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I.G.AZNAURYAN, I.A.NAGORSKAYA, A.N.ZASLAVSKY

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ИЗОТЕНЗОРНЫЙ ЭЛЕКТРОМАГНИТНЫЙ ТОК В НИЗКОЭНЕРГЕТИЧЕСКОМ ФОТОРОЖДЕНИИ π -МЕЗОНОВ

Обсуждаются новые данные по фоторождению пионов в области резонанса Δ (1236). Анализируется роль высокоэнергетических вкладов в дисперсионные интегралы. В дисперсионном подходе получены оценки на величину изотензорного электромагнитного тока по данным различных экспериментальных групп. Несмотря на большое количество экспериментов, оценка пока неоднозначна, поскольку имеются прямые несоответствия между данными различных групп и некоторые данные неполны. Данные некоторых групп совместимы с 10 % вкладом изотензора.

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ISOTENSOR ELECTROMAGNETIC CURRENT IN LOW ENERGY PION PHOTOPRODUCTION

Recent experimental data on single pion photoproduction in the Δ (1236) resonance region are discussed. The role of the high energy contributions into the dispersion integrals are analysed. Estimates for the magnitude of the isotensor contributions are obtained in the dispersion approach using the experimental data of various groups. In spite of the great number of the experiments the estimate is ambiguous yet since there are direct discrepancies between the data of various groups, besides, certain available data are incomplete. The data of some groups are compatible with 10% isotensor contribution.

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Yerevan, 1974

1. Introduction

Recently new experimental results on the $\gamma n \rightleftarrows p\pi^-$ and $\gamma n \to n\pi^0$ reactions in the first resonance region have been obtained and discussed extensively /1-6/. These data would permit to test the properties of the electromagnetic current of hadrons: the isotensor rule $\Delta I \leq 1$ /1-6/ and T -invariance. However, as it is discussed in detail, for instance, in the review paper /7/ the experimental data are unsatisfactory since there are direct discrepancies between the results of various groups.

1. There is a discrepancy between CERN-L-M /8/ and UCLA-LBL /9,10/ data on the $\pi^- p \to \gamma n$ differential cross section; at E_γ = 354 MeV (E_γ is the photon lab. energy for $\gamma n \to p\pi^-$) the data /9,10/ are systematically 3-5 μb/sr higher than the data /8/.

2. In order to obtain the $\gamma n \to p\pi^-$ cross section from the ratio π^-/π^+ measured on deuterium (Tokio /11/ and Bonn /12/) data measured on hydrogen are used. The π^+ -photoproduction data (Orsay /13/ and Bonn /14/) are in disagreement with each other.

3. There is a 10-15% discrepancy between the DESY /15/ and Frascati /16/ measurements on $\gamma d \to pp\pi^-$ cross sections.

Therefore, there is no reason to consider any time reversal invariance violation in the $\gamma n \rightleftarrows p\pi^-$ reactions in the Δ (1236) region. Below using the available data we shall study the properties of the electromagnetic current under assumption that T is conserved.

Let us underline, that theoretically there are two independent ways to estimate the contribution of the isotensor electromagnetic current in photoproduction in the Δ (1236) region:

1. Using the data on the reactions /17/:

$$\gamma p \to p\pi^{0},$$
$$\gamma p \to n\pi^{+}$$
$$\gamma n \rightleftharpoons p\pi^{-}.$$

2. Using the data on the reactions:

$$\gamma p \to p\pi^{0}$$
$$\gamma n \to n\pi^{0}.$$

The neutron cross sections are obtained from the measured deuterium data in two ways:

a) From the measured π^-/π^+ ratios on deuterium and

$$\left(\frac{d\sigma}{d\Omega}(\gamma n \to n\pi^{0}) \Big/ \frac{d\sigma}{d\Omega}(\gamma p \to p\pi^{0})\right)_{D_2}$$

b) From the reactions $\gamma d \to NN\pi$ in the spectator model. As it follows from the experimental results on the ratios

