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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

ЕФИ-ТФ-5(71)

S.G.MATINIAN and YU.G.SHAKHNAZARIAN

PHOTOPRODUCTION OF X^0-MESON IN PERIPHERAL MODEL

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ԵՐԵՎԱՆ 1971 ЕРЕВАН

YEREVAN PHYSICAL INSTITUTE

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M-26

Abstract

On the basis of Dar, Watts and Weisskopf's "New peripheral model" photoproduction of X^0 from nucleons is considered. The dependences of the cross-section $\frac{d\sigma}{dt}(\gamma p \to pX^0)$ of the ratio $\frac{d\sigma}{dt}(\gamma n \to nX^0) / \frac{d\sigma}{dt}(\gamma p \to pX^0)$ and of the asymmetry ratio $\Sigma = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel}$ connected with the linear polarization of the photons on the square of momentum transfer t at various energies are obtained.

In this work we shall study the production of X^0 -meson with quantum numbers $J^P I^G = 0^- 0^+$ in the reaction

$$\gamma + N \to X^0 + N . \qquad (I)$$

We have considered this problem on the basis of the "new peripheral model" recently proposed by Dar, Watts and Weisskopf [I], the difference of which from the well known absorption models consists in the fact that in the expression for the dependence of the partial amplitudes of the process with the given helicities of the participating particles $M^j_{\{\lambda\}}$, on the corresponding partial Born amplitudes $B^j_{\{\lambda\}}$ calculated on the basis of the one particle exchange diagram

$$\langle \lambda_2 | M^j | \lambda, \lambda_1 \rangle = \eta^j \langle \lambda_2 | B^j | \lambda, \lambda_1 \rangle \qquad (2)$$

the absorption coefficients η^j are assumed to be dependent also on the energy of the reaction. Following the paper [I], as a function $\eta^j(S)$ we have taken an expression of the Wood-Saxon type with energy-depending parameters obtained on the basis of the analysis of the reaction $\gamma p \to \pi^0 p$ in [2], and they are assumed to be the same for all the reactions of the photoproduction of pseudoscalar mesons.

Considering the process (I), we have proceeded from the Born amplitude corresponding to the exchange of ρ - and ω-mesons in the t-channel. In the case of the chosen normalization when the c.m.s. cross section of the process is

$$\frac{d\sigma}{dt} = \frac{I}{256 \pi K_0^2 S} \sum_{\lambda, \lambda_1 \lambda_2} | \langle \lambda_2 | M | \lambda, \lambda_1 \rangle |^2 , \qquad (3)$$

the Born amplitude has the form

$$\langle \lambda_2 | B | \lambda, \lambda_1 \rangle = \sum_{V=\rho,\omega} \bar{u}^{(\lambda_2)} (\vec{p}_2) T_V^{(\lambda)} u^{(\lambda_1)} (\vec{p}_1) , \qquad (4)$$

where

$$T_{v}^{(\lambda)} = \frac{1}{m_{v}^{2} - t} \left[\gamma_{\mu} g_{vNN}^{(v)} - \frac{i}{4m_{N}} (\gamma_{\mu}\hat{q} - \hat{q}\gamma_{\mu}) g_{vNN}^{(T)} \right] g_{v} \varepsilon_{\mu\nu\alpha\beta} e_{\nu}^{(\lambda)} K_{\alpha} q_{\beta} \,. \quad (5)$$

Here K is the photon four-momentum, q is the momentum transfer, S is the square of the c.m.s. total energy, $t = -q^{2}$, $g_{vNN}^{(v)}$ and $g_{vNN}^{(T)}$ are the vector and tensor coupling constants of the vector particles with the nucleon, respectively, and g_{v} is the coupling constant in the $vx^{0}\gamma$-vertex.

