

# PROTON POLARIZATION IN REACTION OF DEUTERON PHOTODISINTEGRATION AT ENERGIES OF 0.2-2.4 GeV

*O.G. Konovalov, S.T. Lukyanenko, P.V. Sorokin, A.A. Zyalov*

*National Science Center "Kharkov Institute of Physics and Technology", Ukraine*

e-mail: psorokin@kipt.kharkov.ua

The review of the proton polarization experimental data on two-body deuteron photodisintegration at a photon energy between 0.2 and 2.4 GeV is presented. The NSC KIPT data are compared with the measurements of other centers and with theoretical calculations and phenomenological analysis in the framework of various interaction models with subnuclear (nucleons, mesons, resonances) and non-nucleon (quarks, gluons) degrees of freedom. The NSC KIPT measurements are in full accord with the data of other centers up to 0.8 GeV and confirm the dominant contribution of meson-exchange interactions and isobar configurations in the reaction  $\gamma D \rightarrow pn$ . Above 1 GeV the NSC KIPT data do not agree with the Jefferson Lab (USA) measurements which confirm the quark-gluon hypotheses about zero values of the proton polarization in this region.

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## 1. INTRODUCTION

The two-body deuteron photodisintegration reaction is a source of an information about a deuteron structure, non-nucleon degrees of freedom, properties of virtual nucleons in nuclei etc. The actual problem is the study of reaction mechanisms at various photon energies, a role of meson-nucleon and quark-gluon degrees of freedom. For the photon energies up to 1 GeV there is a lot of examples of the efficiency of the theory with the nucleon, meson and isobar degrees of freedom in the description of majority of experimental data on the cross-sections and the polarization observables in the reaction  $\gamma D \rightarrow pn$ . They evidence about a dominant contribution of the meson-nucleon interaction mechanism in this region [1]. However, there are definite indications about possibilities of manifestation of quark-gluon degrees of freedom in a deuteron for NN-interactions at small relative distances ( $r < 0.5$  fm) for this energy range too. In particular, this manifestation is connected with a possibility of excitation of dibaryon resonances (DR) in a deuteron at energies of a few hundred MeV. The complexity of the DR search in the reaction  $\gamma D \rightarrow pn$  is connected with their absence in the explicit form in the cross-sections of the reaction  $\gamma D \rightarrow pn$ .

For the photon energies above 1 GeV the domination of a traditional meson-nucleon model of the deuteron photodisintegration [3] is problematical so long as the results of the cross-sections evaluation on this model are not agreed with the measurements of SLAC [4] and Jefferson Lab [5]. In these measurements first discovered is the scaling behavior of the deuteron photodisintegration cross-sections. The scaling manifestation at low-level energies is of great interest for the theory of NN-interactions from the viewpoint of testing the adequation of various theoretical approaches to a structure of coupled states of two nucleons at small distances based on the meson theory and QCD [6]. In this connection, in investigations of the deuteron

photodisintegration reaction one of key problems is the question about a mechanism of photon interaction with nucleons and their excited states or structure quarks. The search of quark-gluon effects related with a dibaryon resonance excitation and scaling manifestation in the cross-section measurements is complicated, on the one hand, by a relatively small contribution of DR in their absolute values, on the other hand, by a possibility of scaling description with the use of meson-nucleon model. In this connection the polarization observables and, in particular, proton polarization can be more sensitive to a manifestation of quark-gluon effects in the deuteron. The estimations of 1 GeV proton polarization with involving DR [10] lead to the considerable change of its value in comparison with the estimates only by the meson-nucleon model [3]. Above 1 GeV the quark model [7] predicts zero values of the proton polarization whereas the results obtained by the meson-baryon model [8] give the polarization values being different from zero significantly in the photon energy range from 1 to 1.66 GeV for the angle  $\theta_p = 90^\circ$  cm.

All this evidences on an important role of the proton polarization in the investigations of interaction mechanisms in nuclei and on a necessity of their systematical measurements in the reaction  $\gamma D \rightarrow pn$  at intermediate energies. The  $C_x$  and  $C_z$  components of the proton polarization in the reaction plane with using the circularly polarized photons are of a great interest. Besides the traditional vertical  $P_y$  component of the proton polarization measured relatively to the reaction plane the measurements of new observable,  $C_x$  and  $C_z$  components may be more effective for testing the calculations of the deuteron photodisintegration reaction by various models of interactions.

