

Preprint ~~ВФН~~-866(I7)-86

**ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ**  
**ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ**

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ASSOCIATED MULTIPLICITY OF  $\gamma$ -PARTICLES IN PROCESSES  
OF LEPTON PAIR PRODUCTION ON NUCLEI

**ЦНИИАтоминформ**

**ЕРЕВАН-1986**

Նախնատիպ EՊՄ-866(I7)-86

ՎԱՐԴԱՆՅԱՆ Վ.Ա., ԳԵՎՈՐԳՅԱՆ Ա.Ռ., ԳՈՒԼԲԱՆՅԱՆ Հ.Ռ.

**Գ -ՈՒՄՆԻԿՆԵՐԻ ԶՈՒԳՈՐԴՎԱԾ ԲԱԶՄԱԿԻՈՒԹՅՈՒՆԸ ՄԻՋՈՒԿԻ  
ՎՐԱ ԼԵՊՏՈՆԱՅԻՆ ԶՈՒՅԳԵՐԻ ԾՆՈՒՄՆ ՊՐՈՑԵՍՆԵՐՈՒՄ**

Բազմակի գրման տեսության շրջանակներում ստազված է, լեպտոնային զույգերի խորապես ոչ առաձգական ծնման պրոսեսն ուղեկցող  $g$ -մասնիկների միջին Բազմակիության համար, արտահայտություն: Ատազված արդյունքը թույլ է տալիս տեղեկություն ստանալ այդ պրոսեսներում առաջնային հաղորդի կառուցվածքային առանձնահատկությունների մասին:

Երևանի Ֆիզիկայի ինստիտուտ

Երևան 1986

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Preprint EMI-866(I7)-86

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ASSOCIATED MULTIPLICITY OF  $g$  -PARTICLES IN PROCESSES  
OF LEPTON PAIR PRODUCTION ON NUCLEI

An expression has been obtained for mean multiplicity of  $g$  -particles accompanying the process of deep-inelastic lepton pairproduction on nuclei. The expression allows one to get information on structure peculiarities of leading hadron in this process.

Yerevan Physics Institute

Yerevan 1986

Препринт ВФИ-866(17)-86

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АССОЦИИРОВАННАЯ МНОЖЕСТВЕННОСТЬ  
 $g$  - ЧАСТИЦ В ПРОЦЕССАХ ОБРАЗОВАНИЯ ЛЕПТОННЫХ  
ПАР НА ЯДРАХ

В рамках теории многократного рассеяния получено выражение для средней множественности  $g$  - частиц, сопровождающих процесс глубоконеупругого рождения лептонных пар на ядрах, которое позволяет извлечь информацию о структурных особенностях лидирующего адрона в этом процессе.

Ереванский физический институт

Ереван 1986

The investigation of multiplicity distribution of the so-called  $g$  - particles (which are mostly recoil protons with velocities  $0.3 \leq \beta \leq 0.7$ ) in inelastic collisions of high-energy particles with atomic nuclei allows one to obtain information on multiple interaction processes occurring in nuclear matter. Ref. [1] describes within the multiple scattering theory the available experimental data on mean  $\langle n_g \rangle$  multiplicity of protons with  $T_p = 30 - 300$  MeV energies produced in interactions of different types of hadrons with atomic nuclei at high (50-400 GeV) energies. In this work it is in particular shown that an essential contribution ( $\geq 80\%$ ) to  $\langle n_g \rangle$  comes from secondary interactions in nucleus of relatively low-energy pions from the target fragmentation region, while a contribution to  $\langle n_g \rangle$  made by multiple rescatterings of leading hadron interacting in nucleus with "usual" hadron-nucleon cross section is considerably less ( $\approx 20\%$ ).

In Ref. [2] we obtained predictions for  $\langle n_g \rangle$  (below, the recoil protons with 30 - 300 MeV energy will be implied) for the processes of deep-inelastic lepton-nuclear scattering allowing to determine from a comparison with experiment the averaged cross section of interaction of knocked-out quark or products of its hadronization with the nucleus nucleon and thus to derive information on space-time picture of quark-parton hadronization.

The atomic nuclei experiments also give rise to a principal possibility to investigate the structural peculiarities of hadrons participating in deep-inelastic hadron-nucleus collisions. Thus, Ref. [3] predicts a possibility of revealing the role of the point-like configuration [4] of hadrons in the processes of the Drell-Yan lepton pairproduction on nuclei. According to [3], a dominant role in the processes of lepton pairproduction at large values of the Feynmann variable ( $x_{e\bar{e}} > 0.5$ ) is played by a part of the incident hadron wave function corresponding to a point-like configuration of hadron with a mean-square radius several times as less as its "usual" one. The hadron of such configuration undergoes in the nucleus collisions with the effective cross section  $\sigma^{ef}(x_{e\bar{e}})$  noticeably less than the hadron-nucleon one,  $\sigma_{hN}$ . The mean number of leading hadron collisions  $\bar{N}_{e\bar{e}}$  and hence the  $g$ -particles multiplicity  $\langle n_g \rangle_{e\bar{e}}$  decrease correspondingly.

