

PROTON POLARIZATION IN PHOTODISINTEGRATION OF NUCLEI D, ^3He , ^4He

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The result of proton polarization measurements (period 1993-2000) in the photodisintegration of the nuclei D, ^3He , ^4He at the photon energies $E=350\text{-}750$ MeV are presented. The proton polarization was measured on the 2 GeV linac NSC KIPT with a carbon polarimeter and a magnetic spectrometer. The proton polarization for the nuclei ^3He and ^4He is first measured and analyzed within the framework of "quasi-deuteron" model.

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1. INTRODUCTION

Investigation of the polarization observations in photodisintegration reactions is an effective method for a study of the mechanism of electromagnetic interaction in nuclei, in particular, the NN-correlations in nuclei. Levinger [1] has made a great contribution in the investigations of the mechanism of photonuclear interactions owing to his model of the dominant role of (np)-correlations (quasi-deuterons) in the process of photon absorption in nuclei. This model was examined by means of the cross-section measurements of a photon absorption in nuclei with the registration of emitted nucleons in coincidence [2]. These measurements confirmed Levinger's conclusion about the dominant contribution of the photon absorption by (np)-correlations in the cross sections of a photonuclear absorption and small addition from $\gamma(\text{nn})$ and $\gamma(\text{pp})$ -interactions. The further step may be studying the properties of quasi-deuterons in nuclei, the structure of their wave functions and the mechanism of $\gamma(\text{nn})$ -interactions in various nuclei in comparison with the mechanism of the body photodisintegration of a free deuteron. Of great interest is the investigation of interactions of photons with lightest nuclei ^3He and ^4He . It is expected that influence of a nuclear ^3He , ^4He matter on the properties of (np)-pairs will be minimal and the characteristic of a quasi-deuteron and a free deuteron are rather near. The $\gamma\text{D}\rightarrow\text{np}$ reaction has been investigated more than 60 years and already one obtained a rich theoretical and experimental material. W. Leidemann and H. Arenhovel [3,4] have made the detailed theoretical calculations of the cross-section and polarization parameters at $E_\gamma < 350$ MeV taking into account the meson-exchange currents, isobar configurations of $\text{N}\Delta$, $\Delta\Delta$ -type, relativistic corrections with various NN-potentials. It has been shown that the non-zero value of the proton polarization is mainly due to the contribution of $\text{N}\Delta$ -isobar configurations. Such calculations are absent for $\gamma(\text{np})$ -processes in nuclei and there is no possibility to obtain the information about peculiarities of these processes in comparison with γD -interaction. So, there is the possibility to compare the results of proton polarization for $\gamma\text{D}\rightarrow\text{np}$ and $\gamma(\text{np})$ -processes by measuring the proton polarization under identical kinematical conditions. These measurements were first made at NSC KIPT on the 2 GeV linac.

2. EXPERIMENTAL ARRANGEMENT

Fig. 1 shows the layout of the experimental arrangement. The detailed description of the experimental arrangement is presented in [5].

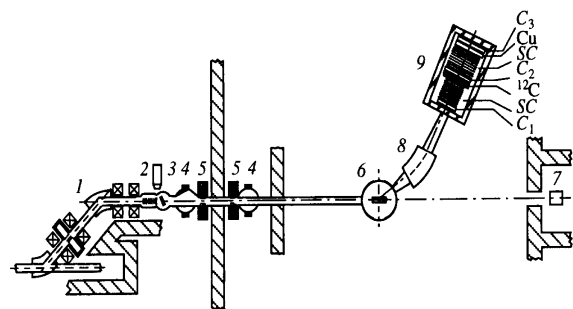


Fig. 1. Experimental layout: 1-magnetic lenses, 2-secondary emission monitor, 3-tantalum radiator, 4-cleaning magnet, 5-lead collimator, 6-liquid nuclear target, 7-Wilson quantometer, 8-magnetic spectrometer, 9-proton carbon polarimeter, SC-spark chambers, C₁, C₂, C₃-scintillation counters, ¹²C-carbon scatterer, Cu-copper moderator

The liquid deuterium target having 40 mm in diameter and 200 mm length along a beam is used for measurements of the proton polarization in the reaction $\gamma\text{D}\rightarrow\text{pn}$. The liquid targets ^3He and ^4He having 35 mm in diameter and 120 mm length are employed in polarization investigations of photodisintegration of lightest nuclei [6]. After interaction of a photon beam with a nuclear target the emitted protons are analyzed by the magnetic spectrometer with the momentum resolution $\Delta p/p=0,2\%$ and are detected by the carbon polarimeter with wire spark chambers. The data handling involved the reconstruction of horizontal and vertical projections, the selection of events of pC-scattering and the calculation of proton polarization.