## 2. THE MEASUREMENTS OF THE PROTON POLARIZATION IN THE REACTION $\gamma D \rightarrow NP$

The reaction of two-body deuteron photodisintegration, in the region above the  $\pi$ -meson

photoproduction threshold (up to 2 GeV) on the nucleon is characterized by the next peculiarities of energy behaviour of the cross-sections: the range  $E_\gamma=0.16-0.45$  GeV where  $\Delta(1232)$ -isobar gives the major contribution into the total cross-section; the range  $E_\gamma=0.45-0.8$  GeV where the channel  $(\gamma N \rightarrow N\pi)$  in the reaction  $\gamma D \rightarrow pn$  contains  $P_{11}(1440)$ ,  $D_{13}(1520)$ ,  $S_{11}(1535)$ -nucleon resonances; the range  $E_\gamma=0.8-2$  GeV where the channel  $(\gamma N \rightarrow N\pi)$  involves up to one and a half ten nucleon resonances and, at the same time, for  $E_\gamma > 1$  GeV is characterized by a scaling meeting the rule of quark account [7].

The first experiment on measurements of  $P_\gamma$  proton polarized has been carried out at the linear electron accelerator Mark 3 (Stanford, USA) [11]. The proton polarization is measured in the range of  $\Delta(1232)$ -isobar at  $E_\gamma=170-440$  MeV and  $\theta_p=40^\circ-117^\circ$  cm with using a magnetic spectrometer, a carbon polarimeter and scintillation counters. The proton polarization has a low value (from  $-0.1$  to  $-0.2$ ) at photon energies from 200 to 300 MeV, however, as the energy rises its value increases up to  $-0.55$  for  $E_\gamma=450$  MeV. In paper [12] the results of the proton polarization measurements at the angles  $\theta_p=75^\circ$  cm ( $E_\gamma=282, 342, 405$  MeV) and  $\theta_p=100^\circ$  cm ( $E_\gamma=358$  MeV) are presented. The experiment described in paper [12] has been carried out at the electron synchrotron 500 MeV (Bonn, Germany) by the method of np-coincidences using the telescope of the scintillation counters and optical spark chambers. In paper [13,14] the results of the proton polarization are presented in the deuteron photodisintegration reaction in the range  $E_\gamma=0.4-0.7$  GeV. The experiment has been carried out at the electron synchrotron INS (University Tokyo) with using the magnetic spectrometer and carbon polarimeter with magnetostrictive spark chambers. The energy dependences of the proton polarization are measured for the proton emission angles  $\theta_p=45^\circ$  cm ( $E_\gamma=450-600$  GeV),  $70^\circ$  ( $E_\gamma=400-600$  GeV),  $90^\circ$  ( $E_\gamma=350-700$  GeV),  $120^\circ$  ( $E_\gamma=450-650$  GeV),  $135^\circ$  ( $E_\gamma=500-550$  GeV). The energy resolution was  $\Delta E_\gamma \pm 25$  GeV. The large value of the proton polarization ( $P \sim 0.8$ ) first was discovered at  $E_\gamma=500-550$  MeV.

The proton polarization has been measured at NSC KIPT at the linear electron accelerator 2 GeV in the reaction  $\gamma D \rightarrow pn$  at  $E_\gamma=0.2-1$  GeV by means of the magnetic spectrometer and the carbon polarimeters with optical and magnetostrictive spark chambers. The detailed description of the procedure of measurements, information accumulation, data processing and obtaining the results with the error analysis is presented in papers [15-20]. The results of these measurements are following:

- 1) the systematic data of energy dependences of the proton polarization first are obtained in the reaction  $\gamma D \rightarrow pn$  in the range of  $\Delta(1232)$  isobar ( $E_\gamma=200-360$  MeV) for the proton emission angles  $\theta_p=25^\circ, 35^\circ, 45^\circ, 55^\circ, 65^\circ, 75^\circ$  and  $90^\circ$  cm [15,16];
- 2) the proton polarization measurements are made in the range  $E_\gamma=350-700$  MeV with the energetic resolution  $\Delta E_\gamma=12.5$  MeV [17,18], that is twice

