

ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ
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EXPERIMENTAL STUDY OF THE PHOTOPRODUCTION

$\gamma d \rightarrow d\pi^0$ AND PHOTODISINTEGRATION $\gamma d \rightarrow pn$,
 $\gamma {}^6\text{Li} \rightarrow pnX$, $\gamma {}^4\text{He} \rightarrow pnX$ PROCESSES BY LINEARLY
POLARIZED PHOTONS IN THE ENERGY RANGE

0.3-1.0 GeV

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ԳԵԱՅԻՆ ԲԵՎԵՌԱՑՎԱԾ ՓՈՏՈՆՆԵՐՈՎ 0,3-1,0 ԳԷՎ ԷՆԵՐԳԻԱՅԻ
ՏԻՐՈՒՅԹՈՒՄ ՓՈՏՈԾՆՈՒՄ $\gamma d \rightarrow d\pi^0$ ԵՎ ՓՈՏՈՏՐՈՀՄԱՆ $\gamma d \rightarrow pn$,
 $\gamma^6\text{Li} \rightarrow pnX$, $\gamma^4\text{He} \rightarrow pnX$ ՊՐՈՑԵՍՆԵՐԻ ՓՈՐՁԱՐԱՐԱԿԱՆ
ՌԻՍՈՒՄՆԱՍԻՐՈՒԹՅՈՒՆԸ

Ներկայացված են կտրվածքի Σ սախմեարիայի չափումների նախ-
նական արդյունքները կոհերենտ ֆոտոծմաման $\gamma d \rightarrow d\pi^0$ և ֆոտոտրոհման
 $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow pnX$, $\gamma^4\text{He} \rightarrow pnX$ սրբցեսնկրում-
երֆի-ի զծային ըւեոացված ֆոտոնային վնջի կիրառամբ էներգիայի
0,3-1,0 ԳԷՎ տիրույթում:

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EXPERIMENTAL STUDY OF THE PHOTOPRODUCTION $\gamma d \rightarrow d\pi^0$
AND PHOTODISINTEGRATION $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow pnX$,
 $\gamma^4\text{He} \rightarrow pnX$ PROCESSES BY LINEARLY POLARIZED PHOTONS
IN THE ENERGY RANGE 0.3-1.0 GeV

The preliminary results on the cross section asymmetry Σ of the coherent photoproduction reaction $\gamma d \rightarrow d\pi^0$ and the photodisintegration processes $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow pnX$ and $\gamma^4\text{He} \rightarrow pnX$ with the linearly polarized photon beam of YERPHI within the energy range 0.3-1.0 GeV are presented.

Yerevan Physics Institute

Yerevan 1988

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ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПРОЦЕССОВ ФОТОРОЖДЕНИЯ
 $\gamma d \rightarrow d\pi^0$ И ФОТОРАСЩЕПЛЕНИЯ $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow p\alpha$ И $\gamma^4\text{He} \rightarrow p\alpha$
ЛИНЕЙНО-ПОЛЯРИЗОВАННЫМИ ФОТОНАМИ В ОБЛАСТИ ЭНЕРГИИ 0,3-1 ГэВ.

Представлены предварительные результаты измерений асимметрии сечения Σ процессов когерентного фоторождения $\gamma d \rightarrow d\pi^0$ и фоторасщепления $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow p\alpha$ и $\gamma^4\text{He} \rightarrow p\alpha$ на линейно-поляризованном фотонном пучке ЕФИ в области энергии 0,3-1,0 ГэВ.

Ереванский физический институт

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The investigation of exclusive and quasiexclusive photo-production and photodisintegration processes on few-nucleon systems by real and virtual photons at intermediate energies is an intensive field of activity at present [1,2]. These investigations are aimed at such actual problems as the modification of nucleon and corresponding elementary amplitudes inside the nuclear medium, the structure and the weights of nucleon-nucleon correlations in the nuclear wave function (among them, the multiquark configurations), qualitative and quantitative aspects of N-N interactions in a nucleus and so on.

For some years investigations of photonuclear reactions [3,4] are carried out on the linearly polarized photon beam of the Yerevan Physics Institute.