$$\left(\frac{d\sigma}{d\Omega}(\gamma p \to p\pi^{0})\right)_{D_2} \Big/ \left(\frac{d\sigma}{d\Omega}(\gamma p \to p\pi^{0})\right)_{H_2}$$ /18,19/ and

$$\left(\frac{d\sigma}{d\Omega}(\gamma p \to n\pi^{+})\right)_{D_2} \Big/ \left(\frac{d\sigma}{d\Omega}(\gamma p \to n\pi^{+})\right)_{H_2}$$ /20/, the

corrections to the spectator model are essential and equal to 20-30% in the Δ (1236) region. Therefore, one must take into account these corrections carefully in the analysis of the neutron data. The double scattering effects in pion photoproduction on deuterons in the Δ (1236) region at large angles ($\theta_{cm} \geq 90^{0}$) are calculated in ref./21/. They explain the nature of the angular and energy dependence of the data /18-20/. According to/21/ one may expect, that the data obtained from the measured π^-/π^+ ratios on deuterium (Tokio /11/ and Bonn /12/) and $\left(\frac{\gamma n \to n\pi^{0}}{\gamma p \to p\pi^{0}}\right)_{D_2}$ (Daresbury /18/ and Frascati /22/) are not sensitive to rescattering correc tions.

Therefore, in order to obtain the isotensor contribution one may separate the following set of data with various sensitivities to the deuteron corrections.

I. The only proton data on the reactions $\gamma p \to p\pi^{\circ}$, $\gamma p \to n\pi^{+}$ and $\pi^{-}p \to \gamma n$. As it is pointed out /17/ these data are sufficieny for this purpose.

II. The proton data on the ractions $\gamma p \to p\pi^{\circ}$, $\gamma p \to n\pi^{+}$ and data on $\gamma n \to p\pi^{-}$ from measured π^{-}/π^{+} ratio on deuterium (Tokio /11/ and Bonn /12/).

III. The data on $(\gamma n \to n\pi^{\circ}/\gamma p \to p\pi^{\circ})_{D_2}$ (...resbury /18/ and Frascati /22/).

IV. a) The data on $\gamma p \to p\pi^{\circ}$, $\gamma p \to n\pi^{+}$ obtained on hydrogen and $\gamma n \to p\pi^{-}$ derived with the spectator model from the data on the reaction $\gamma d \to pp\pi^{-}$ (DESY /15/ and Frascati /16/).

b) The data on $\gamma p \to p\pi^{\circ}$, $\gamma p \to n\pi^{+}$ obtained on hydrogen and $\gamma n \to p\pi^{-}$ obtained from the $\gamma d \to pp\pi^{-}$ data taking into account the deuteron corrections according to /20,21/. The corrections somewhat increase the $\gamma n \to p\pi^{-}$ cross sections measured at Frascati and DESY, however, they do not change the magnitude of the isotensor contribution obtained with these data.

To obtain the isotensor contribution we use the fixed-t dispersion relations (DR). The procedure of the application of DR is described in Section 2.

The analysis /17,23/ shows, that the only essential uncertainties in the DR predictions for the charged pion photoproduction in the Δ (1236) resonance region is connected with the high energy contributions (HEC) into DR and with isotensor current. Let us underline, that the introduction of the essential HEC is necessary for the description of the $\gamma n \to p\pi^-$ data at E_γ = 350-450 MeV and $\theta_{cm} \geq 90^\circ$. For instance, the difference between the DR predictions (without HEC) and the $\gamma n \to p\pi^-$ experimental cross sections is 4-5 μb/sr and 8-10 μb/sr for E_γ = 350 MeV, θ_{cm} = 180° and E_γ =400 MeV, θ_{cm}=180°, respectively. As it is shown /23/ the above mentioned discrepancy is connected mainly with HEC and depends weakly on isotensor.