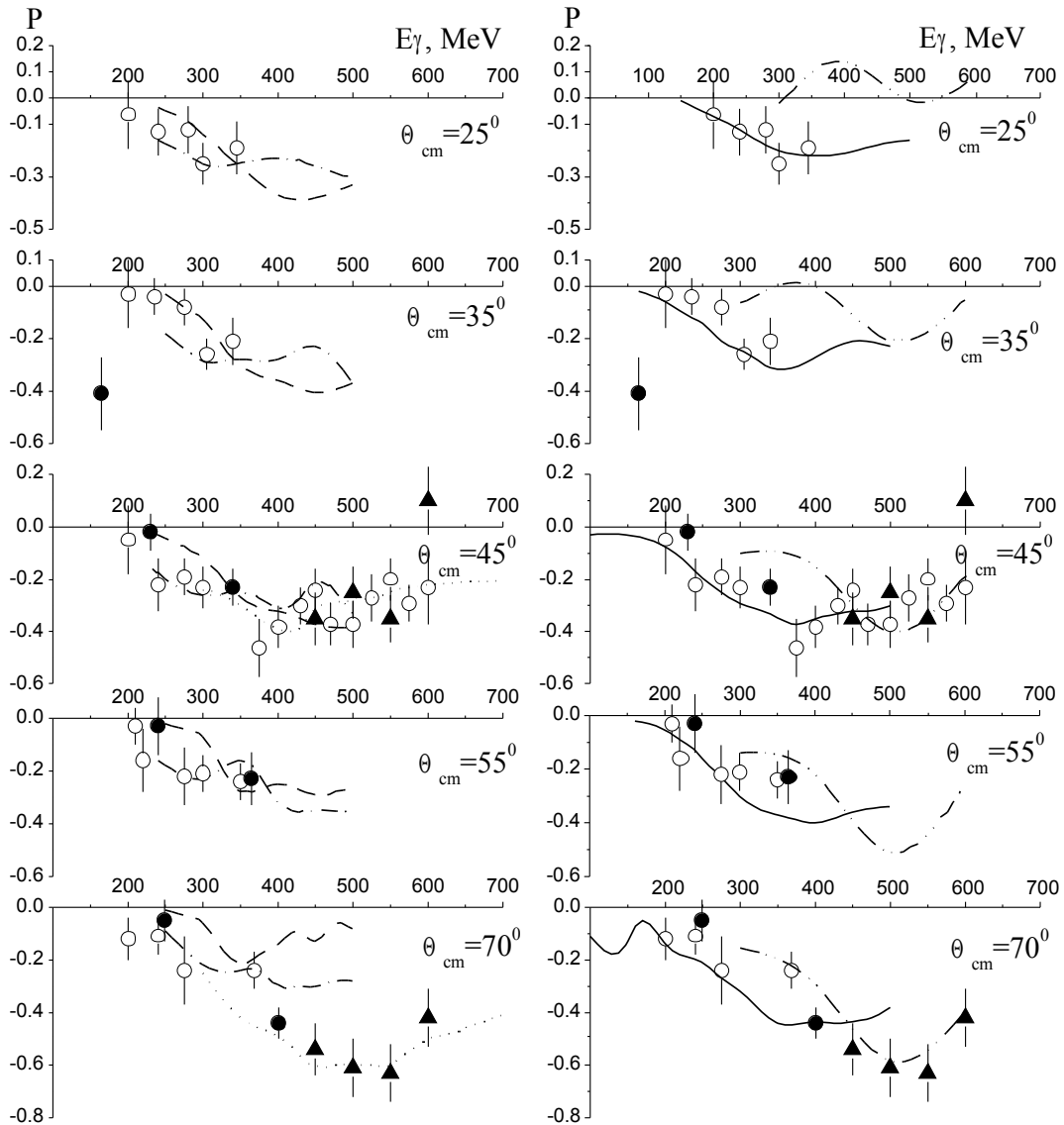
better than in the measurements of [13,14]. These results confirmed the presence of high values of the proton polarization in the range  $E_\gamma=500-550$  MeV, though with less absolute values ( $P \sim 0,6$ );

- 3) the proton polarization first is measured in the reaction  $\gamma D \rightarrow pn$  at  $E_\gamma=0.75-1$  GeV for the proton emission angles  $\theta_p=90^\circ$  and  $120^\circ$  cm [19,20]. It is necessary to mention that the measurements of the proton polarization in this energy range are connected with considerable background problems at the 2 GeV linear electron accelerator (NSC KIPT) because of the low proton yield of the reaction under investigation and the small duty factor of this accelerator (pulse duration  $\sim 1 \mu s$ , frequency 50 Hz). The presence of a large background in the spark chambers can lead to the appearance of a false asymmetry of a pC-scattering which is difficult to monitor in the experiment. It is necessary to use additional criterions for a selection of the pC-scattering events, for example, a back recovery of proton tracks through the magnetic spectrometer in the region of the deuteron target. Such a criterion is not used in this experiment.

