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ON THE FACTORIZATION OF STRUCTURE FUNCTION IN THE PROCESS OF PHOTOPRODUCTION OF CUMULATIVE PROTONS

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К.Ш.ЕГИЯН

О ФАКТОРИЗАЦИИ СТРУКТУРНОЙ ФУНКЦИИ В ПРОЦЕССЕ КУМУЛЯТИВНОГО ФОТОРОЖДЕНИЯ ПРОТОНОВ

Экспериментальные результаты по кумулятивному фоторождению протонов на ^{12}C представлены в зависимости от световой переменной α и от $P_\perp$. Показано, что для $\alpha > 1$ и $P_\perp \geq 0{,}5 \frac{ГэВ}{c}$ структурная функция $f(\alpha, P_\perp)$ факторизуется: $f(\alpha, P_\perp^2) = f_1(\alpha) \cdot f_2(P_\perp^2)$. При этом функции $f_1(\alpha)$ и $f_2(P_\perp^2)$ имеют экспоненциальный вид.

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Experimental results on the photoproduction of cumulative protons on ^{12}C are presented versus the light scaling variable α and $P_\perp$. The structure function $f(\alpha, P_\perp^2)$ is shown to be factorized for $\alpha > 1$ and $P_\perp \geqslant 0{,}5$ GeV/c ; $f(\alpha, P_\perp^2) = f_1(\alpha) \cdot f_2(P_\perp^2)$ The functions $f_1(\alpha)$ and $f_2(P_\perp^2)$ here have an exponential form.

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1. Most of experimental data on the production of cumulative particles are presented as dependences of invariant cross sections on two directly measured values - kinetic energy (or momentum square) and detection angle:

$$E \cdot \frac{d^3\sigma}{d^3p} \equiv f(\vec{p}) = f(p^2, \vartheta) = f(T, \vartheta) \qquad (1)$$

Such a representation has a certain disadvantage: the invariant structure function f is expressed, as in the limiting fragmentation suggested by Yang et al. [1], through variables, one of which (in this case the detection angle) is not invariant (the kinetic energy of the detected particle is an invariant value since for the reaction

$$a + A \rightarrow c + X \qquad (2)$$

$T_c = \frac{P_c \cdot P_A}{m_A} - m_c$, where P_c and P_A are the four-momenta of the particles C and A , respectively).

The final choice of invariant variables for the production of cumulative particles isn't so far made. The use of ordinary Feynman variables $X = \frac{P_{\parallel}}{(P_{\parallel})_{max}}, P_{\perp}$ gives no good results, since the processes of the production of cumulative particles are investigated mainly at moderate energies when the definition of X is not valid.

Recently more and more often is used the light scaling variable[2,3]

$$\alpha = \left[(m_c^2 + P_c^2)^{1/2} - P_c \cos \vartheta_c \right] / m \qquad (3)$$

which coincides in the infinite energy limit with the Feynman variable X . It should be noted that variables of a number of model representations of the production of cumulative particles (for instance, the cumulative number Q in Baldin-Stavinsky approach[4], the variable K_{min} in Amado-Woloshyn-Frankel[5,6] approach etc.) also coincide with the light scaling variable at $S \to \infty$

Experimental data and their comparison with theoretical representations on the production of cumulative protons on nuclei, i.e. in the process (1), when a is the essence of γ - quantum, have been so far presented[7] in the variables (T, ϑ). It has been shown that the structure function $f(T, \vartheta)$ isn't factorized over the variables T and ϑ . This creates certain difficulties as compared with theory.

In the present work we have tried to present the results of the photoproduction of cumulative protons in invariant variables α , $P_\perp$.

2. In fig. 1 the set of experimental data is presented on the angular dependence of the structure function of proton photoproduction on the nucleus ^{12}C at E_γ^{max} = 4.5 GeV and at

a number of values of the proton kinetic energy. As it is seen, no factorization is observed.

In order to make possible the transition from the (T,ϑ)-representation to the $(\alpha, P_\perp)$-representation, all angular dependences were fitted by polynomials over ϑ. The results of such a fitting are presented in fig. 1 by solid lines. Since the number of points in the given ϑ-distribution is fairly large, the accuracy of interpolation on curves is good. The fitting curves have been used to find the points in $(\alpha, P_\perp)$-representation. This has allowed to essentially increase the number of points $(\alpha, P_\perp)$ without prejudice to accuracy.