Expanding the Born amplitudes $\langle \lambda_2 | B | \lambda, \lambda_1 \rangle$ with concrete helicities, among which only four are independent amplitudes, in partial waves[3], and determining the partial amplitudes $\langle \lambda_2 | B^{J} | \lambda, \lambda_1 \rangle$, one may calculate the amplitudes according to (2), and by summing up the corresponding series obtain the unknown amplitudes of the process (1), which determine the cross-section for unpolarized particles (3), as well as the asymmetry given by the expression

$$\Sigma = \frac{\sigma_{\perp} - \sigma_{\parallel}}{\sigma_{\perp} + \sigma_{\parallel}} = 2 \frac{\sum_{\lambda_1} \langle 1/2 | M | 1, \lambda_1 \rangle \langle 1/2 | M | -1, \lambda_1 \rangle^{*}}{\sum_{\lambda_1 \lambda_2} | \langle \lambda_2 | M | 1, \lambda_1 \rangle |^{2}} \,, \quad (6)$$

where $\sigma_{\perp}$ and $\sigma_{\parallel}$ are the cross-sections of the process given rise by the photons with linear polarization perpendicular and parallel to the plane of the reaction. We have calculated also the total cross-section of the reaction (1) at some values of photon energy.

For the constants $g_{vNN}^{(v)}$ and $g_{vNN}^{(T)}$, we have adopted the values given in the paper[2], considering the case when $g_{\omega NN}^{(T)} = g_{\omega NN}^{(v)}$, as well as the case when the relation $g_{\omega NN}^{(T)} = -0{,}12 g_{\omega NN}^{(v)}$, valid for the isoscalar photons, takes place between the above given constants. As to the coupling constants in the $vx^{0}\gamma$-vertex, they can be determined by two different approaches. In the quark model with ηX^0 -mixing angle equal to -10°, their values are[4] :

$$g_V = \frac{g_{VX\gamma}}{m_V}\ ,\quad g_{\omega X\gamma} = \frac{1}{3}\sqrt{\frac{2}{3}}\ g_{\omega\pi\gamma}\ ,\quad g_{\rho X\gamma} = \sqrt{\frac{2}{3}}\ g_{\omega\pi\gamma}\ .$$

In another approach using the effective Lagrangian with SU(3) octet breaking, the corresponding coupling constants have the form[5]

$$g_{\omega} = \frac{2h_0 e}{g}\ \frac{(1-\beta)\sin\theta}{\sqrt{3K_{\omega}}}\ , \tag{7}$$

$$g_{\rho} = \frac{2h_0 e}{g}\ \frac{1+\beta}{\sqrt{K_{\rho}}}\ ,$$

where $K_V = \frac{m^2}{m_V^2}$, $m = 847$ MeV, $\theta = 27.5^{0}$, and β is the symmetry-breaking parameter. It is seen that in such a model, the coupling constants g_V are determined by the parameter β with an accuracy of a common factor.

The obtained results are diagrammed in Figs I - 6. In Figs I and 2 we have plotted the dependence of the differential cross-section of the process $\gamma p \to X^0 p$ on the momentum transfer $-t$ at some values of photon energies from 3 up to I6 GeV for the case of $\frac{g^{(T)}}{g^{(V)}}(\omega pp) = 1$ and $\frac{g^{(T)}}{g^{(V)}}(\omega pp) = -0.12$, respectively. Fig.3 shows the dependence of the total cross-section of the process $\gamma p \to X^0 p$ on the photon energy for the above mentioned two cases. Fig.4 shows the dependence of the asymmetry Σ on the momentum transfer at 3 GeV for the same two cases. Fig.5 shows the dependence of the ratio $\frac{d\sigma}{dt}(\gamma n \to X^0 n) \,/\, \frac{d\sigma}{dt}(\gamma p \to X^0 p)$ on $-t$ at 3 GeV. And, finally, Fig.6 shows the differential cross-sections corresponding to the calculated total cross section normalized to the experimental value[6] at the values of the symmetry-breaking $\beta = -0.7$, -0.5 and -0.3 and at an energy 3 GeV.

Let us note that the obtained estimations for the total cross-section of the process $\gamma p \to X^0 p$ are in agreement with the available experimental data[6].