The first measurements of proton polarization have been made in the reaction  $\gamma D \rightarrow pn$  at  $E_\gamma=0.5-2.5$  GeV at the electron accelerator CEBAF of Jefferson Lab [21]. The main aim of this experiment was the investigation of the proton polarization behavior in the scaling range of cross-sections [4,5]. The magnetic spectrometer and the carbon polarimeter with a drift wire chamber was used for these measurements. Using of the continuous electron beam from the accelerator CEBAF essentially decreases a level of a background in the track detectors. The large electron current of the accelerator provides the effective collection of the pC-scattering events even for the reaction with small cross-sections. Besides, to exclude a background contribution into the proton polarization, we used the procedure of the back recovery of the proton track from the polarimeter through the magnetic spectrometer into a deuteron target region. The  $C_x$  and  $C_z$  components of proton polarization first were measured in the reaction at a photon energy of 0.5-2.5 GeV.

The data of experimental investigations of  $P_\gamma$  proton polarization in the reaction  $\gamma D \rightarrow pn$  at  $E_\gamma=0.2-0.7$  GeV are presented in Fig. 1 and 2 [11-18,21]. The results of measurements [11-14] are agreed with the most full NSC KIPT data [15-18] in this region. The polarization data for angle  $90^\circ$  cm are presented in Fig. 3 in a more wide photon energy interval ( $E_\gamma=0.5-2.5$  GeV) [11,13,15,16,17,19,20,21]. The NSC KIPT data are not agreed with the measurements at Jefferson Lab (USA) in the interval  $E_\gamma=0.75-1$  GeV. As was mentioned above a possible cause of such disagreement is a false asymmetry of pC scattering created by the large background in the spark chambers of the polarimeter at the exit of the 2 GeV linear electron accelerator (NSC KIPT). The results of proton polarization measurements allow one to hold the effective examination of calculations of the reaction  $\gamma D \rightarrow pn$  with the use of

various mechanisms of interactions from the photomeson threshold to 2.5 GeV.