Thus, we think that estimating the isotensor contribution one must clearly analyse the origin of the discrepancy between the DR predictions and the experiment and carry out detail analysis of the energy and angular distributions taking into account HEC. The dip test /2/ ignores the influence of HEC on the energy structure of the π^+ and π^- photoproduction total cross section difference in the Δ (1236) region. For instance, the Frascati data /16/ result in ~ 10% isotensor contribution according to the dip test (x = 0,2/2,16/). However, the analysis shows, that the discrepancy between DR and this experiment (see table I) at $E_\gamma \leq$ 350 MeV may be explained only by means of HEC without any isotensor current, at $E_\gamma \geq$ 350 MeV the data /16/ cannot be described satisfactorily in our approach with both isotensor contribution and HEC.

In spite of great number of the experiments the data of some groups (see table I) are not complete enough to estimate the isotensor contribution. Only the DESY /15/ and Bonn-Bonn /12-14/ data are sufficiently complete and using them we obtain a zero isotensor. The Bonn-Orsay /12,13/ (due to /13/) and CERN-L-M /8/ data are not complete and do not exclude a 10% while the UCLA-LBL /10/ data result in 10% isotensor contribution. The $\gamma n \to n\pi^0$ data /22/ yield

(3 ± 3)% isotensor contribution (G.Shaw /7/).

2. Formulation of the Problem

Let us consider the procedure of the description of charged pion photoproduction reaction at $E_\gamma \leq$ 420 MeV with the help of the fixed-t DR and analyse the uncertainties of this procedure. The pion photoproduction amplitudes have the following isotopic structure /6/:

$$H(\gamma p \to p\pi^0) = H^{(+)} + \left(H^{(0)} + \frac{2}{3} H^{(T)}\right), \tag{1}$$

$$H(\gamma n \to n\pi^0) = H^{(+)} - \left(H^{(0)} + \frac{2}{3} H^{(T)}\right), \tag{2}$$

$$H(\gamma p \to n\pi^+) = \sqrt{2}\left[\left(H^{(0)} - \frac{1}{3} H^{(T)}\right) + H^{(-)}\right], \tag{3}$$

$$H(\gamma n \to p\pi^-) = \sqrt{2}\left[\left(H^{(0)} - \frac{1}{3} H^{(T)}\right) - H^{(-)}\right] \tag{4}$$

where

$$H^{(+)} = \frac{1}{3}\left(H^{\frac{1}{2}} + 2H^{\frac{3}{2}}\right), \quad H^{(-)} = \frac{1}{3}\left(H^{\frac{1}{2}} - H^{\frac{3}{2}}\right), \tag{5}$$

$H^{\frac{1}{2}}$ and $H^{\frac{3}{2}}$ are the isovector amplitudes corresponding to the transitions into the final states with isospin $I = \frac{1}{2}$ and $I = \frac{3}{2}$, $H^{(0)}$ and $H^{(T)}$ are the isoscalar and isotensor amplitudes , respectively.

1. The imaginary parts of the amplitudes (3) and (4) are determined by the resonance multipoles:

$$M_{1+}^{\frac{3}{2}},\ E_{1+}^{\frac{3}{2}},\ M_{1+}^{(T)},\ E_{1+}^{(T)} \tag{6}$$

and by the following combinations of the lowest nonresonance multipoles

$$E_{0+}^{(-)},\ M_{1-}^{(-)},\ E_{0+}^{(0)} - \frac{1}{3} E_{0+}^{(T)},\ M_{1-}^{(0)} - \frac{1}{3} M_{1-}^{(T)}. \tag{7}$$

In this energy region the contribution of the remained multipoles can be neglected since according to the unitarity condition their imaginary parts are proportional to the corresponding small phases of πN -scattering.

2. To determine the real parts of the amplitudes (3) and (4) let us write the fixed-t DR for the invariant amplitudes (we use the notation H of ref./24/) separating HEC:

$$Re H(\nu,t) = R\left(\frac{1}{\nu_B-\nu} \pm \frac{1}{\nu_B+\nu}\right) + \frac{P}{\pi}\int_{\nu_{thresh}}^{\nu_0} Im H(\nu';t)\left(\frac{1}{\nu'-\nu} \pm \frac{1}{\nu'+\nu}\right) + \quad (8)$$

$$+\begin{cases} f_H(t), & \text{if } H \text{ is a } \nu \text{ even amplitude,} \\ \varphi_H(t)\frac{\nu}{\nu_0}, & \text{if } H \text{ is a } \nu \text{ odd amplitude.} \end{cases}$$

