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ABSTRACT

Differential cross sections for the $^2H(\gamma,p)n$ reaction were measured at five laboratory angles, from 32° to 130°, for photon energies 100, 140, 180 and 220 MeV. A quasi-monochromatic photon beam was used and the photon spectrum was measured on-line by a pair spectrometer. The absolute normalization uncertainty is about $\pm 5\%$. Data agree within the total errors with results of recent monochromatic photon experiments.

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In spite of the considerable amount of efforts both theoretical and experimental spent up to now on studies of deuteron photodisintegration, knowledge of the cross section for this reaction is still unsatisfactory. This is in particular true in the energy region between the pion emission threshold and the $\Delta(1236)$ resonance, where the range of variation of the results reported by different Laboratories (Ref. 1-3) is well outside any reasonable estimate of the experimental errors. On the other hand, in this energy region, where the influence of virtual and real effects becomes important, different theoretical approaches (Ref. 4-10) are able to describe the general features of the cross section, but they still differ from each other. Moreover the modifications introduced by the use of different realistic potentials, the addition of explicit exchange effects, the introduction of isobar configurations, result of the same magnitude of the spread between each set of experimental data. Of course, due to the large discrepancy existing between experiments, a close comparison between theory and experiment has not been warranted up to now.

In this letter we present the results of a new measurement of the deuteron photodisintegration cross section carried out using the LEALE (Laboratorio Esperienze Acceleratore Lineare Elettroni) photon beam, produced at Frascati by in-flight positron annihilation on a liquid hydrogen target. The experimental facility has already been described in detail in Ref. (11). Particular care was paid to the beam monitoring: the positron intensity was monitored both by a non intercepting ferrite toroid and a Faraday cup, put in the focal plane of a dumping magnet behind the hydrogen target. The photon energy spectrum was measured on-line by a pair spectrometer[(12)]. Having passed through the deuterium target the photon was finally absorbed in a Komar[(13)] type quantameter which provides a constant sensitivity in our energy range. The used target was a vertical mylar cylinder (4.0 cm diameter, wall thickness 0.08 mm), filled up with liquid deuterium. The deuterium density was kept constant within 2% by a continuous monitoring of the deuterium vapor pressure. The photon beam spot on the target, periodically measured with a beam profile monitor, had a circular shape of 3.8 cm diameter.

Protons were detected by five telescopes connected on-line to a PDP 15/76 computer. Each employed telescope consisted of a dual scintillator counter system. The front counter, a 3 mm thick NE102A scintillator gave a measure of ΔE. The back counter, a 5 cm radius and 12 cm high NaI crystal, gave a simultaneous measurement of the total energy E. The stored data were presented on-line as a ΔE against E plot and the mass discrimination was found to be sufficiently good to distinguish unambiguosly protons from other particles. Proton spectra were simultaneously recorded at lab. angles of 32.5°, 55°, 80°, 105° and 130° with respect to the photon beam and at annihilation photon lab. energies of 100, 120, 140, 180, 200, 220 and 260 MeV. The measurements were made in several runs distributed over two years and the data from each run were separately analyzed and compared. This provided a check for systematic errors arising from factors in the experimental conditions which could have varied from run to run. The results of different runs were consistent within a $\pm 5\%$ fluctuation.

A more complete account of this experiment and the analysis will be given in a forthcoming publication. Here we present only a few results obtained in the energy range $100 \leq E_\gamma \leq 220$ MeV, where no monochromatic photon data exist apart from the recent Bonn results[(3)] at $E_\gamma \geq 200$ MeV.

Fig. 1 shows a typical photon energy spectrum measured on-line at the given positron energy and photon collection angle. The full line curve represents the result of a Montecarlo simulation[(14)] which also reproduces the total photon energy measured by the quantameter. The excellent

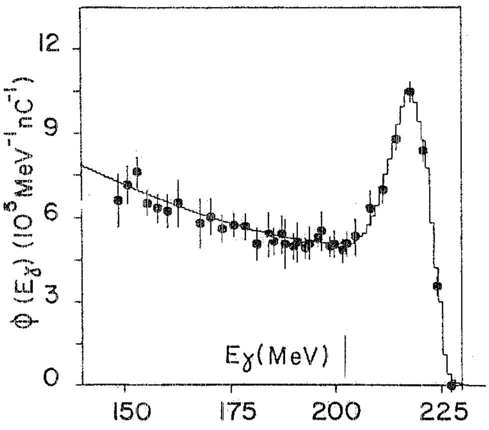

FIG. 1 - Photon energy spectrum measured with the pair spectrometer (positron energy 220 MeV, photon collection angle 0.9° and half angular geometric photon acceptance 3.9 mr). The full line curve is a result of a Montecarlo calculation.

agreement between the computed and the measured spectra was obtained by slightly adjusting the values of two input quantities (positron emittance and photon collection angle) by amounts within the experimental uncertainties.