The predictions for  $\langle n_g \rangle_{e\bar{e}}$  versus  $\sigma^{ef}(x_{e\bar{e}})$  are given in [3]. However these theoretical estimations do not take into account the contribution to  $\langle n_g \rangle_{e\bar{e}}$  from the secondary interactions of low-energy pions produced in the target fragmentation region; meanwhile, as mentioned above, this contribution is dominant [1]. Therefore, more exact theoretical calculations are necessary in order to make quantitative conclusions on the dynamics of deep-inelastic lepton pairproduction on nuclei.

In this work we have obtained the analytical expression for  $\langle n_g \rangle_{e\bar{e}}$  as well as performed calculations which allow, from the comparison with mean multiplicity of  $g$ -particles accompanying the Drell-Yan pairproduction on nuclei, to estimate the effective cross sections  $\sigma^{ef}(x_{e\bar{e}})$  and thus derive information on properties of hadrons participating in deep-inelastic interaction. Using for  $\langle n_g \rangle$  the expression obtained in [1], one can

readily obtain in an analogous way the predictions for a most general case of the considered process when the leading hadron undergoes inelastic collisions with arbitrary cross sections  $\sigma_1$  and  $\sigma_2$  before and after lepton pairproduction in nucleus, respectively. The expression for  $\langle n_g \rangle_{e\bar{e}}$  according to the results of Ref. [1] has the form:

$$\begin{aligned} \langle n_g \rangle_{e\bar{e}} = & \omega_0 + \omega \frac{\sigma_1 + \sigma_2}{2A} \int T^2(B) d^2B + m_0 \omega_1 \left[ 1 - \right. \\ & \left. - \frac{N(0; \sigma_3)}{A} \right] + m \omega_1 \left[ \frac{\sigma_2 - \sigma_1}{\sigma_3} \cdot \frac{N(0; \sigma_3)}{A} + \right. \\ & \left. + \frac{\sigma_1 + \sigma_2}{2A} \int T^2(B) + \frac{\sigma_1}{\sigma_3} \frac{N_1(\sigma_3)}{A} - \frac{\sigma_2}{\sigma_3} \right], \end{aligned} \quad (1)$$

where  $\omega_0$  is mean multiplicity of  $g$ -particles in deep-inelastic hadron-nucleon interaction,  $\omega$  - in hadron-nucleon interaction,  $\omega_1$  - in interactions of low-energy ( $P_{\pi} < 3$  GeV) pions from the target fragmentation region with nucleon; making use of the estimations given in [?] we have:

$$\omega_0 = 0.10 \pm 0.01, \quad \omega = 0.15 \pm 0.01, \quad \omega_1 = 0.40 \pm 0.02$$

(the data are averaged over the number of the target nucleus protons and neutrons).  $m_0$  is mean number of pions (of all signs) from the target fragmentation region, accompanying the Drell-Yan pairproduction:  $m$  is the same in hadron-nucleon collisions before and after the deep-inelastic interaction act. At sufficiently high initial energies (of the order of 100 GeV and higher) the quantity  $m$  is practically independent of collision multiplicity, being equal [1] to  $m \approx 3$ . No experimental data are available concerning  $m_0$ ; the latter may depend on  $X_{e\bar{e}}$  and differ from  $m$ . We assume that on the average  $m_0 \approx m \approx 3$  (this being not in contra-

diction, in particular, to the data on deep-inelastic neutrino-nucleon interactions - see [2] and references therein); note that the admissible error affects the calculation results for  $\langle n_g \rangle_{e\bar{e}}$  insignificantly.  $\sigma_3$  is averaged over momentum spectrum of low-energy pions for cross sections of pion-nucleon interaction; according to [1],  $\sigma_3 \approx 27$  mb.  $T(\beta) = \int \rho(\beta, \vec{z}) d\vec{z}$  is a projection of one-particle nuclear density  $\rho(\vec{z})$  on the impact parameter plane ( $\int \rho(\vec{z}) d\vec{z} = A$ , the Fermi-type density is used in the calculations).  $N(0; \sigma)$ ,  $N_1(\sigma)$  are the so-called effective numbers:

$$N(0, \sigma) = \int \frac{1 - e^{-\sigma T(\beta)}}{\sigma} d^2\beta$$

$$N_1(\sigma) = \int T(\beta) e^{-\sigma T(\beta)} d^2\beta$$

The first two terms of expression (1) describe a contribution to  $\langle n_g \rangle$  from the recoil protons produced in multiple collisions of leading hadron; the last two terms describe a contribution from interactions in the nucleus of the secondary low-energy pions from the target fragmentation region, produced in the deep-inelastic interaction act (the third term) as well as before and after it (the fourth term). Fig.1 shows the results of calculations by formula (1) performed for the following possible cases:

1. The leading hadron before and after the act of deep-inelastic lepton pairproduction preserves the properties of initial hadron and interacts in the nucleus with a cross section equal to the one of hadron-nucleon interaction.  $\sigma_1 = \sigma_2 = \sigma_{hN}$ .