Here

$$\nu = E_\gamma - \nu_1, \quad \nu_1 = \frac{K\omega_q - Kq}{2m} = -\frac{t-\mu^2}{4m}, \quad \nu_B = -\nu_1,$$

$$\nu_{thresh} = \mu + \frac{\mu^2}{2m} - \nu_1, \quad \nu_0 = 1\ GeV,$$

K and q are the photon and pion momenta in c.m., ω_q is the pion energy in this system, m and μ are nucleon and pion mass, R is the Born residue of the amplitude at $\nu = \pm\nu_B$, $f_H(t)$ and $\varphi_H(t)$ are the high energy integrals which for ν under consideration with a good accuracy are functions of only t and are equal to:

$$f_H(t) = \frac{2}{\pi}\int_{\nu_0}^{\infty} Im H(\nu';t)\frac{d\nu'}{\nu'}, \quad (9)$$

$$\varphi_H(t) = \frac{2}{\pi}\int_{\nu_0}^{\infty} Im H(\nu';t)\frac{\nu_0}{\nu'^2}\,d\nu' \quad (10)$$

The amplitudes $C^{(-)}$, $A^{(0)} - \frac{1}{3}A^{(T)}$, $B^{(0)} - \frac{1}{3}B^{(T)}$, $D^{(0)} - \frac{1}{3}D^{(T)}$ (the notations of ref./24/) are ν even while the amplitudes

$A^{(-)}, B^{(-)}, D^{(-)}$ and $C^{(0)} - \frac{1}{3} C^{(T)}$ are odd. Therefore, to describe π^+ and π^- photoproduction it is necessary to introduce the following high energy integrals corresponding to these amplitudes:

$$f_C(t), f_A(t), f_B(t), f_D(t), \qquad (11)$$

$$\varphi_A(t), \varphi_B(t), \varphi_D(t), \varphi_C(t). \qquad (12)$$

In integrals (8) from threshold up to 0,5 GeV we shall take into consideration the contributions of the multipoles (6) and (7) . We have estimated the remained integrals from 0,5 up to 1 GeV by Walker /25/ analysis. Their contribution to the final results does not exceed 2%.

In the region from 0,5 up to 1 GeV there is an ambiguity due to P_{11} (1470) resonance. One may take into account the influence of this ambiguity including it into the HEC (11),(12).

As shown /17,23/ the contribution given by the nonresonance multipoles (7) to $\frac{d\sigma}{d\Omega}$ is not more than 2%. We have taken the multipoles (7) at $E_{0+}^{(T)} = M_{1-}^{(T)} = 0$ from ref./26/.

Thus, describing the experimental data on the reactions $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ at $E_\gamma \leq$ 420 MeV by means of DR the result is expressed in terms of the magnitudes (6),(11) and (12). Below we take into account these magnitudes and analyse the uncertainties connected with them.

Let us analyse the existing experimental data on the $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ differential cross sections by means of DR at $t = t_0 =$ -0,125 GeV^2 corresponding to E_γ =350 MeV and θ_{cm} =90°. The choice of this value of t is connected with the fact that the data at E_γ =350 MeV and θ_{cm}=90° are most sensitive to the isotensor comtribution. For t values corresponding to other angles at E_γ = 350 MeV the differential cross sections on the reactions $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ are less sensitive to the isotensor contribution and determine mainly the values of high energy integrals /23/.

3. Resonance Multipoles

The $\gamma p \to p\pi^0$ experimental data having small background from nonresonance multipoles in the Δ (1236) region determine well combination of the resonance multipoles corresponding to this reaction.

For $M_{1+}(\gamma p \to p\pi^0)$ we take CGLN solution /21/

$$M_{1+}(\gamma p \to p\pi^0) = \frac{2}{3}\left(M_{1+}^{3/2} + M_{1+}^{(T)}\right) = \frac{2}{3} M_{1+}^{3/2}(CGLN), \qquad (13)$$

which describe well the $\gamma p \to p\pi^0$ data and are in agreement with all DR solutions, for instance, with ones of refs. /26,27/.

