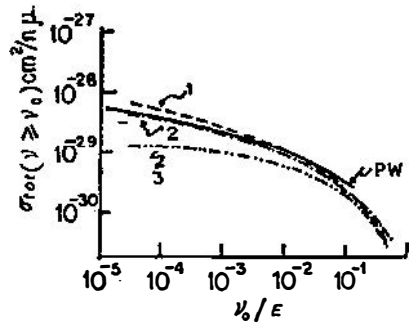


Fig. 2. The νW_2 as a function of q^2 viz. above 0.5 (GeV/c)². Full line is the derived result. Accelerator data: \bullet — Anderson et al. ¹¹⁾.

Fig. 3. The integral cross section $\sigma_{tot}(\nu > \nu_0)$ as a function of ν_0/E . Theoretical curves: Curve 1,2 Constandt et al. ³⁾, curve 3 after Minorikawa et al. ⁵⁾, PW — present work, \circ — Jain et al. ⁶⁾.



The integral cross section $\sigma(\nu \gg \nu_0)$ reveals a scaling feature in ν_0/E . The experimental data lies below the theoretical curve.

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FOTONUKLEARNI UDARNI PRESJEK VISOKOENERGETSKIH MUONA

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Ocijenjen je fotonuklearni udarni presjek upotrebom modificiranog modela Georgi-Politzera za ξ -skaliranje u lepton-hadron raspršenju. Nađeno je ν_0/E skaliranje integralnog udarnog presjeka $\sigma_{tot}(\nu > \nu_0)$ kao funkcija od ν_0/E . Slične rezultate dobili su Dau i suradnici upotrebom generaliziranog modela vektorske dominacije.