Asymmetry of the cross section for the reaction $\gamma d \to pn$ induced by linearly polarized γ rays in the energy region $E_\gamma = 0.4$–0.8 GeV and $\theta_p^{c.m.} = 45°$–$95°$

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The asymmetry (Σ) of the cross section for the reaction $\gamma d \to pn$ has been measured for the energy range $E_\gamma = 0.4$–0.8 GeV and for the angular interval $\theta_p^{c.m.} = 45°$–$95°$. The results are at odds with the calculations by Ogawa *et al.* and by Huneke, both based on phenomenological models, and also with the predictions of the partial-wave analysis by Ideda *et al.*, which incorporates dibaryon resonances.

The photodisintegration of the deuteron is one of the elementary processes which might be used to observe and study the properties of dibaryon resonances. The possible existence of such states is a problem of current interest as part of the effort to test the quark models within the framework of quantum chromodynamics.[4]

The first hint of a possible manifestation of dibaryon resonances in the photodisintegration $\gamma d \to pn$ emerged from a partial-wave analysis[3] by Ikeda *et al.* of data on the differential cross sections ($d\sigma/d\Omega$) and the polarizations (P) of the recoil proton. However, the predictions of this analysis with respect to other polarization observables, Σ (Refs. 5 and 7) and T (Ref. 8) have not found support, possibly because of an inadequate or oversimplified description of the "nonresonant" part of the process by means of a few very simple diagrams. It is apparently necessary to carry out a more systematic study in order to describe the nonresonant background, in particular, to correctly incorporate the NN^* interactions and the rescattering processes in the final state.[9] Further analysis thus requires systematic data on the reaction $\gamma d \to pn$, including data on the various polarization observables, Σ, P, T, etc.

In this letter we report experimental data on the asymmetry (Σ) of the cross section for the reaction $\gamma d \to pn$ induced by linearly polarized γ rays over the ranges $E_\gamma = 0.4$–0.8 GeV and $\theta_p^{c.m.} = 45°$–$95°$.

For the experiments we used the beam of linearly polarized γ rays from the synchrotron of the Erevan Physics Institute at electron energies $E_e = 1.75$–3.5 GeV, along with a two-arm experimental apparatus and a liquid-deuterium target. The protons were detected by a magnetic spectrometer which included a doublet of quadrupole lenses, an analyzing magnet, and a telescope of scintillation counters, S_1–S_4 (Ref. 10). The protons were separated from π^+ mesons on the basis of the time of flight over the S_1–S_4 baseline, ~ 9 m long, in the magnetic spectrometer. The neutrons were detected by a 12-module neutron time-of-flight spectrometer.[11] The time-of-flight analysis of the neutrons was carried out on the baseline between the liquid-deuterium target and the neutron spectrometer, ~ 3.3 m long, with the help of reference signals

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from counter S_1 of the magnetic spectrometer. The γ-ray beam was monitored with a Wilson γ detector, while the energy spectrum of the γ rays was measured and monitored with a nine-channel pair spectrometer.

The reaction of interest was distinguished through a kinematic selection of events through the use of the data from the time-of-flight and coordinate analysis of the neutrons. The contribution of background processes in the kinematic region of the reaction did not exceed 10%.

The asymmetry of the cross section is defined by

$$\Sigma = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel} = \frac{1}{P_\gamma} \frac{C_\perp - C_\parallel}{C_\perp + C_\parallel},$$

where $C_\perp (C_\parallel)$ is the reaction yield found experimentally for the case in which the polarization vector of the γ rays is oriented perpendicular (parallel) to the reaction plane, and $P_\gamma = 50$–70% is the effective polarization of the γ rays.

The energy resolution for the γ rays corresponding to this experimental apparatus is $\sigma(E_\gamma)/E_\gamma \approx 6\%$, while the angular resolution is $\sigma(\theta_p^{\text{c.m.}})$. The errors in Σ include the

