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EXPERIMENTS ON THE STUDY OF THE DEUTERON–PROTON INTERACTIONS AT INTERMEDIATE ENERGIES AT INTERNAL TARGET AT NUCLOTRON

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The experimental program on the study of deuteron–proton interaction at internal target at Nuclotron is discussed. Recent results obtained for dp-elastic scattering and dp-breakup reactions at intermediate energies are presented. The status of the DSS setup upgrade is reported.

Обсуждается экспериментальная программа по изучению дейтрон-протонного взаимодействия на внутренней мишени нуклотрона. Представлены результаты, полученные для реакции dp-упругого рассеяния и dp-развала при промежуточных энергиях. Представлен статус модернизации установки проекта DSS.

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INTRODUCTION

The purpose of DSS (Deuteron Spin Structure) experimental program is to obtain the information on the spin-dependent parts of 2-nucleon and 3-nucleon forces from two processes: dp-elastic scattering in a wide energy range and dp-nonmesonic breakup with two protons detection at the energies of 300–500 MeV.

Nowadays, a new generation of the NN potentials (AV-18 [1], CD-Bonn [2], Nijmegen [3], etc.) was obtained. They reproduce data on the nucleon–nucleon scattering up to 350 MeV with very good accuracy. However, these modern $2N$ forces fail to provide the experimental binding energies of few-nucleon systems. Moreover, the data on the dp-elastic scattering and deuteron breakup are not described properly. Incorporation of the $3N$

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forces makes it possible to reproduce the binding energy of the three-nucleon bound systems and also the data on unpolarized dp interaction. Nevertheless, polarization data for the reactions with participation of three and more nucleons are not described even with the inclusion of $3NF$. Therefore, the obtaining of the additional polarization data in the dp interaction in a wide energy range is very desirable for the study of the spin structure of $2N$ and $3N$ forces [4].

Measurements of the observables in dp-elastic scattering [5] and in dp-breakup reactions will be performed using Internal Target Station [6] of Nuclotron.

1. dp-ELASTIC SCATTERING

Four pairs of the scintillation detectors with the digital dividers located in a horizontal plane were used to study dp-elastic scattering. The signals from one pair of the detectors give coincidences for dp-elastic and quasi-elastic reactions. Another pair records protons from pp-quasi-elastic reaction, which is used as the intensity monitor of the interacting beam with the target for further calculation of the cross section of dp-elastic scattering reaction. This monitor can be used also for polarized measurements, because these detectors are located at 90° c.m. and are nonsensitive to the beam polarization [7].

In Figs. 1 and 2, the dependences of the cross section of dp-elastic scattering in arbitrary units on the angle in the c.m. are plotted for 880 and 500 MeV, respectively. The behavior of the data is reasonable.

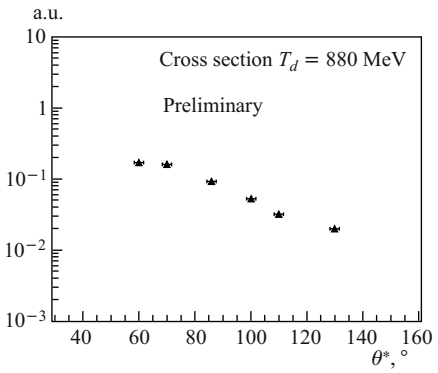

Fig. 1. Cross section of the dp-elastic scattering reaction at the deuteron energy of 880 MeV in arbitrary units

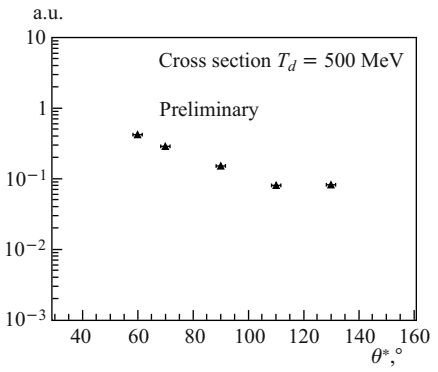

Fig. 2. Cross section of the dp-elastic scattering reaction at the deuteron energy of 500 MeV in arbitrary units

2. dp-BREAKUP REACTION

The experimental data on the deuteron analyzing powers in deuteron exclusive breakup for large phase space were obtained at 130 MeV at KVI [8]. We are planning to obtain the cross section, A_y, A_{yy}, and A_{xx} analyzing powers in the dp-breakup reaction at Internal Target Station (ITS) at 200–500 MeV for different kinematics.

