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S.R.GEVORKYAN, Ar.M.KOTZINIAN, V.M.ZHAMKOCHYAN

PHOTO- AND ELECTROPRODUCTION OF CHARMED PARTICLES ON NUCLEI

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ՀՄԱՅՎԱԾ ՄԱՍՆԻԿՆԵՐԻ ՖՈՏՈ- ԵՎ ԷԼԵԿՏՐԱԾՆՈՒՄԸ ՄԻՋՈՒԿՆԵՐԻ ՎՐԱ

Դիտարկված են հմայված մասնիկների ֆոտո- և էլեկտրածնման պրոցեսները միջուկների վրա: Օգտագործելով բազմակի ցրման տեսությունը՝ կանխագուշակված են արդյունարար նուկլոնային ճմերի մեծությունները: Ցույց է տրված, որ բավական ճշգրիտ փորձնական տվյալների առկայության դեպքում կարելի է գնահատել C -քվարկ-նուկլոն փոխազդեցության կտրվածքը:

Երևանի ֆիզիկայի ինստիտուտ

1986

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S.R.GEVORKYAN, Ar.M.KOTZINIAN, V.M.ZHAMKOCHYAN

PHOTO- AND ELECTROPRODUCTION OF CHARMED PARTICLES ON NUCLEI

The processes of photo- and electroproduction of charmed hadrons h_c on nuclei are considered. The values of effective nucleon numbers are predicted in the framework of multiple scattering theory, using a two-step mechanism of h_c formation. It is shown that in the presence of sufficiently exact experimental data one can estimate the cross section of c-quark-nucleon interaction.

Yerevan Physics Institute

Yerevan 1986

Препринт ЕФИ-873(24)-86

С.Р.ГЕВОРКЯН, В.М.ЖАМКОЧЯН, Ар.М.КОЦИНЯН

ФОТО- И ЭЛЕКТРОРОЖДЕНИЕ ОЧАРОВАННЫХ ЧАСТИЦ НА ЯДРАХ

Рассмотрены процессы фото- и электророждения очарованных адронов h_c на ядрах. В рамках теории многократного рассеяния, с использованием двухступенчатого механизма образования h_c , предсказаны величины эффективных нуклонных чисел. Показано,что при наличии достаточно точных экспериментальных данных возможна оценка сечения взаимодействия C - кварка с нуклоном.

Ереванский физический институт
Ереван 1986

During the recent years the production processes of particles with open charm $h_c\ (\mathcal{D}, \Lambda_c, ...)$ have been intensively investigated. The interest to these processes is due to the fact that the presence of heavy c -quark in the final state gives information about nonvalent component of nucleon wave function.

Thus, e.g. the study of photo- and electroproduction reactions of charmed hadrons $\overset{*}{\gamma} N \to hX$ allows one to determine in a most direct way the distribution function of gluons in nucleons. A good description of experimental data [1] in these processes is attained in the model of photon-gluon fusion with a two-step production of h_c : $\overset{*}{\gamma} g \to c\bar{c}$, $c(\bar{c}) \to h_c X$.

In the present work this mechanism is applied to the description of photoproduction processes (by both real and virtual photons) of charmed particles, which makes it possible to get information about the cross section of c -quark-nucleon interaction $\sigma(cN)$.

From experiments on photoproduction of J/Ψ [2] mesons on nuclei there was obtained an estimate for total cross section of interaction of this meson with nucleon $\sigma(\Psi N) \sim 3$ mb. which seemingly implied that $\sigma(cN) \sim 1$ mb.

Recently, a noticeable progress is achieved with the models in which account is taken of mutual screening (by color) of quark-antiquark pairs at small distances [3] . From the viewpoint of this approach, the smallness of $\sigma(\Psi N)$ is due to mutual screening of $c\bar{c}$ pairs in J/Ψ -meson rather than to smallness of quantity $\sigma(cN)$. This is due to a lesser radius of J/Ψ as compared to ordinary mesons.

