Asymmetry of the cross section for the reaction $\gamma d \to \pi^0 d$ with linearly polarized γ rays at 500–700 MeV and at a c.m. angle $\theta^*_{\pi^0} = 130°$

F. V. Adamyan, G. G. Akopyan, G. A. Vartapetyan, P. I. Galumyan, V. O. Grabskiĭ, V. V. Karapetyan, G. V. Karapetyan, and V. K. Oktanyan

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The asymmetry of the cross section (Σ) of the reaction $\gamma d \to \pi^0 d$ induced by linearly polarized γ rays has been measured at energies $E\gamma = 500$ MeV, $E\gamma = 600$, and $E_\gamma = 700$ MeV at the c.m. angle $\theta^*_{\pi^0} = 130°$. The results disagree with calculations in the impulse approximation. The results can be explained in a qualitative way by appealing to an ${}^3F_3$ (2.26-GeV) dibaryon resonance.

The possible existence of dibaryon resonances has recently attracted extensive experimental study.[1] So far, however, we can draw no definite conclusions about the existence of these resonances from the data available. There is accordingly particular

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interest in a search for and study of new processes in which the effects due to the excitation of dibaryon resonances would be most apparent. From this standpoint, the coherent photoproduction of π^0 mesons at the deuteron is clearly of interest. As Zayats and Omelaenko have shown,[2] there are several advantages in searching for dibaryon resonances in the reaction $\gamma d \to \pi^0 d$ instead of in the familiar photodisintegration $\gamma d \to pn$. The most important of these advantages are that (a) the nonresonance background falls off rapidly with increasing momentum transfer, so that the relative contribution of dibaryon resonances may become large at large π^0 production angles and (b) the nonresonant background can be calculated in the impulse approximation without appealing to a large number of diagrams.

In the present letter we report measurements of the asymmetry of the cross section (Σ) of the reaction $\gamma d \to \pi^0 d$ induced by linearly polarized γ rays at energies $E_\gamma = 500$ MeV, $E_\gamma = 600$ MeV, and $E_\gamma = 700$ MeV and at the c.m. angle $\theta^*_{\pi^0} = 130°$. No experimental data on the asymmetry of Σ have been available in this energy range ($E_\gamma > 500$ MeV), where dibaryon resonances have been predicted to have an important effect.[2]

The experiments were carried out in the beam of linearly polarized γ rays at the Erevan synchrotron.[3] A two-arm experimental apparatus with a liquid-deuterium target was used.[4] The γ rays were monitored by a Wilson γ detector. The γ energy spectrum was measured and monitored with a nine-channel pair spectrometer.

Deuterons from the reaction $\gamma d \to \pi^0 d$ were detected by a magnetic spectrometer[5] including a doublet of quadrupole lenses, an analyzing magnet, and a telescope of trigger counters. One of the γ rays from the decay of the π^0 meson was detected in coincidence with the deuterons. To detect the γ rays we used a shower detector consisting of an anticoincidence counter, a lead converter, and an aperture counter. The deuterons were discriminated from protons and π^+ mesons in the magnetic spectrometer on the basis of their time of flight over a 9-m baseline (Fig. 1). To determine the

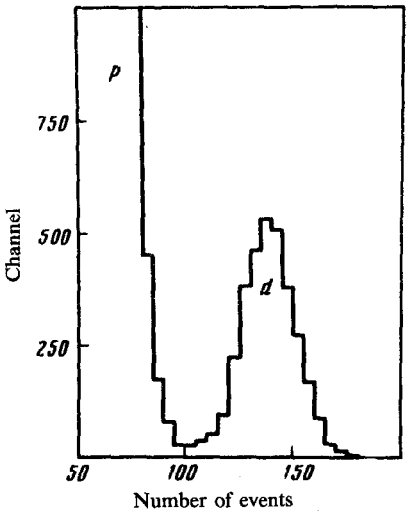

FIG. 1. Time-of-flight spectrum of the deuterons in the magnetic spectrometer.

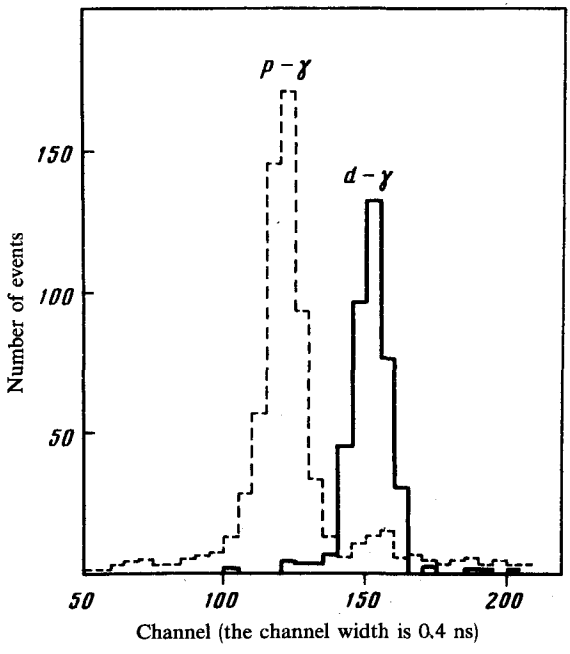

FIG. 2. Temporal spectrum of p, d-γ coincidences. a—Without discrimination against the protons in the magnetic spectrometer (dashed histogram); b—with discrimination against the protons in the magnetic spectrometer (solid histogram).