The $dp \to ppn$ reaction will be investigated using $\Delta E - E$ techniques for the detection of two protons. Eight detectors of this kind are planned to be used in the experiment. Each

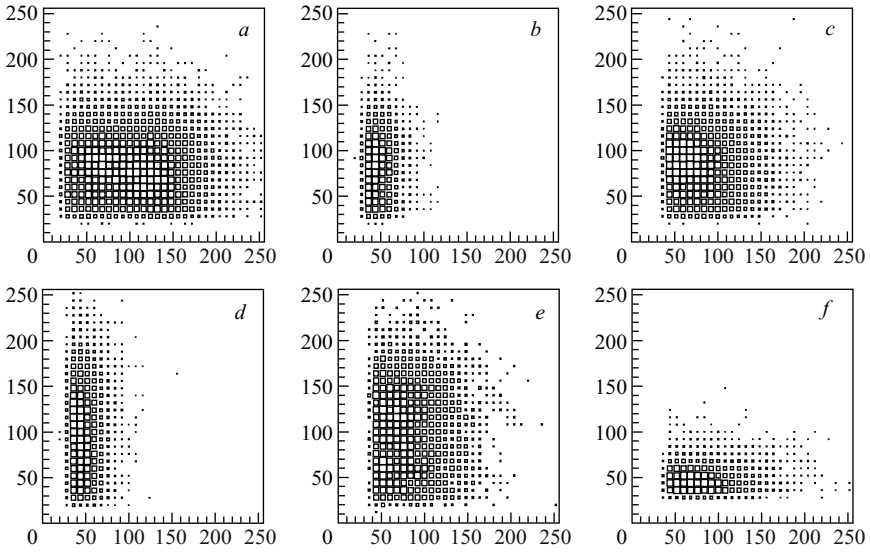

Fig. 3. The correlation of the amplitudes from four E detectors: *a*) $\theta_1 = 34^\circ$, $\theta_2 = 29.3^\circ$, $\Phi_{12} = 180^\circ$; *b*) $\theta_1 = 34^\circ$, $\theta_2 = 45.7^\circ$, $\Phi_{12} = 0^\circ$; *c*) $\theta_1 = 34^\circ$, $\theta_2 = 46.4^\circ$, $\Phi_{12} = 180^\circ$; *d*) $\theta_1 = 29.3^\circ$, $\theta_2 = 45.7^\circ$, $\Phi_{12} = 180^\circ$; *e*) $\theta_1 = 29.3^\circ$, $\theta_2 = 46.7^\circ$, $\Phi_{12} = 0^\circ$; *f*) $\theta_1 = 45.7^\circ$, $\theta_2 = 46.4^\circ$, $\Phi_{12} = 180^\circ$

detector consists of two scintillators ΔE and E [9]. The beam test with four $\Delta E - E$ detectors at ITS has been performed at the initial deuteron kinetic energy of 500 MeV in March 2010. During this test, a new DAQ-system based on the VME standard has been used. The correlations of the energy deposition in different E detectors for 6 possible kinematical configurations are presented in Fig. 3.

CONCLUSIONS

The following results have been obtained.

• The feasibility to measure the dp-elastic cross section at intermediate energies at internal target at Nuclotron using scintillation counters techniques has been demonstrated.

• The setup for the study of deuteron nonmesonic breakup (DAQ, high voltage systems and other) has been made.

• The calibration results for the $\Delta E - E$ counters with cosmic muons and with the deuteron beam at the internal target station at Nuclotron were obtained.

The goal for the nearest run is to measure the cross section of the dp-elastic scattering reaction in a wide deuteron energy range with the step not more than 100 MeV in the region from 500–1000 MeV. This is needed for an experiment to measure analyzing powers for the dp-elastic scattering. We are planing to increase the number of the $\Delta E{-}E$ detectors to 8.

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REFERENCES

1. *Wiringa R. B., Stoks V. G. J., Schiavilla R.* // Rhys. Rev. C. 1995. V. 51. P. 38.
2. *Machleidt R.* // Phys. Rev. C. 2001. V. 63. P. 024001.
3. *Stoks V. G. J. et al.* // Rhys. Rev. C. 1994. V. 49. P. 2950.
4. *Uesaka T. et al.* // Phys. Part. Nucl. Lett. 2006. V. 3. P. 305.
5. *Malakhov A. I. et al.* // Nucl. Instr. Meth. A. 2000. V. 440.
6. *Gurchin Yu. V. et al.* // Phys. Part. Nucl. Lett. 2007. V. 4. P. 263.
7. *Gurchin Yu. V. et al.* JINR Commun. P1-2010-12. Dubna, 2010.
8. *Kistryn St. et al.* // Phys. Rev. 2005. P. 044006.
9. *Piyadin S. M. et al.* // Phys. Part. Nucl. Lett. 2011. V. 8. P. 182.