Comparing the results obtained in this work for the cross-sections of the process (I), and for the asymmetry with those of the experiment, it will be possible to judge on the validity of either models with the help of which the corresponding coupling constants have been calculated.

References

1. A.Dar, T.L.Watts, V.F.Weisskopf, Nucl.Phys., BI3, 477 (I969).
2. A.Dar, T.L.Watts, V.F.Weisskopf, Phys.Lett., 30B, 264 (I969).
3. M.Jacob, G.C.Wick, Ann.Phys., 7, 404 (I959).
4. A.Dar, V.F.Weisskopf, Phys.Lett., 26B, 670 (I968).
5. P.Singer, Phys.Rev., DI, 86 (I970).
6. Aachen et al collaboration, Phys.Rev., I75, I669 (I968).

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$\gamma P \to X^{*} P$

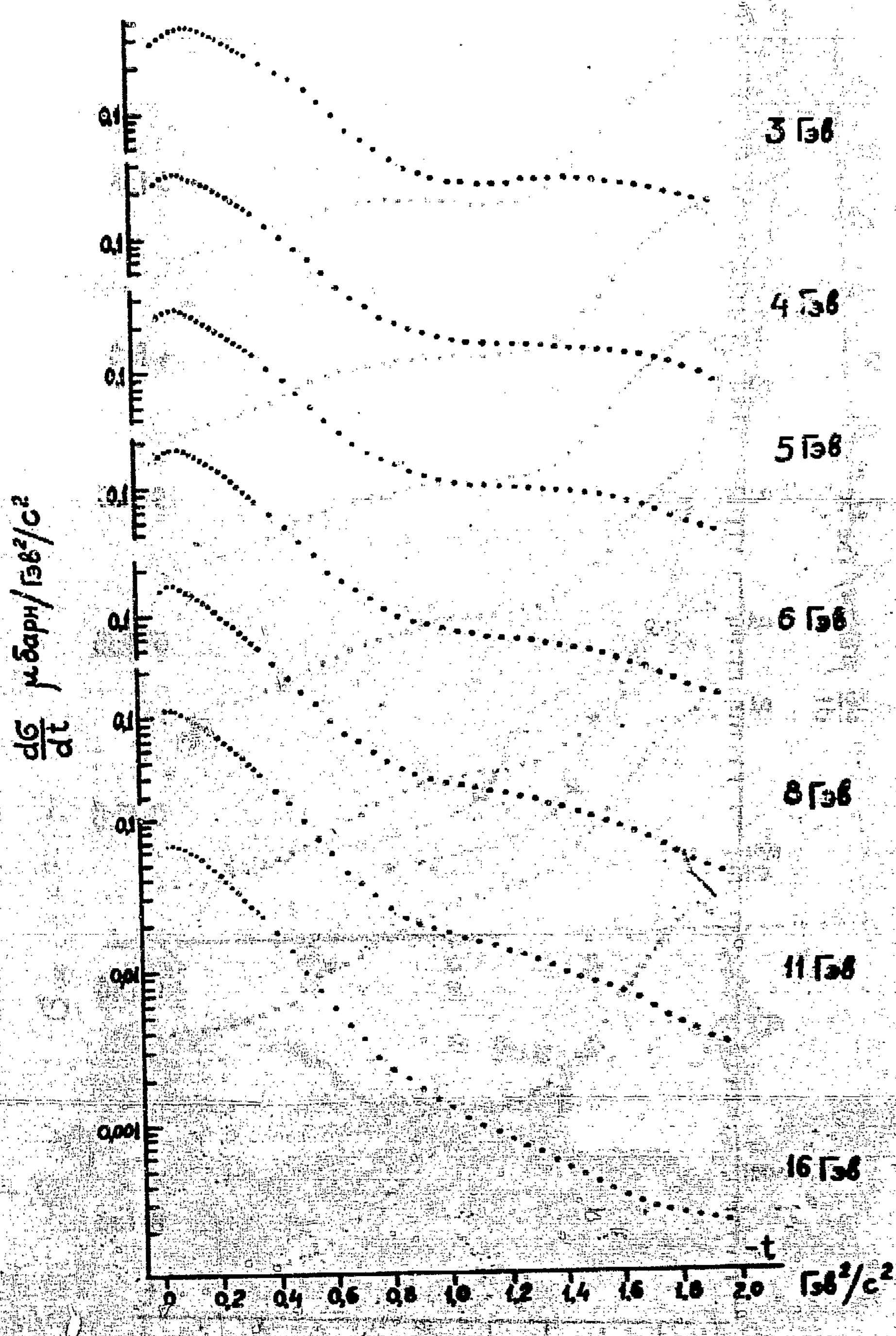


Рис. 1

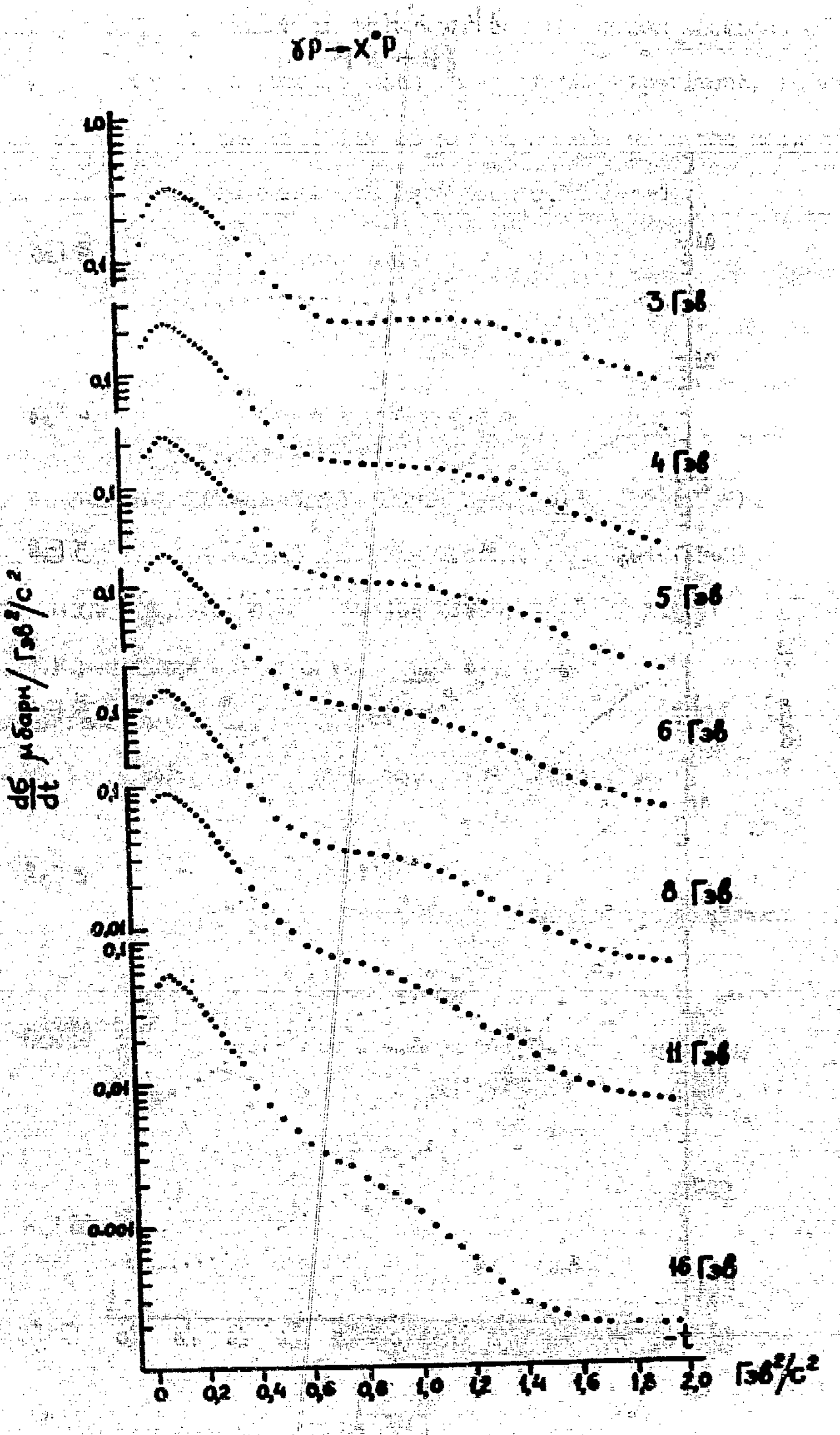
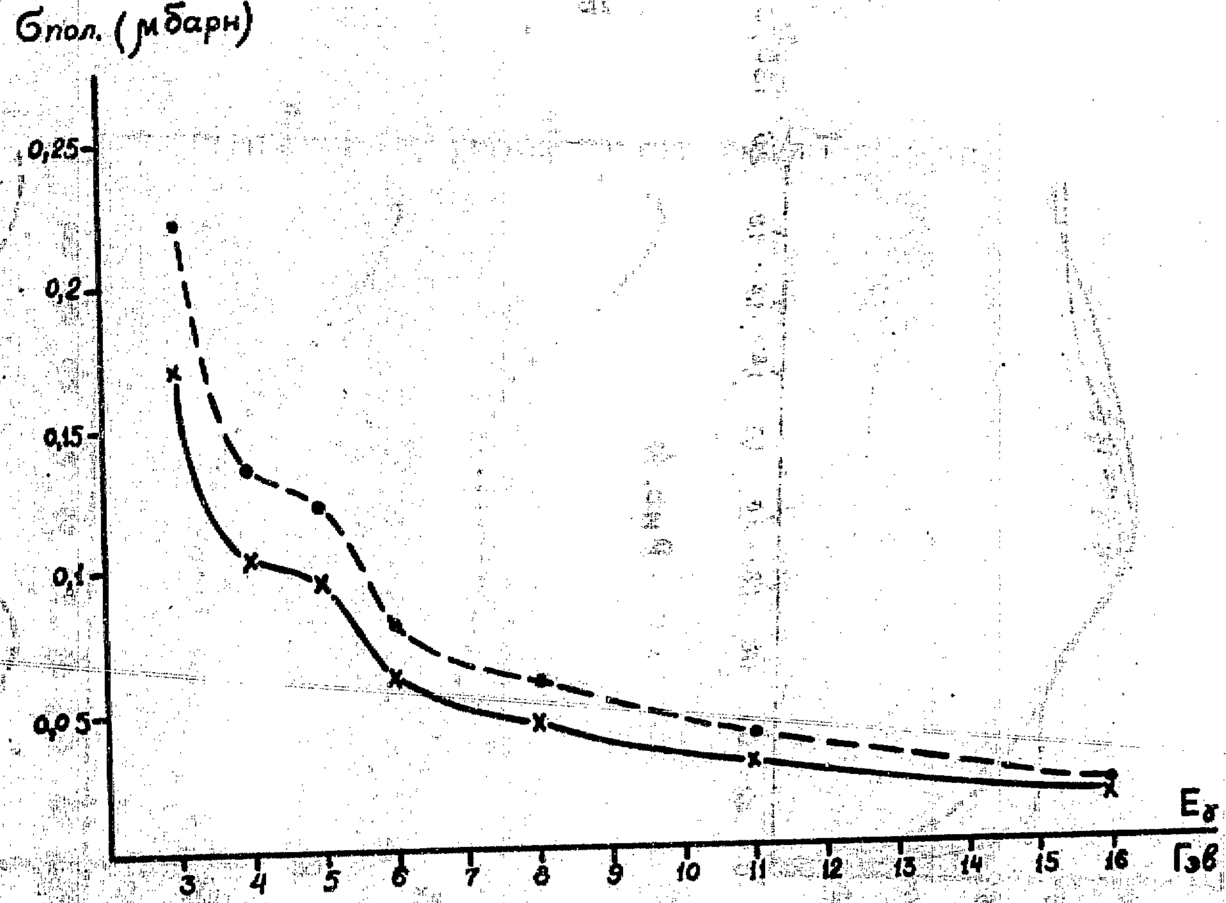