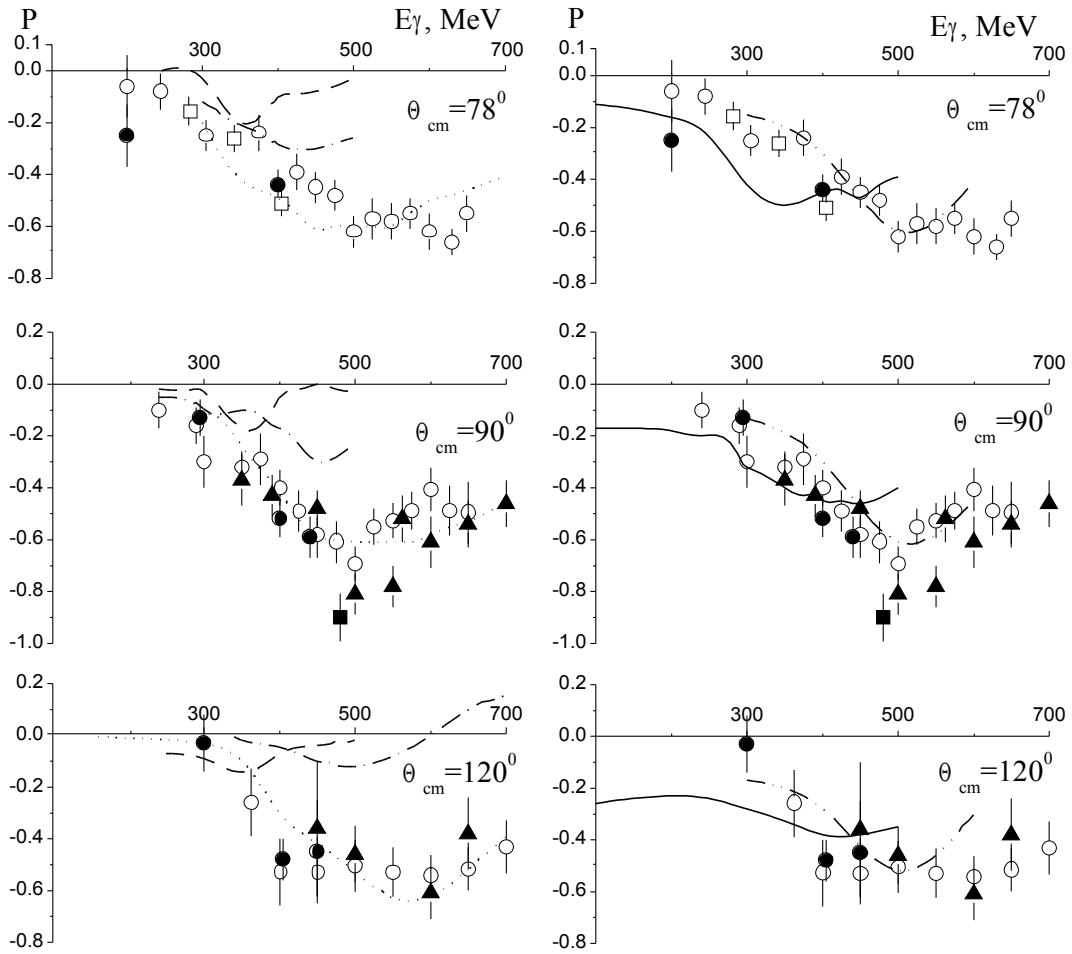


**Fig. 1.** Energy dependences of the proton polarization in the  $\gamma D \rightarrow np$  reaction for the proton angles  $\theta_{cm}=25^\circ, 35^\circ, 45^\circ, 55^\circ, 70^\circ$ . The open circles – Kharkov [15,16,18]; the solid circles – Stanford [11]; the solid triangles – Tokyo [14]; the dash curves – J. Laget [3]; the dash-dotted curves – K. Ogawa [22]; the dotted curves – H. Ikeda [14]; the dash-double dotted curves – V.P. Barannik, V.B. Ganenko [16,28]; the solid curves – V. Leidemann [32]

### 3. COMPARISON WITH THE THEORETICAL ESTIMATIONS OF THE REACTION $\gamma D \rightarrow NP$

Above the photomeson threshold on the nucleon, the first theoretical study of the two-body deuteron photodisintegration with the calculations of the proton polarization was made by Laget [3]. He first used a diagrammatical approach for the description of the reaction  $\gamma D \rightarrow pn$ . The calculation was performed in the no relativistic model with using the pole nucleon and

deuteron diagrams, meson-exchange diagram with excitation of  $\Delta$ -isobar in the intermediate state and the final-state interactions between the two nucleons (FSI). The results of the total cross-section calculations by this model are agreed adequately with the experiment up to  $E_\gamma=500$  MeV. The angular dependences of the cross-section  $d\sigma/d\Omega$  agrees with the experimental data for the photon energy 0.2-0.4 GeV only for the angles around  $90^\circ$  cm. The calculations of the  $\Sigma$ -asymmetry of cross-sections for the linearly polarized photons agree with the experiments at the energies  $E_\gamma=0.2-0.4$  GeV.

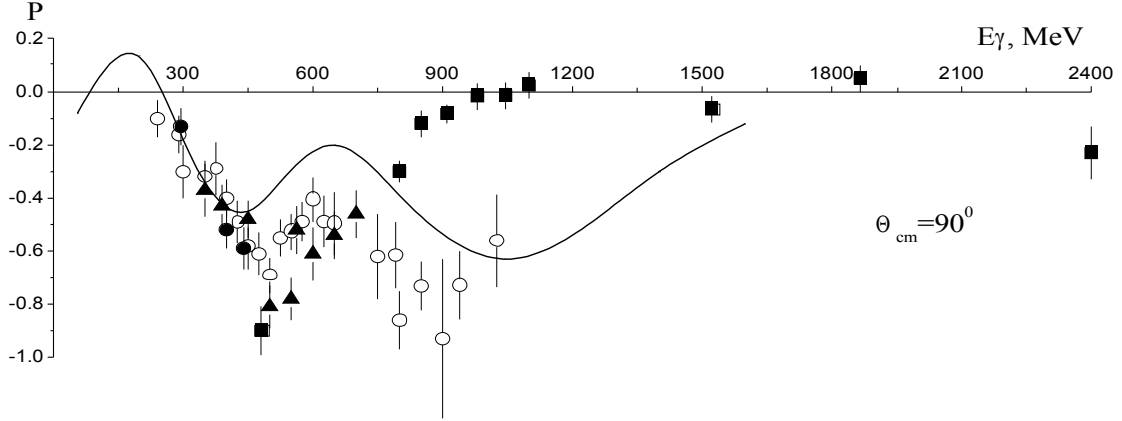


**Fig. 2.** Energy dependences of the proton polarization in the  $\gamma D \rightarrow np$  reaction for the proton angles  $\theta_{cm}=78^\circ, 90^\circ, 120^\circ$ . The open circles – Kharkov [15,16,17,18]; the solid circles – Stanford [11]; the solid triangles – Tokyo [13,14]; the open squares – Bonn [12]; the solid squares – Jefferson Lab [21]. The curves have the same as in Fig. 1