At high energies in the fragmentation region of photon one may believe that the transition of c -quark to hadrons occurs outside the nucleus. This enables one to estimate $\sigma(cN)$ from the A-dependence of inclusive spectra of $\overset{*}{\gamma}A \to h_c X$ process.

Using a standard technique of multiple scattering theory, the inclusive spectrum of this process can be expressed through the elementary spectra as follows:

$$\frac{d\sigma}{dx}^{\overset{*}{\gamma}A\to h_c X}(x) = \int_x^1 \frac{d\sigma}{dx'}^{\gamma A\to cX}(x')\, \mathcal{D}_c^{h_c}\left(\frac{x}{x'}\right)\frac{dx'}{x'} \qquad (1)$$

$$\frac{d\sigma}{dx}^{\gamma A\to cX} = \sum_{n=0} M_n(\sigma)\int \frac{d\sigma}{dx_0}^{\gamma\to c}\cdot\frac{1}{\sigma}\frac{d\sigma}{dx_1}^{c\to c}\cdots\frac{1}{\sigma}\frac{d\sigma}{dx_{n-1}}^{c\to c}\delta(x-x_0\cdots x_{n-1})\,dx_0\cdots dx_{n-1} \qquad (2)$$

In these expressions the following notations are used:

$$M_n(\sigma) = \begin{cases} N(0,\sigma)\,, & n=0 \\ N(0,\sigma) - \sum_{i=1}^{n} N_i(\sigma)\,, & n\geqslant 1 \end{cases} \qquad (3)$$

$N_n(\sigma) = \frac{1}{\sigma_n!}\int(\sigma T)^n e^{-\sigma T} d^2 b\ ;\ T(b) = \int \rho(b,z)\,dz$ is a projection of one-particle nuclear density on impact parameter plane: $N(0,\sigma)$ =

$$= \sum_{n=1}^{\infty} N_n(\sigma) \quad .$$

The integrand in (2) represents an inclusive spectrum of c -quark which suffered n-1 inelastic collisions in nucleus; $\frac{d\sigma^{\gamma(c)\to c}}{dx}$ is an inclusive spectrum of $\gamma(c)N \to cX$; $\sigma \equiv \sigma^{in}(cN)$, and $\mathcal{D}_c^{h_c}(x)$ is fragmentation function of c -quark in h_c . In view of the fact that the charmed quark in h_c carries a larger fraction of momentum, we shall take for simplicity that

$$\mathcal{D}_c^{h_c}(x) = \delta(1-x) \tag{4}$$

The spectrum of $\gamma N \to cX$ process was chosen in the form: $\frac{d\sigma}{dx} \sim x^3(1-x)^3$. This parametrization describes satisfactorily experimental data [4] on $\gamma N \to \mathcal{D}_c X$ process (using (4)).

At $Q^2 \neq 0$ the spectrum of $\overset{*}{\gamma} N \to cX$ process was parametrized as follows:

$$\frac{d\sigma^{\overset{*}{\gamma}\to c}}{dx} \sim \left[x^3(1-x)^3 + \alpha x^2(1-x)^2 + \beta x(1-x)\right]$$

(α = -0.66, β = 0.13 at Q^2 = 20 (GeV/c)^2; α = -0.55, β = 0.09 at Q^2 = 80 (GeV/c)^2, which describes well the calculated spectrum in the photon-gluon fusion model (Fig.18 of Ref. [5]). By analogy with leading hadrons spectra, it was assumed that $\frac{1}{\sigma}\frac{d\sigma^{c\to c}}{dx} \equiv 1$