In this paper the preliminary results on the cross section asymmetry of coherent photoproduction $\gamma d \rightarrow d\pi^0$ within $E_\gamma = 0.5-0.9$ GeV and c.m. angle $\theta_{\pi^0}^* = 130^\circ$ and photodisintegration $\gamma d \rightarrow pn$ within $E_\gamma = 0.3-1.0$ GeV and $\theta_p^* = 45-90^\circ$, $\gamma {}^6\text{Li} \rightarrow pnX$ within $E_\gamma = 0.3-1.0$ GeV and $\theta_p^* = 90^\circ$, and $\gamma {}^4\text{He} \rightarrow pnX$ within $E_\gamma = 0.45-0.55$ GeV and $\theta_p^* = 90^\circ$ are presented.

1. The Experimental Set-Up

The layout of the experimental set-up is shown in Fig.1 . The experiment was carried out on the linearly polarized beam of Yerevan Physics Institute (YERPHI). The photon beam was generated by the coherent bremsstrahlung of 3-3.5 GeV electrons in a diamond monocrystal. The beam-monitoring system consisted of a 30-channel pair spectrometer, a fast monitor and a Wilson-type quantometer.

Liquid-deuterium and liquid-helium targets were used [5], with thickness 9 cm along the beam as well as a target of enriched ${}^6\text{Li}$ (94%), 2.54 g/cm² thick. Protons and deuterons from the investigated reactions were detected by a magnetic spectrometer [6] with a time-of-flight identification system. Neutrons from the reactions $\gamma d \rightarrow pn$ and $\gamma A \rightarrow pnX$ were detected by a neutron multichannel time-of-flight spectrometer [7]. One of the gamma quanta from the π^0 -decay was detected by a lead-glass Cerenkov spectrometer. A time-of-flight analysis was carried out between two arms of the experimental set-up. The background of accidentals and multiparticle processes from the high-energy tail of the bremsstrahlung spectrum did not exceed 5-10% . The typical energy spectrum of coherent bremsstrahlung measured by a pair spectrometer and the calculated spectrum of photon polarization in the region of the first coherent peak are shown in Fig.2 .

2. Deuteron Photodisintegration

Despite active investigation of $\gamma d \rightarrow pn$ in previous years, especially in connection with the problem of dibaryon resonances, the present experimental data are still not enough, in particular those on polarization observables, and the state of the theoretical descriptions is still unsatisfactory.

We have carried out the measurements of the cross section asymmetry Σ in a wide kinematical range of angles $\theta_p^* = 45^\circ - 90^\circ$ and energies $E_\gamma = 0.3 - 1.0$ GeV. The obtained results are shown in Fig.3. Together with our old data [8] they present the main part of the asymmetry data in the angular range $\theta_p^* < 90^\circ$. The energy dependence of $\Delta\Sigma(\theta) = \Sigma(\pi - \theta) - \Sigma(\theta)$ obtained from our data for $\theta_p^* = 45^\circ$ and data of Bonn [9] at $\theta_p^* = 135^\circ$ are shown in Fig.4. As it is seen from the figure, a structure is observed in $\Delta\Sigma$ with a maximum near $E_\gamma = 0.55$ GeV which appeared also in our old data [8]. As it was ibidem shown, the nonzero value of $\Delta\Sigma$ is due to the interference of isovector and isoscalar amplitudes and in the region of the isovector amplitude dominance (the first and the second πN -resonances) may be particularly sensitive to the appearance of isoscalar dibaryon resonances. This statement is confirmed by the second solution of the phenomenological analysis [10], which predicts a qualitatively analogous behaviour of $\Delta\Sigma$ allowing for the contribution of the isoscalar resonance $0(3^+)$ (see Ref.[8]). Unfortunately, the quality of predictions of this analysis as a whole is unsatisfactory which does not allow one to make any definite conclusions.