The estimations of the proton polarization by the Laget's model [3] are presented in Figs. 1 and 2. The Laget's results coincide with the measurements of proton polarization only for the angles  $\theta_p < 55^\circ$  cm in the region of  $\Delta(1232)$ -isobar. However, for  $\theta_p > 55^\circ$  cm significant disagreements between the model results and the measurements were observed.

In the framework of a covariant approach Ogawa et al [22] have calculated the amplitude of the deuteron photodisintegration with including the pole nucleon and deuteron diagrams and the diagram with an excitation of the  $\Delta(1232)$ -isobar and nucleon resonance  $P_{11}(1440)$ . In this model various simplifying assumptions are made in contrast to the Laget's model. For example, the following items are disregarded: the deuteron D-state wave function in the calculation of the one-pion reabsorption diagram; the contribution of the two-pion exchange diagram; the final-state interaction between the two nucleons; the Fermi motion of the nucleons in

the deuteron. The results of the cross-section calculations agree with the measurements up to the photomeson threshold. However, for  $E_\gamma > 300$  MeV, it is clearly necessary to take into account nucleon resonances higher than the  $P_{33}$ . A problem here is that it is almost prohibitive to make covariant calculations for higher resonances, since their vertex function is not well known. In this model the virtual process  $\gamma N \rightarrow N^* \rightarrow N\pi$  was presented by the phenomenological helical single-pion photoproduction amplitudes given by Moorhouse et al [23]. Such a procedure gave the possibility to improve essentially the description of the cross-section in this region. Besides the cross-section, the proton polarization was calculated in this model. These results are presented in Figs. 1 and 2. The agreement of the theoretical values of proton polarization with the experiments only for  $\theta_p < 55^\circ$  cm and  $E_\gamma = 200-300$  MeV is observed. To improve the agreement with the experiments, the dibaryon resonances were introduced



**Fig. 3.** Energy dependences of the proton polarization in the  $\gamma D \rightarrow np$  reaction for the proton angles  $\theta_{cm}=90^\circ$ . The open circles – Kharkov [15,16,17,19,20]; the solid circles – Stanford [11]; the solid triangles – Tokyo [13]; the solid squares – Jefferson Lab [21]. The solid curve – Y. Kang [8]

in the analysis [22]. To explain the polarization data the partial-wave analysis with including the dibaryon resonances in the deuteron photodisintegration [13,14] was made. The basic assumptions adopted in this analysis are as follows:

- 1) the  $\gamma D \rightarrow pn$  amplitudes consist of the non-resonant part and resonant part;
- 2) the non-resonant amplitudes are calculated and consist of the nucleon-exchange Born term and one-pion reabsorption term;
- 3) the one-pion reabsorption term based on the model Ogawa et al is calculated [22];
- 4) the resonant amplitudes are due to the s-channel formation of dibaryon resonances.

The resonant amplitudes are taken into account through E, H-multipole expression and are parametrized by Breit-Wigner form, where the masses  $W_0$ , widths  $\Gamma$  and coupling parameters were determined from  $\chi^2$ -minimization fits to the experimental data. The criteria for acceptable fits are:

- 1)  $\chi^2/df$  (degrees of freedom) < 2;
- 2)  $\Gamma < 350$  MeV;
- 3)  $2200 \text{ MeV} < W_0 < 2480 \text{ MeV}$ .

