Asymmetry of the cross section for disintegration reaction of a deuteron polarized by 80 to 600 MeV photons

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The measurement results of the asymmetry of the cross sections for the $\gamma d \to np$ reaction with 80 to 600 MeV polarized photons for proton angles of 75°–150° in the c.m.s. are presented. The experimental data are compared with the predictions of theoretical analyses with allowance for dibaryon resonance states.

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A two-particle disintegration of a deuteron is considered one of the elementary processes suitable for obtaining basic information on the effect of internal degrees of freedom of nucleons on the *N-N* interaction in nuclei, on the role of mesonic exchange currents in the electromagnetic interactions of hadrons, on Δ-*N* interaction, on the existence of dibaryon resonances, etc.

Theoretical studies of these problems[1–3] have shown that the available experimental data for deuteron phot disintegration are insufficient for a unique solution of the problem of the reaction mechanism and for determination of the parameters for the specific theoretical model of the process under consideration. Of particular interest in this case are the experimental data for different types of polarization parmeters, in particular, the parameter for the asymmetry of the cross section for a reaction induced by linearly polarized photons.

The experimental data for this parameter have been published in the literature for the energy range of photons $E_\gamma = 80$–200 MeV at angles of 45°, 90°, and 135° (Ref. 4), for $E_\gamma = 200$–400 MeV at an angle of 90° (Ref. 5), and for $E_\gamma = 600$–850 MeV at an angle of 135°.[6]

In this paper we present new experimental data for asymmetry of the cross section $\Sigma(\theta,E_\gamma) = (d\sigma_\perp - [d\sigma_\parallel])/(d\sigma_\perp + d\sigma_\parallel)$ for the $\gamma d \to np$ reaction in the energy range 80–400 MeV for angles of emission of a proton in the center-of-mass system 75°, 90°, 105°, 120°, 135°, and 150°, in addition to the data for $E_\gamma = 400$–600 MeV that were published earlier.[7]

The experiment was pertormed using the 2-GeV electron linear accelerator of the Khar'kov Physicotechnical Institute. A beam of linearly polarized photons was obtained from electron radiation in a 2-mm-thick diamond single crystal. We used two 50- and 20-mm-diam liquid deuterium targets, depending on the energy of the recorded protons. Two magnetic spectrometers, placed at different angles, and a scintillation-counter telescope were used to record the protons. The equipment used in the experiment was described in detail elsewhere.[8]

Since only protons were recorded in the experiment, we investigated the $\gamma d \to np$ reaction in those kinematic regions where the contribution from the $\gamma N \to \pi N$ reactions induced by intranuclear nucleons did not exceed 30%. This occured at emission angles of protons greater than 70° in the c.m.s.

The initial electron energy E_0 was varied from 1200 to 600 MeV in order to provide optimum conditions for production of polarized photons in the energy range 80–400 Mev. The energy resolution, which was determined by the angular, pulsed capture of the detecting apparatus and by the target thickness, was $\leqslant 12\%$.