3. Coherent Photoproduction of Deuteron

The recent interest in this process was also stimulated by the problem of dibaryon resonances. In particular, in Tokyo [11] there were carried out systematic measurements of the differential cross section in the kinematical region of energies $E_\gamma = 0.5-0.9$ GeV and c.m. angles $\theta_\pi^* > 90^\circ$ most favourable from the point of view of sensitivity to the contribution of isovector dibaryon resonances [12]. Polarization data in this kinematical range are presented by only few data points an asymmetry Σ from our previous work [4]. We performed more detailed measurements of the cross section asymmetry Σ at $\theta_\pi^* = 130^\circ$ in the energy range $E_\gamma = 0.5-0.9$ GeV (Fig.5). The predictions of the impulse approximation (IA) [12] are also shown for comparison. As stated in Ref. [13], the cross section asymmetry Σ is defined mainly by IA and must be weakly sensitive to the rescattering effects. As it is seen from the figure, this confirmation is rather justified at low energies (low transfers) in agreement with the results of Ref. [14, 15]. At the same time, for energies higher than 600 MeV IA becomes invalid. This is the first experimental establishment that the rescattering terms are important both for differential cross section and the cross section asymmetry.

The two existing analyses [11] and [15] fairly well reproduce the cross section of the reaction $\gamma d \rightarrow d\pi^0$ in a wide kinematical region. The first analysis takes ${}^3F_3(2.26)$ and ${}^1G_4(2.51)$ dibaryons into account. The analysis [15] was made in the framework of "ordinary" scattering and rescattering

terms only. Since the obtained results on Σ are the first polarization results, it will be very important to compare them with the predictions of these analyses.

4. Photodisintegration Reactions $\gamma^6\text{Li} \rightarrow \text{pnX}$
 and $\gamma^4\text{He} \rightarrow \text{pnX}$

The weight of N-N correlations in the wave function of light nuclei, their structure at short distances, the role in pion and photon absorption, etc., were intensively investigated during last years using pion, photon and electron beams. In a series of experiments (see Ref. [16]) on photodisintegration of n-p correlations (quasideuterons) in light nuclei (^4He , ^9Be , ^{12}C) by unpolarized tagged photons, an information was extracted about the wave function of n-p pairs in a nucleus. As it was expected, the experimental data indicate to a considerable increase in the contribution of short ranges between two nucleons as compared to a "porcus" deuteron. This is quantitatively expressed by the Levinger factor and must bring to the qualitative change of N-N interaction, i.e. to the increase of the heavy meson exchange contributions, to the higher possibilities of formation and excitation of six-quark configurations, etc., From this point of view, the polarization observables may be very useful. We have measured the cross section asymmetry Σ for the quasideuteron photodisintegration on a ^6Li and ^4He nuclei in the energy range $E_\gamma = 0.3-1.0$ GeV and $E_\gamma = 0.45-0.55$ GeV, respectively, and at $\theta_p^* = 90^\circ$ in accordance with the kinematics of a free deuteron.

The obtained data are presented as an energy dependence in Figs.6,7 together with the data of $\gamma d \rightarrow pn$ at $\theta_p^* = 90^\circ$. As it is seen from Fig.6, despite the presence of a qualitative agreement between the asymmetry data on 2D and 6Li , a noticeable quantitative difference is observed, particularly in the sign, within the energy range 0.5-0.55 GeV, which is also confirmed by the data on 4He (Fig.7). We are faced to find the nature of that difference.