In conformity with these criteria the best fit to the experimental data of the cross-section and the proton polarization was ensured in the interval  $E_\gamma=0.2-0.7$  GeV by DR with  $I(J^P)=1(3^-)$  ( $W_0=2300$  MeV,  $\Gamma=213$  MeV),  $0(1^+)$  ( $W_0=2350$  MeV,  $\Gamma=342$  MeV) and  $0(3^+)$  ( $W_0=2380$  MeV,  $\Gamma=215$  MeV) in the combinations  $1(3^-)+0(1^+)$  and  $1(3^-)+0(3^+)$  with the non-resonant part of the amplitude of the reaction. The results of the fits to experimental data are following:

- 1) the including of DR with quantum numbers  $I(J^P)=1(3^-)$ ,  $0(1^+)$  and  $0(3^-)$  improved essentially the description of the differential cross-sections in the region  $E_\gamma=0.4-0.7$  GeV for the angles  $\theta_p=90^\circ$  cm in comparison with the non-resonant model [22];
- 2) the results of the partial-wave analysis [13,14] with the consideration of three DR agree with the measurements of the proton polarization in the

reaction  $\gamma D \rightarrow pn$  in the energy range from 0.4 to 0.7 GeV and at angles  $\theta_p=45^\circ-135^\circ$  cm, i. e. in the region of its maximum values (Fig. 1 and 2);

- 3) the prediction for the partial-wave analysis [14] with the given set of DR does not describe the angular distributions of the experimental data on the  $\Sigma$ -asymmetry of cross-sections with linearly polarized photons for energies between 0.25 and 0.6 GeV [24];
- 4) the prediction for the polarized target asymmetry is in bad conformity with the experimental data.

Although the results of analysis [14] agree badly with the experimental data of  $\Sigma$  and T-asymmetries, the success of the description of the proton polarization in the region 0.4-0.7 GeV with using DR became a definite confirmation of a mechanism related to with a manifestation of quark degrees of freedom in the deuteron [26,27]. This result promoted a further development of partial-wave analysis of the experimental data in the reaction  $\gamma D \rightarrow pn$  with an aim to examine the efficiency of the DR model for description of a more wide set of polarization observables.

In the papers [16,28] offered the results of multipole analysis (NSC KIPT) of the reaction  $\gamma D \rightarrow pn$  in the region  $E_\gamma=0.2-0.6$  GeV with using  $d\sigma/d\Omega$ ,  $\Sigma$ , T and P experimental data. This analysis was made in the framework of the gauge-invariant pole model considering the  $\gamma N \rightarrow N\pi$  amplitudes and the deuteron structure without DR and with different sets of isovector and isoscalar DR knowing from papers [29,30,31]. In total this analysis included nine DR with quantum numbers  $I(J^P)=1(2^+)$  ( $W_0=2150$  MeV,  $\Gamma=106$  MeV),  $1(3^-)$  ( $W_0=2260$  MeV,  $\Gamma=154$  MeV),  $1(0^+)$  ( $W_0=2050$  MeV,  $\Gamma=195$  MeV),  $1(1^-)$  ( $W_0=2179$  MeV,  $\Gamma=87$  MeV),  $1(4^+)$  ( $W_0=2470$  MeV,  $\Gamma=150$  MeV),  $0(1^+)$  ( $W_0=2140$  MeV,  $\Gamma=342$  MeV),  $0(3^+)$  ( $W_0=2362$  MeV,  $\Gamma=238$  MeV),  $0(3^-)$  ( $W_0=2230$  MeV,  $\Gamma=150$  MeV). DR amplitudes are parametrized in the Breit-Wigner form but with the fixed values of the mass  $W_0$  and width  $\Gamma$  unlike [13,14]. Residues  $m_l$ , phase factor  $\exp(i\phi_{DR})$  and barrier parameter X are used as parameters of fits to the

experimental data. In these fits to  $d\sigma/d\Omega$ ,  $\Sigma$ ,  $T$ ,  $P$  data various sets of DR and without DR were included with the use of pole and  $N\Delta$ -diagrams only starting from a minimization of  $\chi^2/df$ . The minimum value of  $\chi^2/df=1.74$  was got with including all the nine DR. The results of the given partial-wave analysis of the reaction  $\gamma D \rightarrow pn$  in the region  $E_\gamma=0.2-0.6$  GeV are as follows:

- 1) the satisfactory description of angular distributions of the cross-sections, in particular, in the region  $\theta_p < 60^\circ$  cm, where the results of the analysis [14] do not agree with the experiment has been obtained;
- 2) the results of analysis [28] entirely repeat the  $\Sigma$ -asymmetry cross-section angular distribution with linearly polarized photons in the interval  $E_\gamma=0.18-0.4$  GeV and partly at energies  $0.5-0.6$  GeV [24];
- 3) in the framework of the given analysis the satisfactory description of the proton polarization in the region between  $0.35$  and  $0.6$  GeV for the angles  $\theta_p > 45^\circ$  is achieved, however, for  $\theta_p < 45^\circ$  the agreement is not observed (Fig. 1 and 2);
- 4) the results of analysis [28] agree mainly with the measurements of a polarized target  $T$ -asymmetry [25].