For the resonance amplitude

$$E_{1+}(\gamma p \to p\pi^0) = \frac{2}{3}\left(E_{1+}^{3/2} + E_{1+}^{(T)}\right) \qquad (13a)$$

there are some DR solutions satisfying the $\gamma p \to p\pi^0$ data. The uncertainty in $\pi^\pm$-photoproduction differential cross sections connected with the differences between these solutions is within the experimental errors. The analysis has shown, that the estimate for the isotensor contribution does not depend on this uncertainty. Our results correspond to the solution /26/ for (13a).

The resonance isotensor multipoles $M_{1+}^{(T)}$ and $E_{1+}^{(T)}$ satisfy DR with zero Born terms. The solutions of such DR coincide practically with the homogeneous solutions obtained in ref./27/. In our calculations we have used solutions given in Fig.6 of ref./27/.

Since their height is arbitrary let us define $M_{1+}^{(T)}$ and $E_{1+}^{(T)}$ in the following way*:

$$M_{1+}^{(T)}(E_\gamma) = x_T M_{1+}^{(homog)}(E_\gamma), \quad E_{1+}^{(T)}(E_\gamma) = y_T E_{1+}(E_\gamma), \tag{14}$$

where at $E_\gamma = 350$ MeV

$$M_{1+}^{(homog)} = E_{1+}^{(homog)} = M_{1+}^{\frac{3}{2}}\ (CGLN). \tag{15}$$

It is shown /17/, that y_T is small $\left(y_T \approx -\frac{x_T}{3}\right)$. Since the cross section energy dependence on y_T (see table I) has the same resonance character as the dependence on x_T further we shall consider the estimate for $M_{1+}^{(T)}$ assuming $y_T \simeq 0$.

4. High Energy Contributions

Taking into account the high energy integrals /11/ and /12/ it appears, that $\frac{d\sigma}{d\Omega}(t=t_o)$ at $E_\gamma \leq 420$ MeV is described by the following combinations of $f_H(t)$ and $\varphi_H(t)$ at t = to:

$$\frac{4\pi}{V_o^2} F_A(t_o) \approx f_A + (0{,}02 \div 0{,}05) V_o^2 f_B + (0{,}1 \div 0{,}12) V_o \varphi_C + (-0{,}06 \div 0{,}08) V_o f_D, \tag{17}$$

$$\frac{4\pi}{V_o^3} F_C(t_o) \approx f_C + (0{,}7 \div 0{,}86) \frac{\varphi_A}{V_o} + (0{,}01 \div 0{,}04) V_o \varphi_B + (-0{,}04 \div 0{,}07) \varphi_D,$$

where $V_o = 1$ GeV, $F_A(t_o)$ and $F_C(t_o)$ are dimensionless quantities.

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* The relation between x_T and x introduced by Sanda and Shaw /2/ is: $x = -2x_T$

In these combinations the contributions of the high energy integrals f_B, f_0, φ_B and φ_A are strongly suppressed. Because of the smallness factor $\frac{\nu_0}{V}$ in φ_A and φ_C (see (9) and (10)) one may reduce (17) to the combinations

$$\frac{4\pi}{\nu_0^2} F_A(t_0) = f_A + 0{,}1\, \nu_0 \varphi_C \qquad \frac{4\pi}{\nu_0} F_C(t_0) = f_C + 0{,}8\, \frac{\varphi_A}{\nu_0} . \qquad (18)$$

Thus, $\pi^{\pm}$-photoproduction differential cross sections at $t = t_0$ and $E_\gamma \leq$ 420 MeV are determined by means of three unknown parameters: x_T, $F_A(\nu_0)$, $F_C(t_0)$.