The procedure for measuring the asymmetry and for calculating the corrections

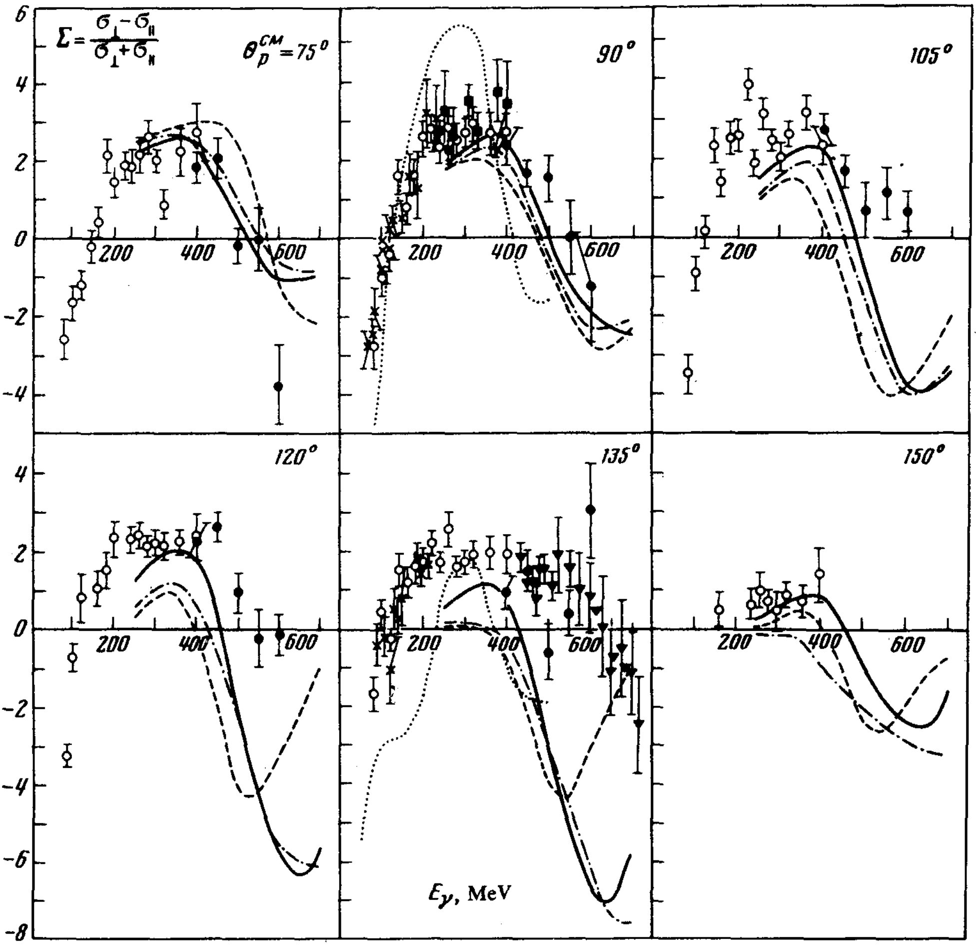

FIG. 1. Photon asymmetry excitation functions of the $\gamma d \to np$ process for angles of emission of a proton in the c.m.s. θ_p = 75°, 90°, 105°, 120°, 135°, and 150°. ×, Stanford 65 (Ref. 4); ■, Frascati 66 (Ref. 5); ▼, Bonn 79 (Ref. 6); ●, Khar'kov 79 (Ref. 7); ○, our work. The dotted curve represents Laget's calculation[1] and the dot-dash curve represent the results of Ref. 3.

was described in Ref. 8. The background from the high-energy, incoherent part of the photon spectrum was determined from the effective polarization of gamma-ray quanta

$$P_{\text{eff}} = k_p \frac{2(1-x)}{1+(1-x)^2} \frac{\beta - 1}{\beta} \quad ,$$

where $x = E_\gamma / E_0$ is the relative photon energy, k_p is a coefficient which varies from 0.89 to 0.98 in the investigated energy range, $\beta = (C_\perp + C_\parallel)/2C_0$ is the magnitude of the coherent effect, $C_\perp$ and $C_\parallel$ are the proton yields for a corresponding orientation of the polarization vector of photons relative to the reaction plane, and C_0 is the yield of the incoherent part of the spectrum. The value of P_{eff} varied from 0.40 to 0.80 in this experiment.

The values of the asymmetry parameter $\Sigma(\theta, E_\gamma) = (d\sigma_\perp - d\sigma_\parallel)/(d\sigma_\perp + d\sigma_\parallel)$ obtained by us are presented in Fig. 1, together with the data obtained by other investigators and the results of theoretical calculations.

The dotted curve represents Laget's[1] calculation with Holinde's wave function (HM2); the results of an analysis[3] are illustrated by the following curves in Fig. 1: the solid curve represents the result with allowance for the Born diagrams and for one-pion reabsorption, and the dashed curve and the dot-dash curve represent the results with addition of dibaryon resonances with the quantum numbers $[I = 1, J^P = 3^-(2260)] + [I = 0, J^P = 3^+(2380)]$ and $\{I = 1, J^P = 3^-(2260) + (I = 0, J^P = 1^+(2380)\}$, respectively.

We can see that this investigation has enabled us to obtan more comprehensive information on the asymmetry parameter Σ for the $\gamma d \to np$ reaction in the energy range of 80 to 600 MeV. The theoretical calulations do not satisfactorily describe the experimental data.

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