Taking into account the above-quoted assumptions we obtain the following expression for inclusive spectrum of $\gamma A \to h_c X$:

$$\frac{d\sigma^{\gamma A\to h_c X}}{dx}(x) = \frac{d\sigma^{\gamma N\to h_c X}}{dx}(x)\left[N(0,\sigma) + \sum_{n=1} M_n(\sigma)\int_x^1 \frac{d\sigma^{\gamma N\to h_c X}}{dx_1}(x_1)\frac{(\ln\frac{x_1}{x})^{n-1}}{(n-1)!}\frac{dx_1}{x_1}\right. \tag{5}$$

In the calculations we used the Fermi parametrization for one-particle nuclear density:

$$\rho(r) = \frac{\rho_0}{1 + \exp\frac{r-R}{c}}$$

with parameters from Ref. [6] .

Fig.1 shows the dependence of effective nucleon numbers

$$N_{eff}^{\gamma A \to h_c X} \equiv \frac{\frac{d\sigma}{dx}^{\gamma A \to h_c X}}{\frac{d\sigma}{dx}^{\gamma N \to h_c X}}$$

on A at $x = 0.5$. while Fig.2 - on x at A=207 (Pb) for different values of Q^2 and σ .

Fig.3 presents curves which describe the dependence of superscript α on x in generally accepted approximation $N_{eff} = \beta(x) A^{\alpha(x)}$ at $Q^2 = 0$.

As is shown in the plots, the value of $N_{eff}^{\gamma A \to h_c X}$ is rather sensitive to the value of quark-nucleon cross section. Thus, e.g. at σ = 1.5 mb and σ = 10 mb the values of effective nucleon number for a Pb nucleus differ by 40%.

Thus, in the presence of sufficiently precise experimental data, one can draw some certain conclusions about the value of cN-interaction inelastic cross section.

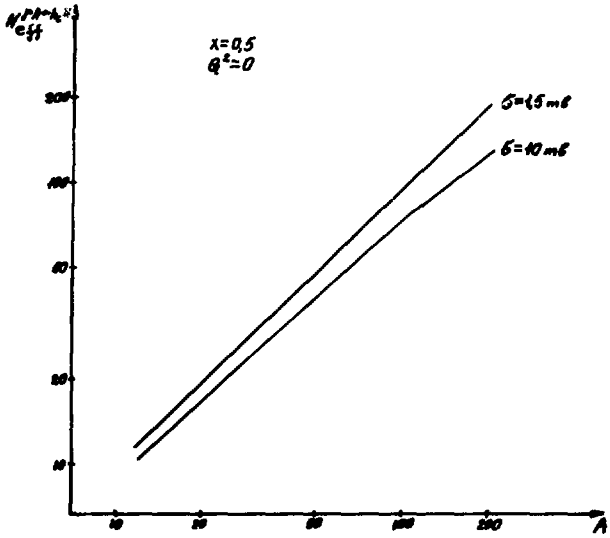
x=0,5
Q²=0
σ=15 mb
σ=10 mb
A

Fig. 1

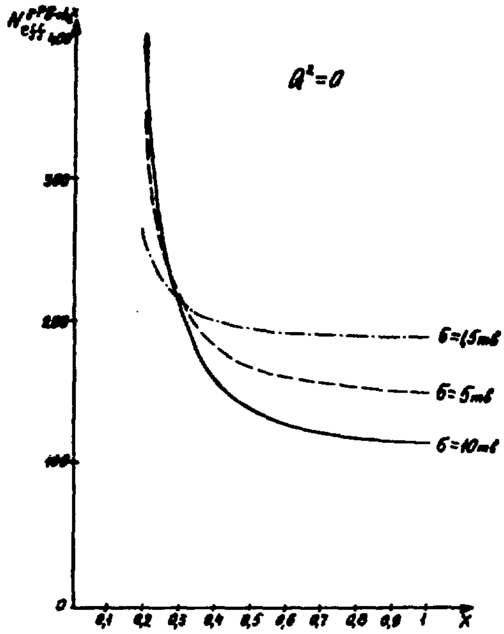
Q²=0
σ=15mb
σ=5mb
σ=10mb
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
x