5. Dispersion Relation Predictions for Differential Cross Sections

The results of our calculations for $\pi^{\pm}$-photoproduction differential cross sections at $E_\gamma \leq$ 420 MeV and $t = t_0 = -0{,}125$ GeV^2 obtained with the help of DR (8), multipoles (6) and (7) and high energy integrals (11) and (12) are given in tables I and II. The differential cross sections taking into account only the main corrections caused by the isotensor and high energy contributions may be presented in the form:

$$\frac{d\sigma}{d\Omega} = \left[a + b x_T + c y_T + d F_A(t_0) + e F_C(t_0)\right] \frac{\mu b}{sr} . \qquad (19)$$

The values of a, i.e. $\frac{d\sigma}{d\Omega}$ for $x_T = y_T = F_A = F_C = 0$ as well as the values of the parameters b, c, d, e are given in the tables.

Note, that the contribution of x_T to $\frac{d\sigma}{d\Omega}(\gamma p \to n\pi^+)$ is small since according to (3) and (13)-(15) it is determined only by the contribution of $M_{1+}^{(T)}$ to the nonsingular part of the integrals (8). The contribution of x_T to $\frac{d\sigma}{d\Omega}(\gamma n \to p\pi^-)$ is determined mainly by the contribution of $M_{1+}^{(T)}$ to the imaginary part of the amplitude (4) and has a resonance feature.

From table I it is seen, that the cross section dependence on the isotensor contributions x_T and y_T differs essentially from the dependence on the high energy integrals $F_A(t_0)$ and $F_c(t_0)$. HEC to the cross section decrease smoothly with increase of the energy while the isotensor contribution to $\gamma n \to p\pi^-$ has a resonance shape. Therefore, the experimental data on the $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ differential cross sections allow to determine the isotensor contribution.

6. Determination of the Isotensor Contribution and Discussion of the Results

The theoretical predictions on the $\gamma n \to p\pi^-$ and $\gamma p \to n\pi^+$ cross sections allowing to take into consideration the isotensor and high energy contributions are given in tables I and II. The experimental data of various groups on the reactions $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ are also given. Taking the CERN-L-M data /8/ a rough extrapolation to the required angles was made. For convinience, the magnitude $\Delta\{th-exp\}$ (the difference between theory at $x_T=y_T=F_A=F_c=0$ and experiment) which permits to determine the isotensor and high energy contributions is given.

Complete experimental data for all the energies of the table I would allow to obtain unambignos estimation for isotensor current. We hope this table will be useful for the experimentalists in order to determine the isotensor contribution with the help of more complete future data.

Let us consider the determination of the isotensor contribution using the available experimental data.

1. Bonn-Bonn /12,14/. These data are complete sufficiently for our estimations: they cover the necessary energy interval. The $\Delta\{th-exp\}$ energy dependence has a nonresonance shape and is described completely by HEC with $x_T = 0$

2. Bonn-Orsay /12,13/. Note, that the Orsay $\gamma p \to n\pi^+$ data need essential HEC (see table II), while the Bonn data /14/ do not need HEC. The Bonn-Orsay data are incomplete (due to /13/), they do not exclude a 10% isotensor (x_T =0,1). However, these data can be described only by HEC. To obtain reasonable estimates data covering all the energy interval are required.

3. DESY /15/. The data are sufficiently complete and exclude isotensor contribution (x_T =0).

4. Frascati /16/. The theory gives a poor description of these data. At $E_\gamma \leq 350$ MeV they can be explained only by HEC (without isotensor) while at $E_\gamma \geq 350$ MeV the data /16/ cannot be described satifactorily in our approach with both isotensor and high energy contributions. In view of these uncertainties it is clear, that from the Frascati data we cannot infer the existence of an isotensor current. These data need corrections in order to obtain estimates for isotensor contribution.

5. UCLA-LBL /10/. The data are incomplete. Nevertheless, they permit to make a rough estimate of 10% isotensor ($x_T = 0,1$) It is very desirable to obtain data at lower energies.

6. CERN-L-M/8/. The data are very incomplete. A rough angular extrapolation is necessary in order to use them for our purpose. These data are compatible with x_T =0 and can be explained only by high energy contributions.

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References

1. V.G.Grishin,V.L.Lyuboshits,V.I.Ogievetsky,M.I.Podgoretsky, Yad.Fis.4(1966)126; N.Dombey,P.K.Kabir, Phys.Rev.Lett.17(1966) 730.