The results of the differential cross sections in the centre-of-mass system are plotted as solid dots in Fig. 2, for the given laboratory photon energies. The errors quoted are statistical only and do not include a $\pm$5% systematic uncertainty on the absolute value. Fig. 2 also shows the results of the

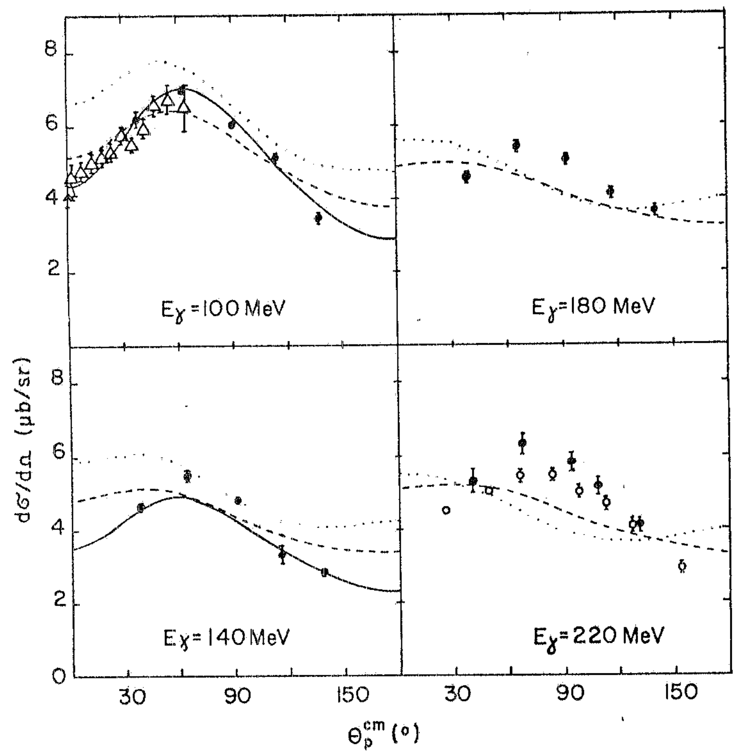

FIG. 2 - d(γ,p)n differential cross section for the given photon energies. Our data (solid dots) are compared to IUCF[15] (open triangles) and to Bonn[5] (open dots) results. The curves are theoretical calculations discussed in the text and are from Ref. (9) (solid line) Ref. (6) (dashed line) and Ref. (8) (dotted line).

IUCF radiative neutrons capture[15] (open triangles) and of the Bonn tagged photon experiments[3] (open-dots). The IUCF data are found to be in agreement with our results. If the systematic uncertainties of Frascati (±5%) and Bonn (±4%) experiments are taken into account, also these measurements become compatible.

Also shown in Fig. 2 are the results of the most recent calculations: the dashed line results from a calculation performed by Laget[6] using an expansion of the photodisintegration amplitude in terms of dominant diagrams. Final state interactions are taken into account by including the neutron-proton rescattering in S and P waves. In this calculation Laget has used the values Λ_π=1.2 GeV, for the cut-off mass of the pion-baryon form factor, and G_ϱ^2/G_π^2=1.6, for the ratio between the square of the ϱ- and π-baryon coupling constants. The dotted curve is a result from Leidemann and Arenhövel[8] who have extended their low energy calculation beyond the pion photoproduction threshold with explicit Δ degrees of freedom in a coupled channel treatment including all final state interactions. The full line curve refers to results from Cambi, Mosconi and Ricci[9] who have studied the effect of higher-order contributions to the one-body (Darwin-Foldy and spin orbit terms plus relativistic correction to the wave functions) and to the two-body (one-pion-exchange in pseudoscalar coupling) charge densities.

The full line curve shape seems to agree better with experimental points, particularly at E_γ =100 MeV, while the other two curves are sistematically larger at foreward and backward angles, the discrepancy increasing with the photon energies. It is however encouraging that the new data obtained by using quasi-monochromatic photon beams are found to be in a closer agreement (within a 10-15%) between each other. Consequently a stronger constraint is offered to the theory.

In conclusion we stress that the use of a quasi-monochromatic photon beam, the simultaneous measurement of profile, energy spectrum, and flux of the photon beam are important improvements for a correct determination of the absolute value of the deuteron photodisintegration cross section.

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