3. In fig. 2a the dependences of structure function on α at four values of $P_\perp$ are presented. Curves are drawn through points to make it more obvious. According to fig. 2a the dependences of structure function on α have the same form for all values of $P_\perp$. At $\alpha \approx 1$ the maximum of $f(\alpha, P_\perp^2)$ is observed. Apparently, this testifies the change of the proton generation mode at $\alpha \approx 1$ (it should be noted that to the values $\alpha > 1$ corresponds the cumulative region, i.e. the forbidden region for the reaction (2) on a free, stationary nucleon).

In the region $\alpha > 1$ the function $f(\alpha, P_\perp^2)$ is factorized

$$f(\alpha, P_\perp^2) = f_1(\alpha)\, f_2(P_\perp^2) \qquad (4)$$

then $f_1(\alpha)$ has an exponential form

$$f_1(\alpha) \sim \exp(-\alpha/\alpha_0) \qquad (5)$$

with $\alpha_0 = 0.147$. In the case of primary hadrons with the energy 8.9 GeV $\alpha_0 = 0.166$ [8,9]. It should be mentioned, howevethat α_0 in [8,9] is defined for a special case only, when $P_\perp = 0$ (the proton detection angle is $\vartheta_p = 180^\circ$). Unfortunately, for other values of $P_\perp$ such an analysis is lacking.

A number of dependences of $f(\alpha, P_\perp')$ on $P_\perp^2$ for various α are presented in fig. 2b. Firstly, one can see fairly well the factorization of the function $f(\alpha, P_\perp^2)$ on $f_1(\alpha)$ and $f_2(P_\perp^2)$. Secondly, two regions of the function $f_2(P_\perp^2)$ stand clearly out. In the case of small values of α ($\alpha \leq 1$) $f_2(P_\perp^2)$ is described by two exponents with different $P_{\perp 0}^2$, namely, for small $P_\perp$ the exponent is a more falling one ($P_{\perp 0}^2 = 0.121$ (GeV/c)^2) than for large $P_\perp$ ($P_{\perp 0}^2 = 0.195$ (GeV/c)). The validity region of the small exponent is considerably extended with the increase of α.

Thus we can assert that for the values $\alpha > 1$ and $P_\perp \geq 0.5$ GeV/c the structure function is not only factorized into two functions $f_1(\alpha)$ and $f_2(P_\perp^2)$, but also that these two functions have an exponential form.

In conclusion I would like to express my thanks to A.M. Baldin for useful discussions and interest in this work as well as to the staff of photonuclear reactions laboratory of YePI for the help in data processing.