2. A.I.Sanda,G.Shaw, Phys.Rev.Letters 24(1970) 1310; Phys.Rev.D3 (1971) 243.

3. A.Donnachie,G.Shaw, Phys.Letters 35B(1971) 419; Phys.Rev.D25 (1972) 1111.

4. F.A.Berends, D.L.Weaver, Phys.Rev.D4 (1971) 1997.

5. D.Schwela, Nucl.Phys. B.26(1971) 525; W.Pfeil,D.Schwela, Nucl. Phys.B45 (1972) 379.

6. I.G.Aznauryan,A.N.Zaslavsky, Phys.Letters 39B(1972) 226.

7. Proc.of the meeting on experimental tests for exotic electromagnetic currents, Daresbury (1973), Daresbury Laboratory preprint DL/R 32 (1973); K.Fisher, Rapporteur talk at the Int. Symp.on electron and photon interactions at high energies,Bonn (1973).

8. Le L.Huong,C.Joseph, Tran M.Tam et al., Proc.of Daresbury Study Weekend N.7(1973), Daresbury Laboratory preprint DL/R 32 (1973).

9. P.A.Berardo,R.P.Haddock,B.M.K.Nefkens et al., Phys.Rev.Letters 26(1971) 201; J.C.Comiso,D.J.Blasberg,R.P.Haddock et al., Contribution to the 16th Int.Conf.on high energy physics, Batavia, Illinois (1972).

10. B.M.K. Nefkens, Proc.of Daresbury Study Weekend N.7(1973), Daresbury Laboratory preprint DL/R 32 (1973).

11. T.Fujii,S.Homma,K.Huke et al., Phys.Rev.Letters 28(1972) 1672.

12. G.von Holtey, G.Knop,H.Stein et al., Phys.Letters 40B(1972) 589.

13. C.Betourne,J.C.Bizot,J.Perez-Y-Jorba et al., Phys.Rev. 172 (1968) 1343.

14. G.Fischer,G.von Holtey,G.Knop,J.Stumpfig,Z.Phys.253 (1972)38.

15. P.Benz et al., Nucl.Phys. B 65(1973) 158.

16. V.Rossi,A.Piazza,G.Sussino et al., Nuovo Cimento 13A(1973) 59.

17. I.G.Aznauryan,I.A.Nagorskaya, Yad.Fiz.(1974) 136.

18. R.Clifft,E.Gabathuler,L.Littenberg et al., Proc.of Daresbury Study Weekend No.7(1973), Daresbury Laboratory preprint DL/R 32 (1973).

19. C.Bocci,R.Baldino-Celio,B.Esposito et al., Nuovo Cimento Letters 4 (1972) 5.

20. P.V.Sorokin et al., Yad.Fiz., to be published.

21. I.G.Aznauryan, Yad.Fiz. 19(1974) 640.

22. E.Di Capua,V.Pocci,M.Severi et al., Nuovo Cimento Letters 8 (1973) 692.

23. I.G.Aznauryan, A.N.Zaslavsky, Yad.Fiz. 17(1973) 374; preprint YePI-9(72), Yerevan (1972).

24. G.F.Chew, M.L.Goldberger,F.E.Low,Y.Nambu, Phys.Rev.106(1957) 1345.

25. K.L.Walker, Phys.Rev. 182(1969) 1729.

26. F.A.Berends,A.D.Donnachie,D.L.Weaver, Nucl.Phys.B4(1967)1.

27. D.Schwela,R.Weizel, Z.Phys. 221 (1969) 71.

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Table 1

Values of parameters in formula (19) and experimental data for $\gamma n \rightleftarrows p\pi^-$ reaction.