γp → X°p
dσ/dt μбарн/Гэв²/c²
3 Гэв
4 Гэв
5 Гэв
6 Гэв
8 Гэв
11 Гэв
16 Гэв
-t
Гэв²/c²
0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8
2,0
0,1
0,01
0,001

Рис. 2



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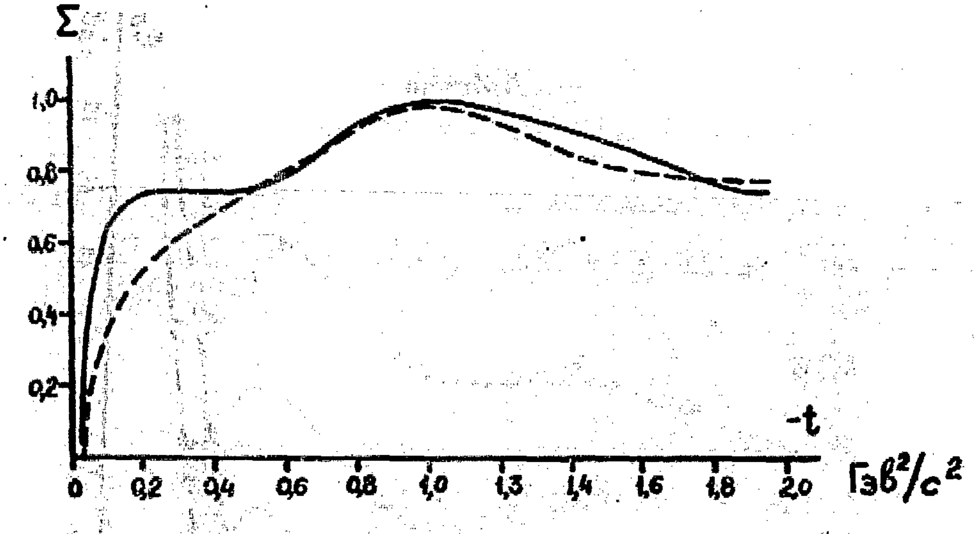
Σ
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-t
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0,4
0,6
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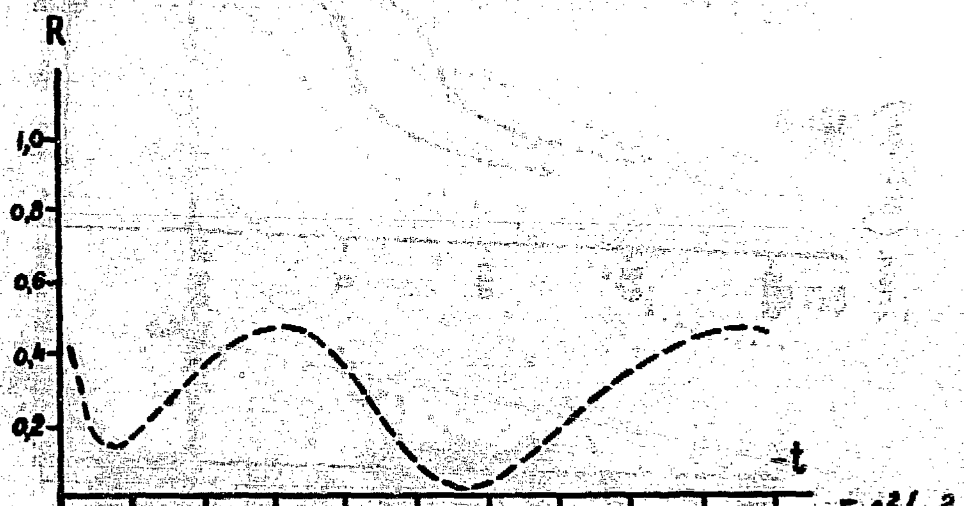
1,4
1,6
1,8
2,0
Гэв²/c²