As a whole the addition of the meson-baryon model by diagrams with the DR excitation in the intermediate state is a rather effective means for the description of the experimental data in the reaction of the deuteron photodisintegration in the photon energy range from  $0.3$  to  $0.7$  GeV and at proton emission angles  $\theta_p=45^\circ-135^\circ$  cm. However, in the meson-baryon model which were used in the analysis [13,14,16,28] one did not considered the whole set of possible effects which can influence on the description of the experimental data. These effects are following: FSI, meson-exchange currents, various isobar configurations in the intermediate state, the consideration of more high resonances, relativistic effects, the features of deuteron wave function behaviour at small distances etc. It is necessary to study in detail all these and other possible effects in the framework of meson-baryon model, their contributions in the cross-section and the polarization observables to convince in the necessity of including DR for the description of the reaction.

This is evidenced by the results of the  $d\sigma/d\Omega$ ,  $\Sigma$  and  $P$  estimation in the  $\gamma D \rightarrow pn$  at the energies  $E_\gamma=0.16-0.5$  GeV [32] where the DR contribution is not considered but the contribution meson-exchange currents, various  $N\Delta$  and  $\Delta\Delta$ -isobar configurations and FSI are analyzed in detail. The final-state interactions are considered in the approach of the  $(NN, N\Delta, \Delta\Delta)$ -coupling channels in the states  $(^{2S+1}L_J)$  with  $J \leq 3$  for every channel. The results of the calculations of the  $\Sigma$ -asymmetry and the cross-sections agree adequately with the experiments. The proton polarization calculations are shown in Fig. 1 and 2. We should note the significant improvement of the description of the proton polarization measurements by this model in comparison with MBM from papers [3,13,14,16,22,28], though the difference in the region of maximal values of the proton polarization is remained. The including of  $D_{13}(1520)$  and  $S_{11}(1535)$ -nucleon resonances did not lead to a

significant improvement of the proton polarization description.

The calculation of the deuteron photodisintegration has been carried out in the range from the photomeson threshold to  $1.6$  GeV on the base of the meson-baryon model [8]. This estimate includes  $\pi$ ,  $\rho$ ,  $\eta$  and  $\omega$ -exchanges, plus all good established nucleon and  $\Delta$ -resonances with a mass less than  $2$  GeV and  $J \leq 5/2$ . The calculation suggests that final-state interaction effects are insignificant and that the Born amplitudes are nearly real. The results of the proton polarization calculation together with the experimental data are presented in Fig. 3 for the angle  $\theta_p=90^\circ$  cm. The calculated proton polarization has the maximum value  $P \sim 0.5$  in the photon energy range  $0.25-0.7$  GeV and are enough near to the results of partial-wave analysis with including DR [13,14,16,28]. This result evidences about the necessity of further theoretical investigations of the reaction  $\gamma D \rightarrow pn$  in the framework of MBM in the given region.

In the range  $E_\gamma=0.7-1.6$  GeV the maximum values of the proton polarization [8] are close to the NSC KIPT measurements [19,20] and are do not agree with the Jefferson Lab measurements [21]. The zero values of the proton polarization [21] confirm the quark mechanism of the photon absorption in the deuteron [7] in the scaling region of the cross-sections, although such results for the cross-sections are obtained in the framework of the asymptotic meson-exchange model [8,9]. The results of the measurements of the  $C_x$  and  $C_z$  components of the proton polarization [21] do not agree with the prediction of the quark model [7].

The results of the systematic polarization investigations of the deuteron photodisintegration up to  $1$  GeV evidence about a dominant contribution of the meson-baryon mechanism of interactions although in the theory of this process there is not united concept about contributions of FSI, nucleon resonances, various meson-exchange mechanisms et al. In these conditions the DR role remains for now problematic. First of all it is necessary to improve the precision of the theoretical and experimental investigations of the deuteron photodisintegration to have a possibility to distinguish even the small contributions of these resonances. In the range  $E_\gamma=1-4$  GeV the systematic polarization investigations practically are only at the start but the study of a role of meson-baryon and quark mechanisms of interactions at the level of cross-sections does not give still an unambiguous answer in favour of one or another mechanism.

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