							Experiment											
							Bonn - Bonn /13/ - /14/		Bonn - Orsay /12/ - /13/		DESY /15/		Frascati /16/		UCLA - LRL /10/		CERN - L - [illegible] /4/	
E_γ (MeV)	θ_{cm} (degr)	a	b	c	d	e	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$	$\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	$\Delta_{(t-e)}$
245	I80	24.28	-7	8	-38.2	I4.5	20.6 ±2 *	3.8										
250	I60	24.95	-I0	I3	-38.5	I4.5	22.4 ± 2 *	2.6			I9.2 ± I.5	5.8	I6.9 ± 3	8.I				
260	I4I	26.43	-I6	23	-38.6	I4.6							2I.2 ± 2.I	5.2			2I ± 2	5.4
270	I3I	27.87	-25	30	-38	I4.4					24.6 ±I.3	3.3						
280	I22	29.36	-34	39	-35.8	I4.3	27.8 ±I.26	I.6					22.8 ±2.I	6.6				
285	II9	29.7I	-37.5	43	-35	I4.I											27 ±2.7	2.7
290	II5	29.83	-40.5	47	-34	I4					26.4 ±I.2	3.4						
300	II0	30.36	-47	54	-30.5	I3.4			25.4 ±2 *	5.0			23.5 ±2.2	6.9				
305	I07	30.29	-49	57	-30	I3.I									27 ±3	3.3	25 ±2.5	5.3
3I0	I05	30.I2	-5I.5	59	-29	I2.9					26.7 ±I.2	3.4						
320	I00.5	28.73	-54	62	-27.5	I2.2	26.I ±I.2	2.6	23.5 ±I.0	5.2	25.I ±I.2 *	3.6	22.8 ±2.2	5.9	2I.5±I.4 *	7.2	24 ±2.4	4.7
330	96.5	27.0I	-53.5	62	-25	II.5					23.9 ±I.2	3.I						
340	93	24.76	-50	60	-23.5	I0.9							I7 ± 2	7.8			20.4 ±2	4.4
350	90	22.3I	-44	57	-22.3	I0.4					I8.0 ±I.I	4.3						
355	88.5	2I.53	-42	53	-2I.7	I0.I									I4.3 ±I.2	7.2	I8.7 ±I.9	2.8
360	87	20.43	-39	49	-2I.2	I0	I8.2 ±0.8	2.2	I7.2 ±0.8	3.2								
370	84.7	I8.45	-35	42	-20.5	9.7					I7.6 ±I.I	0.9	I6.I ±I.5	2.4				
380	82	I6.78	-3I	35	-I9.8	9.4							I6.3 ±I.5	0.5				
390	80	I5.40	-28	27	-I9	9.2					I3.0 ±0.9	2.4						
400	78	I4.27	-25	I8	-I8	9.2	I3.4 ±0.6	0.9	I2.3±0.7	2.0								
4I0	76	I3.35	-22	I0	-I7.5	9.I							I3.I ±I.4	0.3	I0.7 ±I.2	2.7		
420	74.3	I2.63	-I9	4	-I7	9					I0.2 ±0.6	2.4	I3.I ±I.4	-0.5				

* these data are obtained by energy extrapolaition.

Table 2

Values of parameters in formula (19) and experimental data for $\gamma p \to n\pi^+$ reaction

E_γ (MeV)	θ_{cm} (degr)	a	b	c	d	e	experiment: Bonn /14/ $\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$	experiment: Orsay /13/ $\frac{d\sigma}{d\Omega}\left(\frac{\mu b}{sr}\right)$
245	180°	13,85	5,5	-15,2	30,0	10,0	13,0 ± 0,8	
260	141°	16,51	4,2	-13,9	30,1	11,3	16,04 ± 0,55	
280	122°	20,93	2,8	-13,1	28,6	11,6	20,90 ± 0,68	
300	110	23,29	1,8	-11,6	25,3	10,9	24,20 ± 0,78	2[illegible],0 ± 0,6
320	100	23,11	1,8	-9,9	22,3	9,9	22,17 ± 0,71	20,0 ± 0,6
350	90	18,55	2,8	-8,2	19,9	8,1	17,20 ± 0,54	16,62 ± 0,[illegible]
380	82	12,95	4,1	-6,1	17,5	6,2	13,13 ± 0,4[illegible]	11, 9 ± 0,4
420	74,3	9,55	5,9	-4,2	13,9	4,3	9,89 ± 0,32	9,3 ± 0,3

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