Рис. 4


R
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0,4
0,2
-t
0
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0,4
0,6
0,8
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1,4
1,6
1,8
2,0
Гэв²/c²

Рис. 5

$\gamma p \to X^0 p$

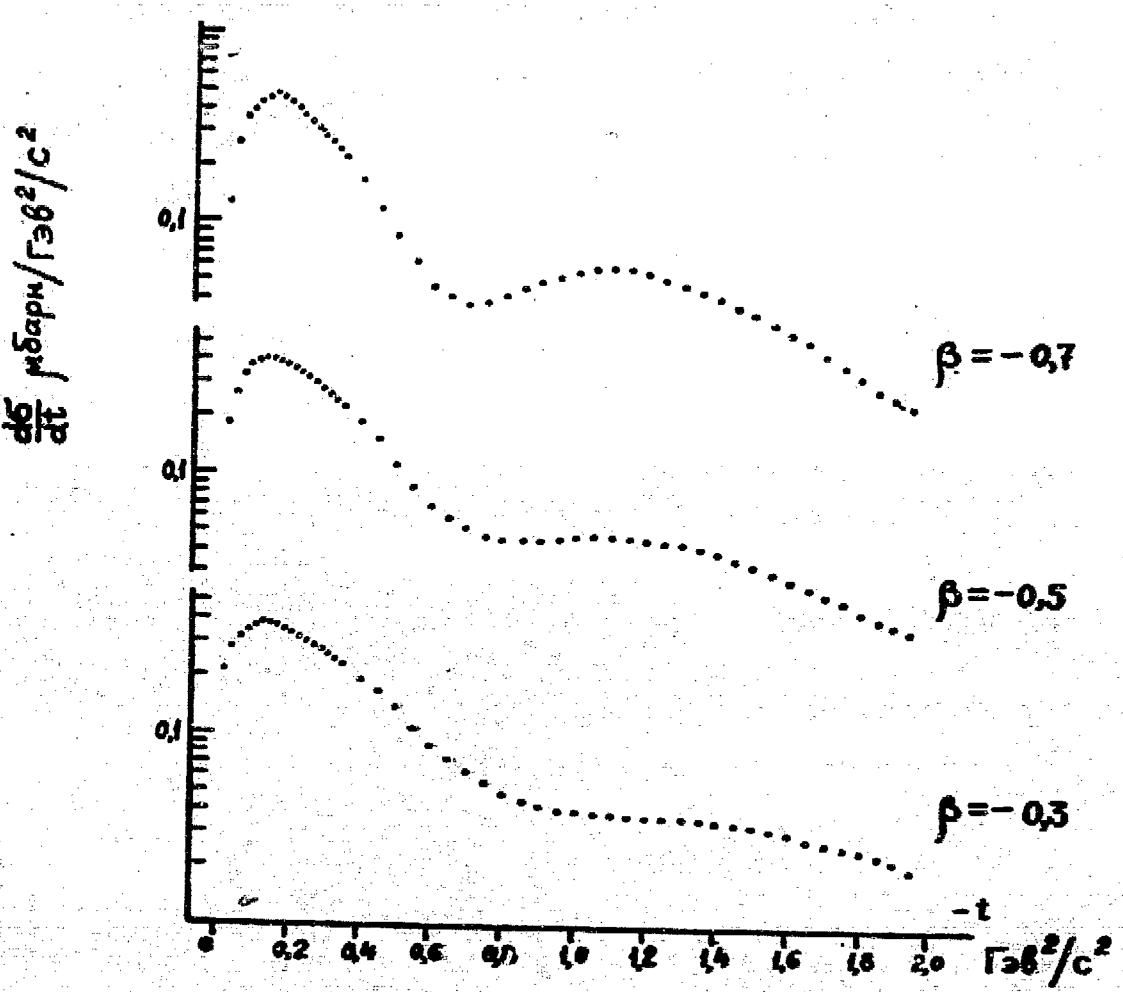

Рис. 6

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