Investigation of the asymmetry of the cross sections of the reaction $\gamma d \rightarrow np$ by polarized photons in the 400–600 MeV energy interval

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This paper presents the first results of an investigation of the asymmetry of the cross sections of the deuteron photodisintegration reaction, obtained in a beam of linearly polarized photons in the 400–600 MeV energy interval. The measurements were made in conjunction with a search for two-nucleon resonances with masses of 2200–2400 MeV.

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At the present time there is considerable interest being expressed in studying the $\gamma d \rightarrow np$ reaction in conjunction with the search for two-nucleon resonances.[1,2]

An analysis of existing data on the cross section and polarization of recoil nucleons[3,4] does not exclude the possibilities of dibaryon resonances with masses of 2200–2400 MeV appearing in this reaction, and, above all, the $3^-(2260)$ resonance, persistent indications of which have been obtained from the p-p scattering data.[5]

The conclusions of the analysis,[4] however, are ambiguous and new experimental data are needed on the deuteron photodisintegration process.

The present paper presents the first results of a measurement of the asymmetry of the cross sections $\Sigma \equiv (d\sigma_{\parallel} - d\sigma_{\perp})/(d\sigma_{\parallel} + d\sigma_{\perp})$ of the $\gamma d \rightarrow np$ reaction with linearly polarized photons with an energy of 400–600 MeV; this corresponds to resonance masses of 2200–2400 MeV.

The experiment was carried out on the KhFTI linear electron accelerator at 2 GeV. The equipment used and the parameters of the beam of quasimonochromatic linearly polarized photons from a diamond single crystal have been described in Ref. 6. A 20-cm long extended liquid-deuterium target was used in order to reduce the background from the target walls.

Since only the protons were recorded in the experiment, the studies were performed in those kinematic regions where the contribution from the $\gamma N \rightarrow \pi N$ reactions by intranuclear nucleons did not exceed 30%. Calculations, performed in the momentum approximation, showed that for the investigated energy interval such a contribution occurs for proton escape angles exceeding 75° in the center of momentum system and it is caused by the high-energy noncoherent part of the photon spectrum.

The initial energy of the electron beam was $E_0 = 1500$ MeV for studying the cross section asymmetry in the 400–500 MeV interval and was increased to 1600 MeV for $E_\gamma = 600$ MeV. The energy resolution of $\delta E_\gamma / E_\gamma$ was determined by the finite angu-

TABLE I.

E_γ, meV	θ^*				
	75°	90°	105°	120°	135°
400	−0,18 ±0,04	−0,25 ±0,03	−0,27 ±0,04	−0,23 ±0,05	−0,09 ±0,04
450	−0,21 ±0,05	−0,16 ±0,03	−0,17 ±0,04	−0,26 ±0,04	−0,15 ±0,06
500	0,02 ±0,04	−0,15 ±0,06	−0,07 ±0,07	−0,09 ±0,05	−0,06 ±0,07
550	0,01 ±0,08	0,00 ±0,09	−0,12 ±0,07	0,03 ±0,08	−0,04 ±0,07
600	0,38 ±0,11	0,13 ±0,14	−0,07 ±0,05	0,02 ±0,05	−0,30 ±0,13

lar and momentum ranges of the detecting apparatus and did not exceed 12%. Diamond single crystals with a thickness of 0.3 and 2.0 mm were used, depending on the value of the differential cross sections of the reaction being studied.

The procedure used in the asymmetry measurements and for keeping record of the corrections was similar to the that used earlier by us for studying the $\gamma p \to \pi^0 p$ reaction.[7] The background from the high-energy noncoherent part of the photon spectrum was taken into account by introducing the effective polarization of the γ-quanta

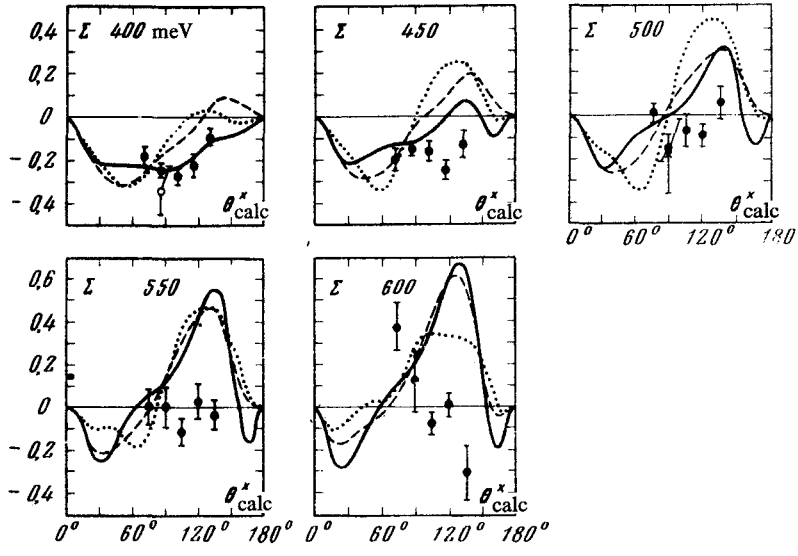

FIG. 1. Angular distributions of the cross section asymmetry of the reaction $\gamma d \to np$; ‡ ‡ are the results of this work, Φ are the data from Ref. 8.

$$\bar{P} = k_{\text{calc}} \frac{2(1-x)}{1+(1-x)^2} \frac{\beta-1}{\beta},$$

where $x = (E/E_0)$ is the relative energy of the photon; k_{calc} is a calculated coefficient, varying from 0.97 to 0.94 in the 400–600 MeV energy interval; $\beta = (C_\perp + C_\parallel/2C_0)$ is the value of the coherent effect, related to the experimentally measured proton yields $C_\perp$ and $C_\parallel$ (the subscripts "$\perp$" and "$\parallel$" denote the direction of the photon polarization vector with respect to the plane of the reaction) and C_0 is the yield from the noncoherent part of the spectrum. The value of the effective polarization $\bar{P}$ varied, depending on the experimental conditions, within the limits from 0.59 to 0.3.

The cross section asymmetry values of the reaction $\gamma d \to np$ $\Sigma = 1/P \times (C_\parallel - C_\perp)/(C_\parallel - C_\perp)$ are listed in Table I. The results of this work are also shown in Fig. 1 together with data measured at Frascati[8] at $E_\gamma = 400$ MeV and $\theta^* = 90°$. The cross in the figure denotes the asymmetry value for $E_\gamma = 500$ MeV and $\theta^* = 90°$, obtained by us during the recording of a proton and neutron in coincidence. The agreement of one branch with experiment is satisfactory. The large statistical error of the correlation experiment result is due to the low efficiency of the neutron counter and the impossibility of making measurements at the maximum photon beam intensity because of the appreciable background of random coincidences.

The results obtained do not agree with Laget's calculations[9] nor with the predictions for the asymmetry values following from the analysis of Ref. 4.

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