3. RESULTS AND DISCUSSION

All proton polarization measurements for the photodisintegration of the nuclei ^3He and ^4He was made in the kinematic of two-body photodisintegration of a free deuteron having identical values of the angle Θ_p and the momentum p of emitted protons for the reaction $\gamma\text{D}\rightarrow\text{np}$ and $\gamma(\text{np})$ in the nuclei ^3He and ^4He . The Fig. 2 presents the results of proton polarization measurements [5,7,8].

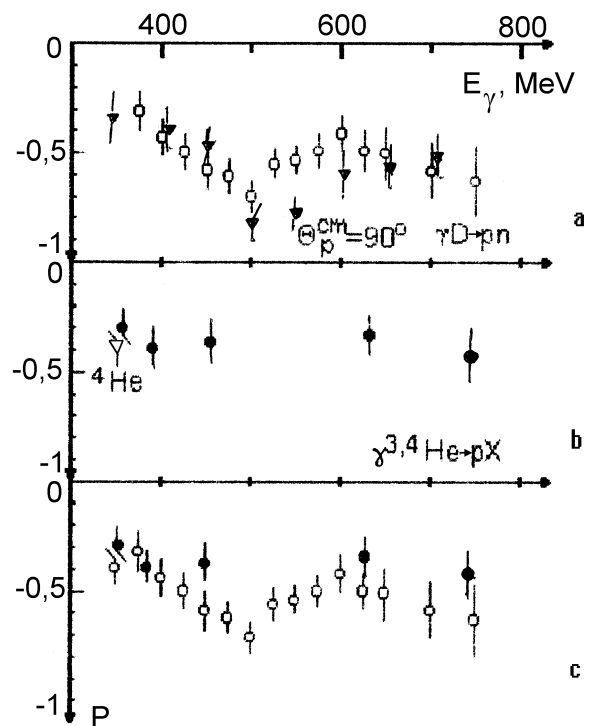


Fig. 2. The proton polarization in the reactions $\gamma D \rightarrow np$ and $\gamma(np)$ for the nuclei ${}^3\text{He}$, ${}^4\text{He}$: \circ - the results [5,7,8], ∇ - [9] for the $\gamma D \rightarrow np$, \bullet - ${}^3\text{He}$, ∇ - ${}^4\text{He}$

The polarization data for the reaction $\gamma D \rightarrow np$ of [9] are presented here (Fig. 2a). Our measurements have been performed with the better statistics and the energy step $\Delta E_\gamma = 25$ MeV at $\Delta E_\gamma = 50$ MeV from [9]. They confirmed the presence of a high value of the proton polarization ($P \sim 0,4-0,7$) in the reaction $\gamma D \rightarrow np$ at $E_\gamma = 350-750$ MeV. This polarization is not described only by the pole and meson-exchange diagrams. To describe the high proton polarization value near 550 MeV T. Kamae and T. Fujita [10] have used the pole nucleon diagram, nucleon-resonance diagram with the meson exchange and the diagram with the dibaryon resonances in the intermediate state. Only the consideration of dibaryon resonances made it possible to describe the polarization behaviour, however, this model failed to reproduce the angular dependences of the Σ -asymmetry measured by the use of a polarized photon beam [11]. The Fig. 2b shows the results of proton polarization measurements for the nuclei ${}^3\text{He}$ and ${}^4\text{He}$ [5,7,8]. These measurements are made for the first time. For the nucleus ${}^4\text{He}$ there is only the proton polarization at the energy $E_\gamma = 350$ MeV which agrees with the analogous measurement for ${}^3\text{He}$. The proton polarization in the photodisintegration of the nucleus ${}^3\text{He}$ differs from nought ($P \sim 0,35-0,45$) in all the energy interval of the measurements. The Fig. 2c presents the comparison of the proton polarization in the photodisintegration of nuclei ${}^3\text{He}$, ${}^4\text{He}$ and a free deuteron ($\gamma D \rightarrow np$). The results of this comparison allowed one to make the next conclusions:

-the signs of the proton polarization in the photodisintegration of ${}^3\text{He}$, ${}^4\text{He}$ and the free deuteron coincide and the values of the polarization are near each other;

-the results of the polarization measurements for the nuclei ${}^3\text{He}$, ${}^4\text{He}$ confirm the dominant contribution of "quasideuteron" mechanism of the photon absorption in lightest nuclei;

-the polarization measurements with nuclei ${}^3\text{He}$ and ${}^4\text{He}$ show that the effect of influence of a nuclear matter has not noticeable contribution for lightest nuclei;

-the near values of the polarization in the reactions $\gamma D \rightarrow np$ and the $\gamma(np)$ in nuclei ${}^3\text{He}$, ${}^4\text{He}$ can evidence that the quantum numbers of the free deuteron and "quasi-deuteron" are equal.

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