2. Point-like configuration in the leading hadron is dominant before and after the deep-inelastic interaction [4] and multiple interactions in nucleus proceed with cross sections noticeably less than the hadron-nucleon ones:

$\sigma_1, \sigma_2 < \sigma_{hN}$  (Fig.1 shows predictions for particular cases  
 $\sigma_1 = \sigma_2 = 3 \text{ mb}$  and  $\sigma_1 = \sigma_2 = 10 \text{ mb}$ ).

3. In the leading hadron, before the deep-inelastic interaction act, there dominates a point-like configuration ( $\sigma_1 \ll \sigma_{hN}$ ) which "is broken" as a result of the interaction, and the leading hadron undergoes then collisions in the nucleus with the "normal" hadronic cross section ( $\sigma_2 = \sigma_{hN}$ ).

4. The leading hadron before the deep-inelastic interaction act preserves properties of the "normal" hadron and interacts with the cross section  $\sigma_1 = \sigma_{hN}$ , and after such interaction it loses a part of its gluonic field and as a result the subsequent collisions in the nucleus proceed with noticeably less cross section ( $\sigma_2 < \sigma_{hN}$ ).

As one can see from Fig.1, the predicted absolute values and A-dependences of mean multiplicity of  $g$ -particles are sensitive enough to parameters  $\sigma_1, \sigma_2$  in order to extract them from experimental data.

Fulfilment of experiments on deep-inelastic lepton pairproduction (at different values of their effective mass and Feynmann variable) with a simultaneous registration of accompanying  $g$ -particles as well as the comparison of experimental data with the results of calculations performed in this work will allow to establish which one among the above-mentioned mechanisms is realized, and will give an important information on strong interaction dynamics.

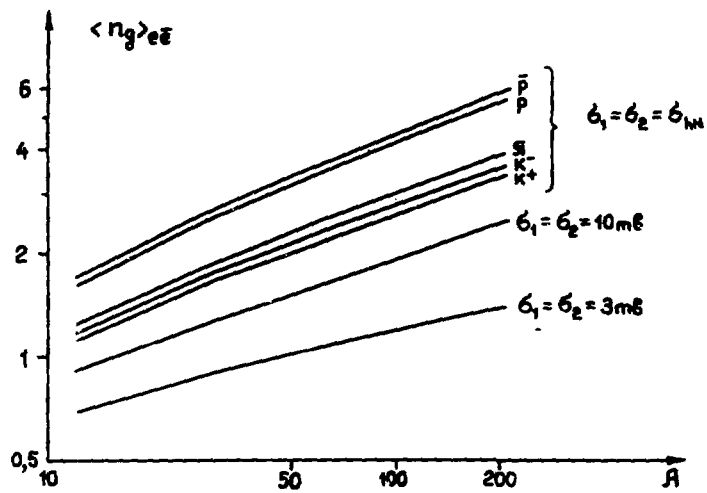


Fig. 1a

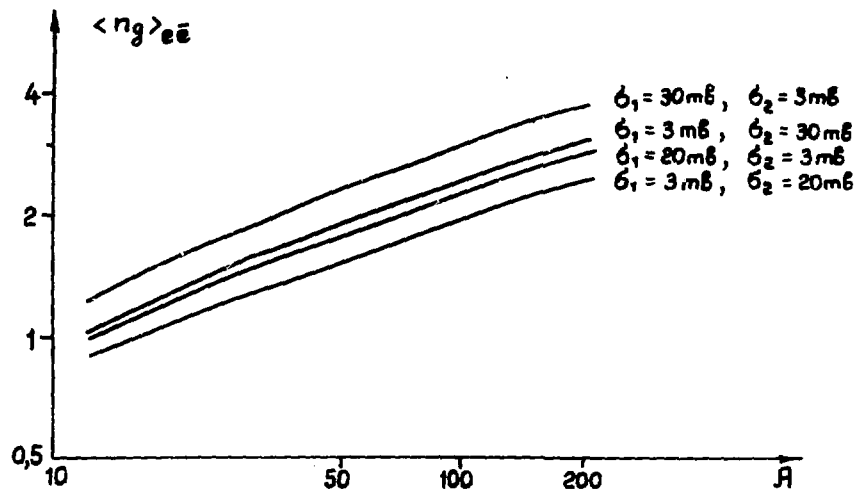


Fig. 1b

Fig. 1a,b. Mean multiplicity of  $g$ -particles as a function of  $\sigma_1$  and  $\sigma_2$  cross sections (see the text).

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The manuscript was received 5 March 1986

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АССОЦИИРОВАННАЯ МНОЖЕСТВЕННОСТЬ  $g$  - ЧАСТИЦ В ПРОЦЕССАХ  
ОБРАЗОВАНИЯ ЛЕПТОННЫХ ПАР НА ЯДРАХ

( на английском языке, перевод З.Н.Асланян )

Редактор Л.П.Мукаян .

Технический редактор А.С.Абрамян

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Подписано в печать 13/У-86г. ВФ-05506 Формат 60x84/16  
Офсетная печать. Уч. изд. л. 0,5 Тираж 299 экз. Ц. 8 к.  
Зак. тип. № 287 Индекс 3624

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Отпечатано в Ереванском физическом институте  
Ереван 36, Маркаряна 2

индекс 3624



ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