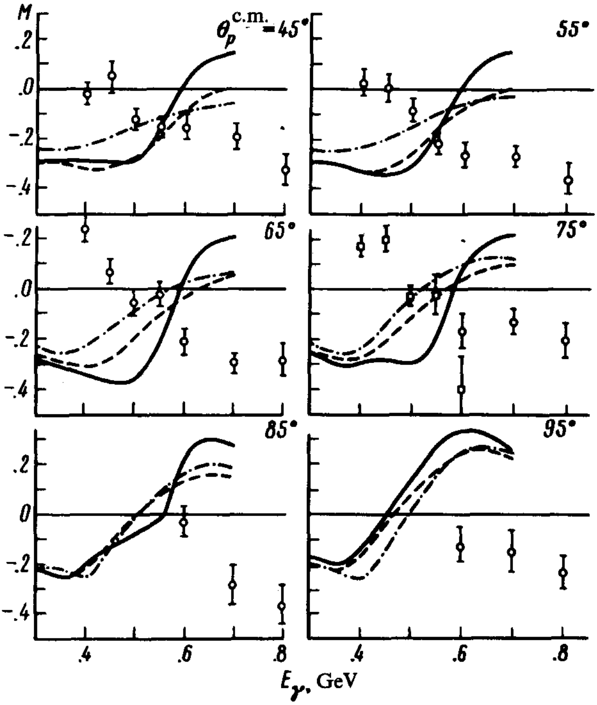

FIG. 1. Experimental results on the asymmetry (Σ) of the cross section for the reaction $\gamma d \to pn$ for several c.m. proton emission angles, $\theta_p^{\text{c.m.}} = 45°, 55°, 65°, 75°, 85°$, and 95°. Points: ×—Bond[5]; ■—Khar'kov[6]; ●—present study. Curves: Dot-dashed—Calculations of Ogawa *et al.*[1]; dotted—calculations of Huneke[2]; dashed and solid—partial-wave analysis by Ikeda *et al.*[3] incorporating the dibaryon resonances $1(3^-)$, $0(1^+)$ and $1(3^-)$, $0(3^+)$, respectively.

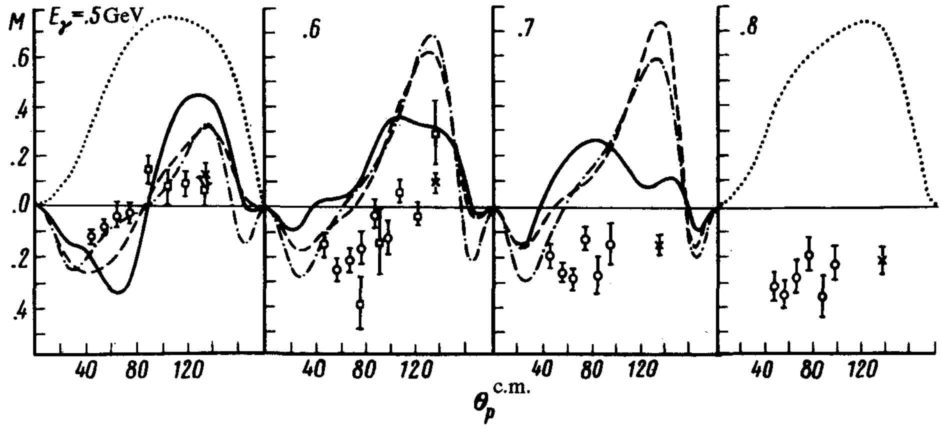

FIG. 2. Angular dependence of the asymmetry (Σ) of the cross section for the reaction $\gamma d \to pn$ at γ energies $E_\gamma = 0.5$, 0.6, 0.7, and 0.8 GeV in the laboratory frame of reference (the points and curves are explained in the Fig. 1 caption).

statistical error in the determination of $C_\perp$ and $C_\parallel$, and also an error on the order of 10% in the polarization P_γ.

Our results on the asymmetry Σ in the cross section for the reaction $\gamma d \to pn$ are shown in Figs. 1 and 2 as energy and angular dependences. The curves in the same figures are theoretical predictions: that of Ogawa *et al.*,[1] based on the use of the amplitudes for the reactions $\gamma N \to \pi N$ found from the MOR phenomenological analysis,[12] and that of Huneke,[2] based on a covariant model.[13] We see from Figs. 1 and 2 that the calculated curves do not satisfactorily fit the experimental data.

Also shown in Figs. 1 and 2 are the predictions of the partial-wave analysis by Ikeda *et al.*,[3] which incorporate the dibaryon resonances $1(3^-)$ (2.26), $0(1^+)$ (2.36) (solution *I*) and $1(3^-)$ (2.26), $0(3^+)$ (3.35) (solution II). The nonresonant background was described in this analysis on the basis of the results of Ref. 1. It can be seen from Figs. 1 and 2 that the dibaryon resonances do not significantly improve the fit of the experimental data.

In summary, our data on the asymmetry of the cross section for the reaction $\gamma d \to pn$ constitute further evidence that the existing theoretical calculations are unsatisfactory and demonstrate the need for new theoretical work.

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