Fig.2a

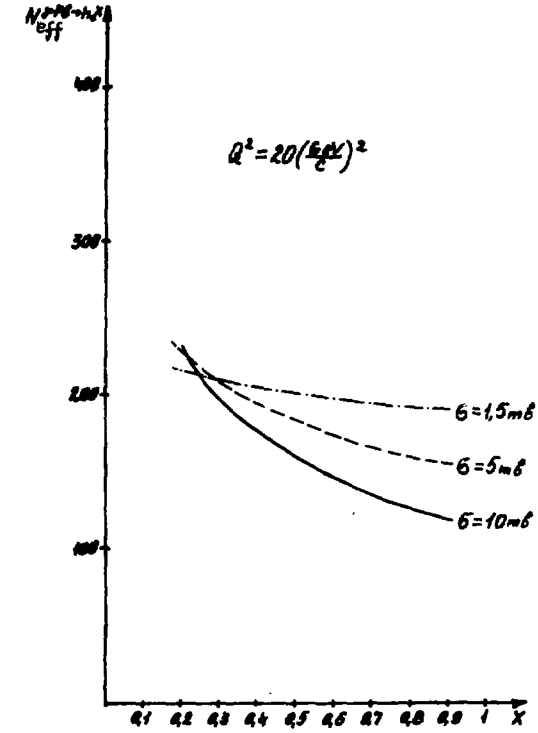
N_{eff}
400
300
200
100
$Q^2 = 20\left(\frac{GeV}{c}\right)^2$
σ=1,5mb
σ=5mb
σ=10mb
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
X

Fig.2b

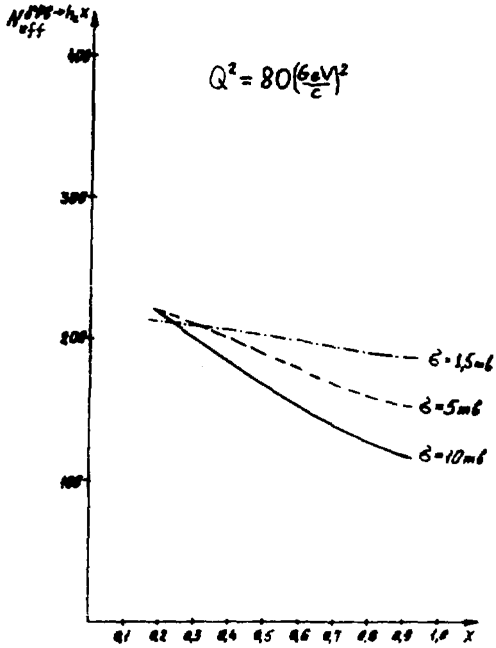
N_{eff}
400
300
200
100
$Q^2 = 80\left(\frac{GeV}{c}\right)^2$
σ=1,5mb
σ=5mb
σ=10mb
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1,0
X

Fig.2s

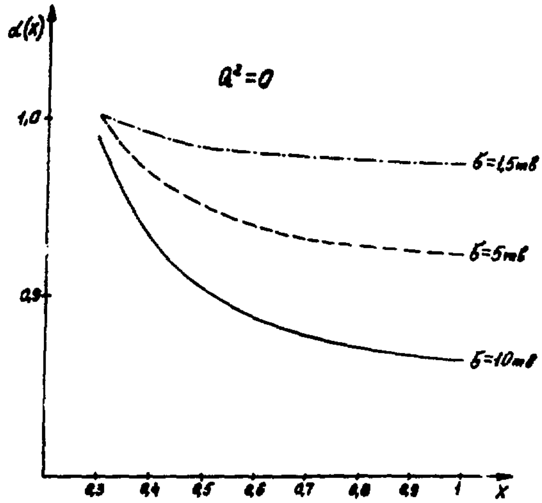

Fig.3

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