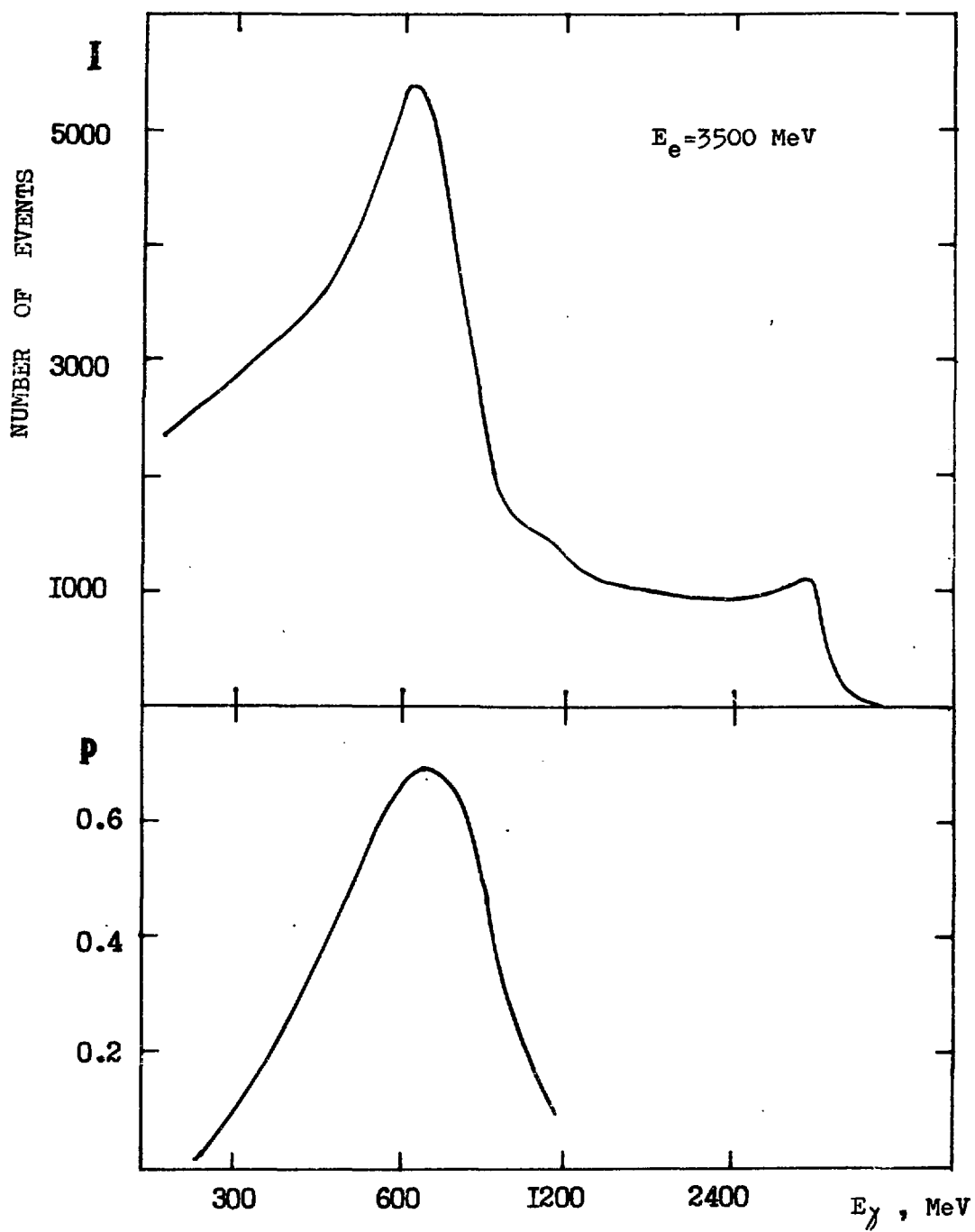


Fig.2

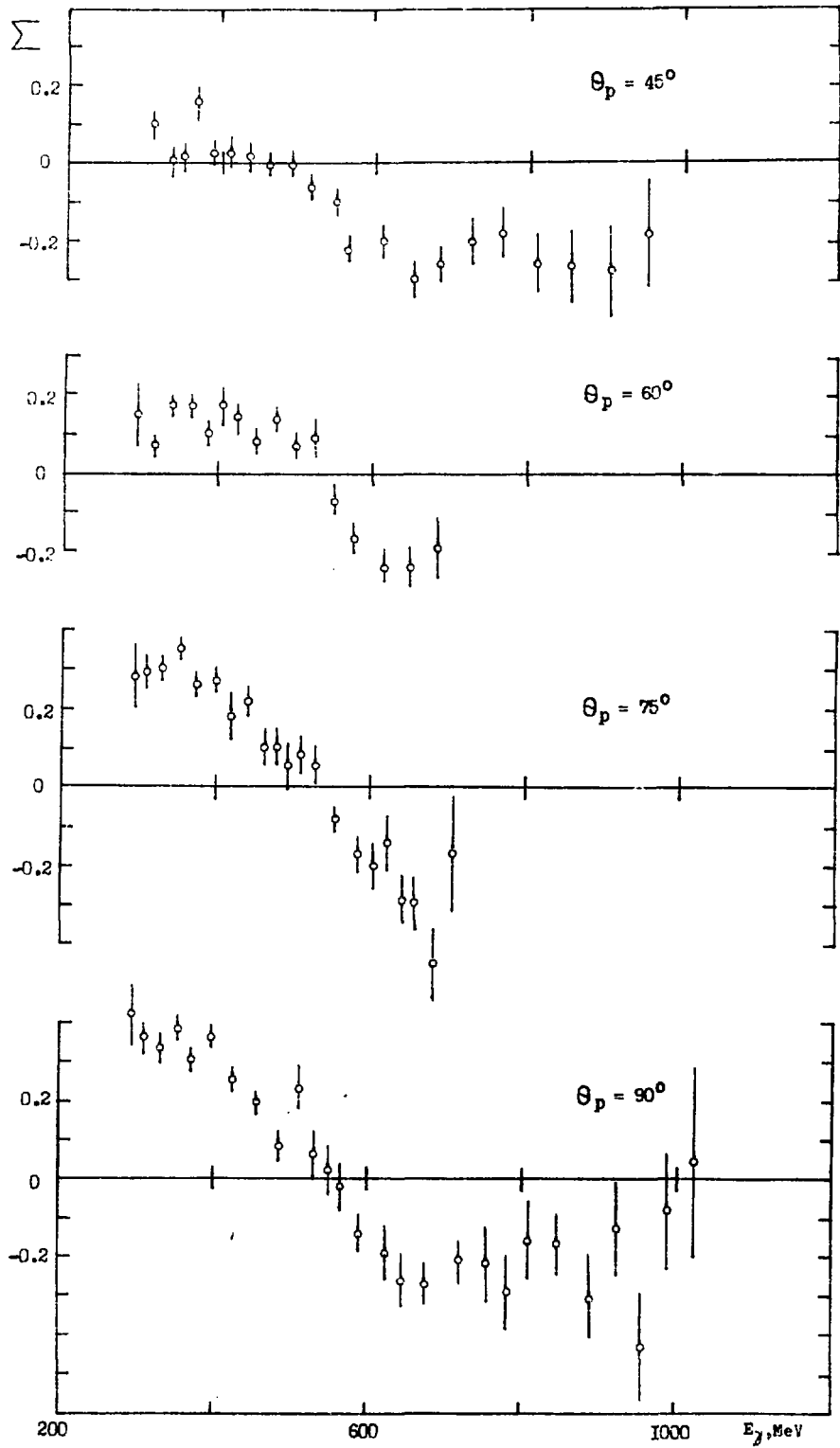


Fig. 3

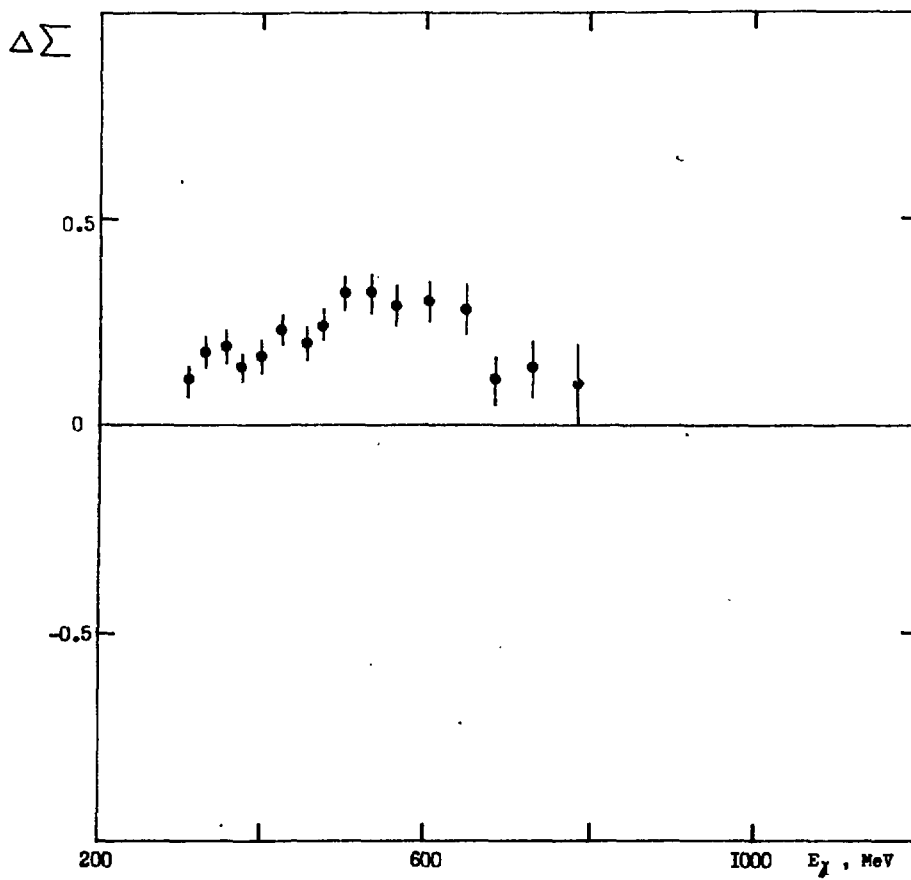


Fig. 4

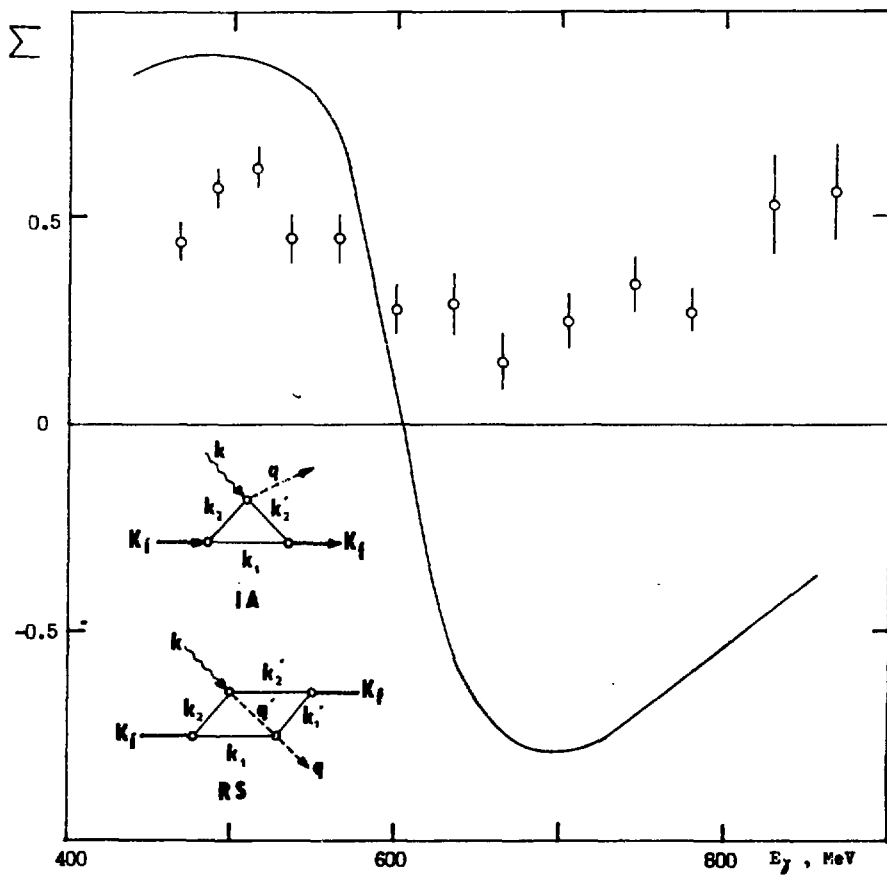


Fig. 5

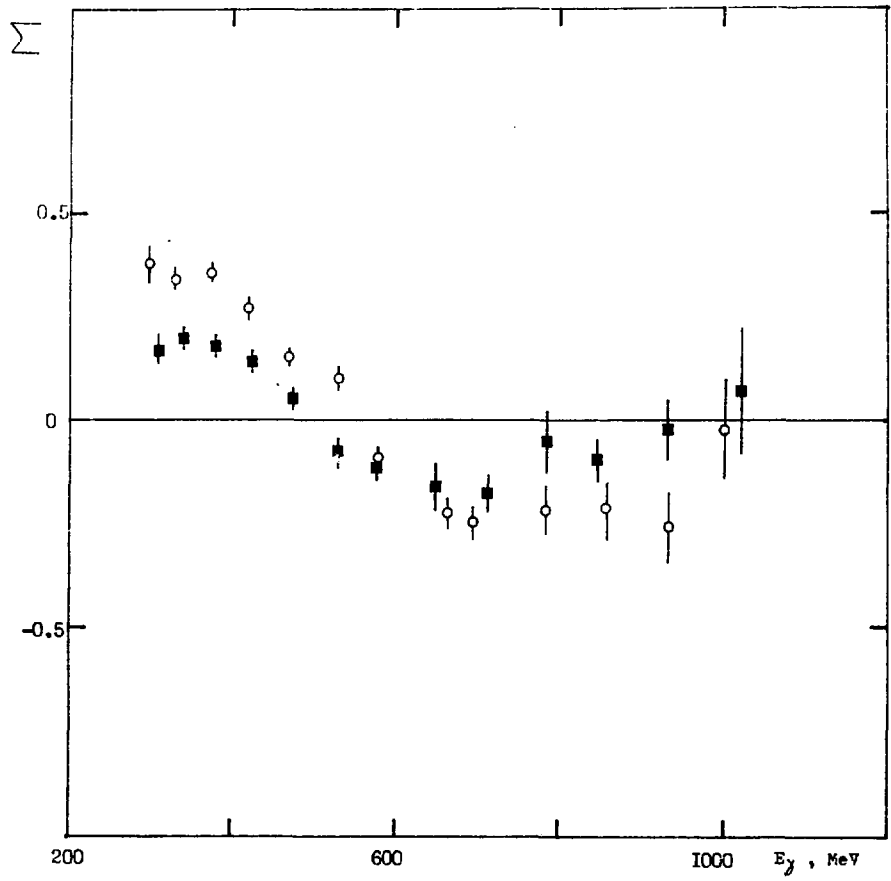


Fig. 6

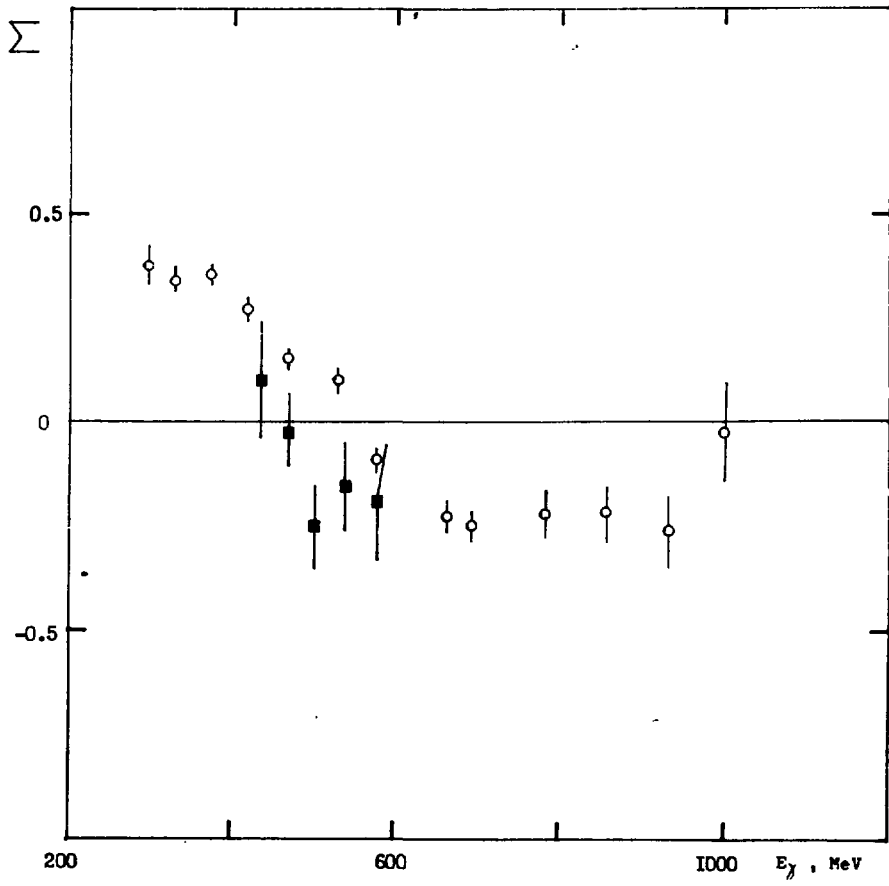


Fig. 7

Figure Captions

Fig.1 Layout of the experimental set-up.

a) Photon beam facility

D - diamond crystal target

K1, K2 - collimators

SM1, SM2 - cleaning magnets

C2 - converter

M - fast monitor with a shower counter SC