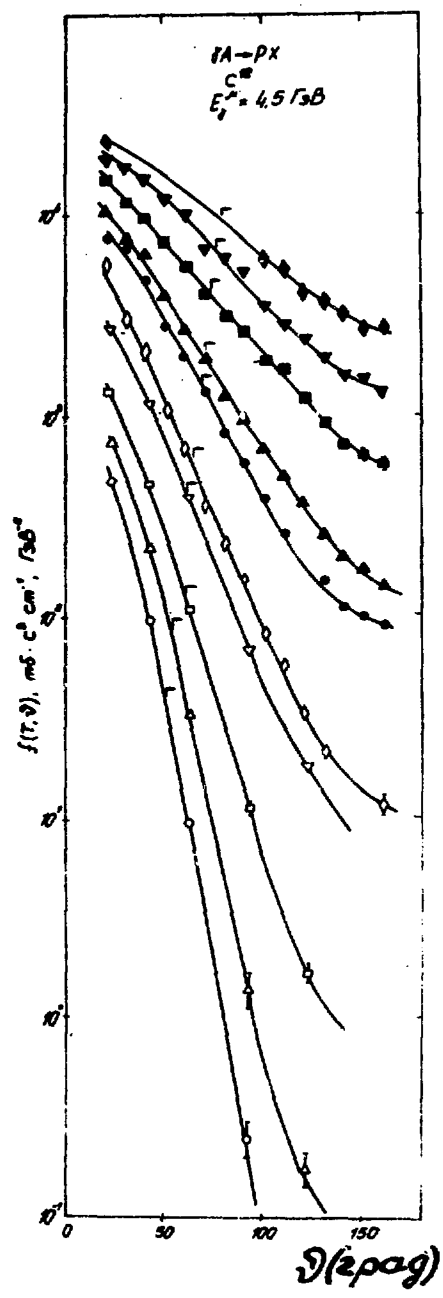

Fig. 1

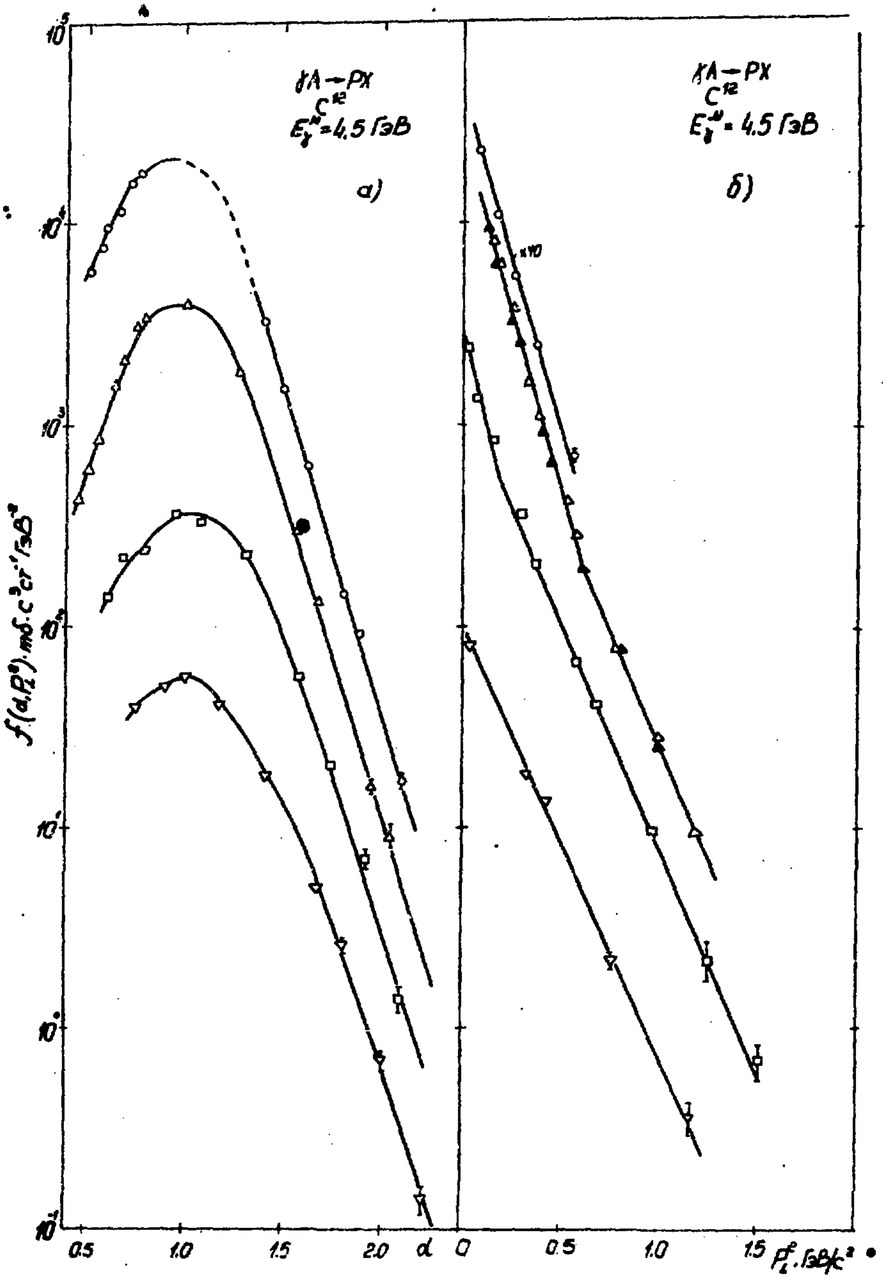

Fig. 2

Figure Captions

Fig. 1 Angular distributions of the reaction $\gamma\,^{12}C \to pX$ yield at E_{γ}^{max} = 4.5 GeV. Experimental points: ♦ - for the proton momentum P_p = 0.4 GeV/c, ▼ - 0.44 GeV/c, ■ - 0.52 GeV/c, ▲ - 0.608 GeV/c, ● - 0.66 GeV/c, ◊ - 0.79 GeV/c, ∇ - 0.84 GeV/c, □ - 0.98 GeV/c, Δ - 1.131 GeV/c, ○ - 1.25 GeV/c. The curves are drawn through experimental points by a polynomial over ϑ_p by the least squares method.

Fig. 2 a) Dependence of the structure function $f(\alpha, P_{\perp}^2)$ on the light scaling variable α for various $P_{\perp}$. Experimental points: ○ - $P_{\perp}$ = 0.25 GeV/c, Δ - 0.5GeV/c, □ - 0.75 GeV/c, ∇ - 0.95 GeV/c. The curves are drawn through experimental points to make it more obvious.

b) Dependence of the structure function $f(\alpha, P_{\perp}^2)$ on $P_{\perp}^2$ at various values of α. Experimental points: ○ - α = 0.5, ▲ - 0.82, Δ - 1.0, □ - 1.5, ∇ - 1.9. The lines are drawn through experimental points using the least squares method by the exponential law.

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