quality of the p-d separation in the magnetic spectrometer we measured the time of flight of deuterons over the 5-m baseline from the liquid-deuterium target to the magnetic spectrometer through a temporal analysis of $\bar{p}$, d-γ coincidences. Figure 2 shows the temporal structure of the p, $d \to \gamma$ coincidences in the cases with and without p-d separation in the magnetic spectrometer. We see that with p-d separation there is essentially no background of p-γ coincidences in the d-γ-coincidence region.

The asymmetry of the cross section Σ was determined from the reaction yields $C_\perp$ and $C_\parallel$ with the γ polarization vector respectively perpendicular and parallel to the reaction plane:

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

where p_γ is the effective γ polarization (60–70%).

To determine $C_\perp$ and $C_\parallel$ we considered a possible background from many-particle reactions, $\gamma d \to \pi^0\pi^0 d$, $\eta^0 d$, etc., due to the high-energy part of the quasimonochromatic γ bremsstrahlung spectrum. The background was estimated in measurements with a "disrupted" kinematics for the two-particle reaction and also in measurements with an "amorphous" γ spectrum; it did not exceed 10–15%.

Figure 3 shows the values found for the asymmetry of the cross section (Σ) for the reaction $\gamma d \to \pi^0 d$, along with the predictions of Zayats and Omelaenko[2] based on the impulse approximation[6] (solid curve) and with a contribution from the dibaryon reso-

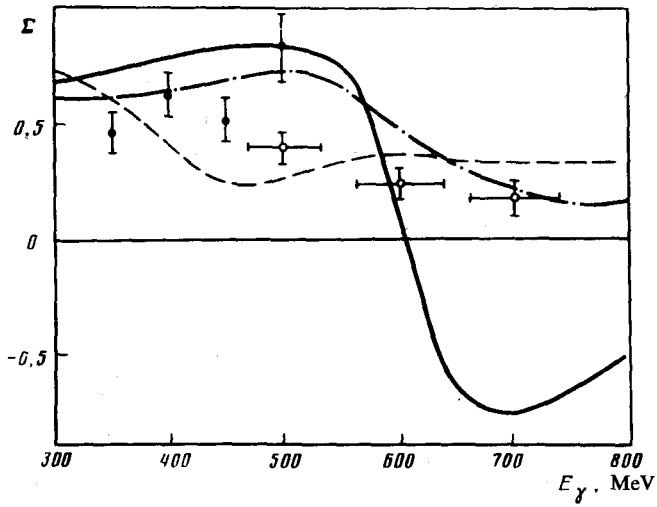

FIG. 3. Asymmetry of the cross section (Σ) for the reaction $\gamma d \to \pi^0 d$ at $\theta^*_{\pi^0} = 130°$. ●—Data of Ref. 9 ($\theta^*_{\pi^0} = 135°$); ×—present measurements. Solid curve—Impulse approximation; dashed curve— impulse approximation $+ {}^3F_3$ ($C = -0.5\ \mu b^{1/2}$); dot-dashed curve—impulse approximation $+ {}^3F_3$ ($C = 0.5\ \mu b^{1/2}$).

nance ${}^3F_3$ (2.26) (dashed curves). We see from Fig. 3 that the data on the asymmetry of the cross section do not agree with the predictions of the impulse approximation; in particular, there is a disagreement in terms of the expected change in the sign of the asymmetry near $E_\gamma = 600$ MeV. On the other hand, there is a qualitative agreement between the experimental data and the curves reflecting a contribution of the ${}^3F_3$ dibaryon resonance.

Zayats and Omelaenko[2] calculated the constant C, which characterizes the contribution of the ${}^3F_3$ resonance to the reaction $\gamma d \to \pi^0 d$, on the basis of a visual agreement of the calculations with experimental data on the differential cross sections $d\sigma/d\Omega$ at $\theta^*_{\pi^0} = 130°$. We have independently estimated the constant C with the help of the ${}^3F_3$ parameters found from data on other reactions: the value of the dominant amplitude $M_2({}^3F_3)$ from a partial-wave analysis of the reaction[7] $\gamma d \to pn$ and the ratio of partial widths of the decay of ${}^3F_3$ into πd and pp from a phase-shift analysis.[8] The value found, $|C| = 0.25\ \mu b^{1/2}$, is consistent in order of magnitude with the result obtained by Zayats and Omelaenko,[2] $C = 0.5\ \mu b^{1/2}$.

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