SPIN EFFECTS IN PHOTODISINTEGRATION REACTIONS $\gamma d \to pn$

W. Meyer

To cite this version:

W. Meyer. SPIN EFFECTS IN PHOTODISINTEGRATION REACTIONS $\gamma d \to pn$. Journal de Physique Colloques, 1985, 46 (C2), pp.C2-455-C2-457. <10.1051/jphyscol:1985254>. <jpa-00224569>

HAL Id: jpa-00224569
https://hal.archives-ouvertes.fr/jpa-00224569

Submitted on 1 Jan 1985

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
SPIN EFFECTS IN PHOTODISINTEGRATION REACTIONS $\gamma d \rightarrow pn$

W. Meyer

Physikalisches Institut der Universität Bonn, F.R.G.

Abstract - New results of the deuteron photodisintegration reaction $\gamma d \rightarrow pn$ are presented. The target asymmetry $T$ was measured at a photon energy of $550 \pm 50$ MeV and at proton center-off-mass angles between 25 and 155 degrees. For the first time ND$_3$ was used as polarized target material yielding a maximum deuteron polarization of 41%. The target asymmetry data show a structure which cannot be described by the existing analyses. First double-polarization measurements of the recoil-neutron polarization $P^x$ were performed with linearly polarized photons in the energy range $E_\gamma = 300-500$ MeV and at a proton c.m.s. angle of 50°.

The investigation of few nucleons systems is of particular interest to understand the nature of elementary interactions between nuclear constituents. In particular, the deuteron photodisintegration $\gamma d \rightarrow pn$ as a relative simple reaction is a good tool for experimental and theoretical studies. The deuteron is a two-nucleon system, where no problems with many particle approximation as with other nuclei exist. The properties of proton and neutron are well known and the binding energy of the nucleons is small. However, both the theoretical and the experimental situation in deuteron photodisintegration is unsatisfactory. There are a number of theoretical analyses. Some of them are based on non-relativistic calculations /1,2,3/, some on relativistic ones /4,5,6/. References /5/ and /6/ in addition include dibaryon resonances. Quark model calculations for the deuteron disintegration reaction do not exist yet.

The experimental situation (above $K_\gamma \sim 100$ MeV) is characterized by discrepancies between different data sets for the differential cross sections. Data above $K_\gamma \sim 900$ MeV do not exist. Latest experiments have been performed in Bonn, Frascati and at MIT. Due to the complicated spin structure of the deuteron photodisintegration reaction, 12 complex helicity amplitudes are required to characterize completely the $\gamma d \rightarrow pn$ process; hence 23 different observables have to be measured as a function of the photon energy and the proton c.m.s. angle. Only few experiments have been performed to investigate single polarization quantities like target asymmetry (using a vector polarized deuteron target), beam asymmetry (using linearly polarized photons) and recoil-nucleon polarization. First double polarization measurements were performed in Kharkov. There the recoil-proton polarization $T_1$ with linearly-polarized photons was measured.

Especially the measurement of the recoil-proton polarization at a photon energy
of 550 MeV, performed by a Tokyo group in 1977 /7/, produced a lot of excitement. The strong enhancement in the proton polarization was confirmed by a later experiment in Kharkov /8/. It was interpreted as an indication of dibaryon resonances. Since the dibaryon hypothesis is not conclusive from recoil polarization measurements only, it is very important to look at additional observables.

New data for a double polarization measurement were now presented from a Yerevan group /9/. For the first time the recoil-neutron polarization $P_x$ with linearly-polarized photons in the range $E_\gamma = 300-500$ MeV at a proton c.m.s. angle of 50° was determined. In fig. 1 the preliminary results for the neutron polarization $P_x$ are shown. It can be seen that there is a structure in the energy dependence with a high value for $P_x$ of $0.43 \pm 0.12$ at $E_\gamma = 400$ MeV. Further measurements with a higher photon energy resolution are planned /10/. Unfortunately theoretical predictions for $P_x$ do not exist yet.

At the Bonn 2.5 GeV synchrotron an angular distribution measurement of the target asymmetry at a photon energy of 550 MeV and at proton c.m.s. angles between 25° and 155° is now complete /11/. The measurement was performed in several runs over a period of three years. During this time the polarized target technique was substantially improved, using a $^3$He/He dilution refrigerator /12/ and a new target material ND$_3$ /13/.

The data of the target asymmetry measurement are plotted in fig. 2. Measurements of a Tokyo group /14/ at photon energies of 525 MeV and 575 MeV and at proton c.m.s. angles of 70°, 100°, 130° and an earlier measurement in Bonn /15/ at photon energies of 500 MeV and 600 MeV and at a proton c.m.s. angle of 135° are in satisfactory agreement with these data.

There are two theoretical analyses which give results for the target asymmetry $\gamma d \rightarrow p n$. A phenomenological analysis was carried out by a Tokyo group /6/. The prediction of the model is given by the dot-dashed curve in fig. 2. The dashed curve shows the result, where in addition two dibaryon resonances with masses 2260 MeV ($I = 1, J^P = 3^-$) and 2380 MeV ($I = 0, J^P = 3^+$) are taken into account. Obviously the Tokyo analysis cannot describe the data.

A relativistic analysis carried out at Bonn /5/ calculates the nucleon and deuteron Born terms and box graphs with propagating nucleon and delta. Fig. 2 also shows the result of this calculation. The data around the proton c.m.s. angle of 90° however indicate a second minimum which cannot be fitted. It is remarkable that the result of the Bonn analysis changes only by about 10% when the Tokyo dibaryon resonances are included.
It should be noted, that none of the analyses are able to fit even the differential cross section data in a sufficient way. Also the big differences in the results of the analyses without dibaryon contributions are obvious. At the moment a really conclusive statement about dibaryon resonances in the reaction \( \gamma d \rightarrow pn \) cannot be made. More fundamental work on the analyses is urgently needed. In addition, more data for the polarization observables must be produced, to understand the physics of the deuteron. Also new experiments, which require the combined use of a (linearly or circularly) polarized photon beam and a (vector or tensor) polarized deuteron target should be performed.

References

9. H.V. Vartapetyan, contribution to the 6th Int. symp. on high energy spin physics (Marseille)
10. H.V. Vartapetyan, private communication
11. K.H. Althoff et al., to be published in Z.Phys. C - Particle and Fields
12. W. Meyer et al., Nucl. Instr. and Meth. 204 (1982) 59
13. W. Meyer et al., to be published in Nucl. Instr. and Meth.