Q - Wilson quantometer

PS-30 - pair spectrometer consisting of an analyzing magnet PSM, changeable converters C1, eleven telescopes of scintillation counters BF-BB and SF-SB.

b) Magnetic spectrometer MS consisting of a doublet of lenses L_1 , L_2 , bending magnet M, trigger telescope S_1 - S_5 scintillation hodoscope H_x and four MWPCs.

c) 12-module neutron time-of-flight spectrometer NS representing a (4x3) matrix, a hodoscope of four anticoincidence counters A and a lead shield K.

d) Total absorption Cerenkov spectrometer CS consisting of a lead-glass shower counter C, an anticoincidence counter A, a lead converter K and a trigger counter S.

Fig.2 Characteristic spectra of the coherent bremsstrahlung intensity and polarization.

Fig.3 Energy dependence for the cross section asymmetry Σ for $\gamma d \rightarrow pn$ reaction.

Fig.4 Energy dependence of the cross section asymmetry difference $\Delta \Sigma = \Sigma(135^\circ) - \Sigma(45^\circ)$ for the $\gamma d \rightarrow pn$ reaction.

Fig.5 Energy dependence of the cross section asymmetry Σ of the $\gamma d \rightarrow d\pi^0$ at $\theta_{\pi^0}^* = 130^\circ$. The curve results from IA predictions [8]. In the diagrams IA is the impulse approximation and RS is the pion rescattering.

Fig.6 Energy dependence of the asymmetry Σ for $\gamma^6\text{Li} \rightarrow pnX$ (\blacksquare) together with the data on $\gamma d \rightarrow pn$ (ϕ) at $\theta_p^* = 90^\circ$.

Fig.7 Energy dependence of the asymmetry Σ for $\gamma^4\text{He} \rightarrow pnX$ (\blacksquare) together with the data on $\gamma d \rightarrow pn$ (ϕ) at $\theta_p^* = 90^\circ$.

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ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПРОЦЕССОВ ФОТОРОЖДЕНИЯ $\gamma d \rightarrow d\pi^0$
И ФОТОРАСЩЕПЛЕНИЯ $\gamma d \rightarrow pn$, $\gamma^6\text{Li} \rightarrow pn\alpha$ И $\gamma^4\text{He} \rightarrow pn\alpha$
ЛИНЕЙНО-ПОЛЯРИЗОВАННЫМИ ФОТОНАМИ В ОБЛАСТИ ЭНЕРГИИ 0,3-1 ГэВ.
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