Письма в ЭЧАЯ. А. 2011. Т. 8, № 10. С. 79–82

INVESTIGATION OF THE ANGULAR DEPENDENCE OF THE ANALYZING POWERS IN THE DEUTERON–PROTON ELASTIC SCATTERING AT THE NUCLOTRON

P. K. Kurilkin [a, j, 1], *V. P. Ladygin* [a, j], *T. Uesaka* [b], *K. Suda* [c], *Yu. V. Gurchin* [a], *A. Yu. Isupov* [a], *K. Itoh* [d], *M. Janek* [a, e], *J. -T. Karachuk* [a, f], *T. Kawabata* [b], *A. N. Khrenov* [a], *A. S. Kiselev* [a], *V. A. Kizka* [a], *V. A. Krasnov* [a, g], *N. B. Ladygina* [a], *A. N. Livanov* [a, g], *Y. Maeda* [h], *A. I. Malakhov* [a], *S. G. Reznikov* [a], *S. Sakaguchi* [b], *H. Sakai* [b, i], *Y. Sasamoto* [b], *K. Sekiguchi* [c], *M. A. Shikhalev* [a], *T. A. Vasiliev* [a, j]

[a] Joint Institute for Nuclear Research, Dubna

[b] Center for Nuclear Study, University of Tokyo, Tokyo

[c] RIKEN Nishina Center, Saitama, Japan

[d] Department of Physics, Saitama University, Saitama, Japan

[e] Physics Dept., University of Žilina, Žilina, Slovakia

[f] Advanced Research Institute for Electrical Engineering, Bucharest

[g] Institute for Nuclear Research, Moscow

[h] Kyushu University, Hakozaki, Japan

[i] University of Tokyo, Tokyo

[j] Moscow State Institute of Radio-Engineering Electronics and Automation (Technical University), Moscow

New polarimeter based on the asymmetry measurement in dp-elastic scattering has been constructed at internal target at Nuclotron (JINR). The results on the deuteron analyzing powers A_y, A_{yy}, and A_{xx} in the deuteron–proton (dp) elastic scattering at the energies of 880 and 2000 MeV are presented. They are compared with different theoretical approaches.

Новый поляриметр, основанный на измерении асимметрии выхода событий dp-упругого рассеяния, сконструирован на станции внутренней мишени нуклотрона. Представлены результаты измерения анализирующих способностей дейтрона A_y, A_{yy} и A_{xx} в дейтрон-протонном упругом рассеянии, полученные при энергиях 880 и 2000 МэВ. Данные сравниваются с вычислениями, выполненными в рамках различных теоретических моделей.

PACS: 29.20.dk; 25.45.De

[1] E-mail: pkurilkin@jinr.ru

INTRODUCTION

The deuteron is an ideal system for testing nuclear theory. Due to its simple structure, a relatively complete theoretical treatment of the scattering process is feasible. The spin structure of the deuteron has been investigated over the last decades by using both electromagnetic and hadron probes. These investigations at intermediate and high energies were performed to deduce information about the high-momentum component of the nucleon distribution in order to study manifestations of the relativistic effects and non-nucleonic degrees of freedom.

The main goal of the DSS project is the systematic studies of the polarized deuteron-induced reactions at the Nuclotron. One of the main directions of the DSS project is the measurements of the cross section, vector A_y, and tensor A_{yy} and A_{xx} analyzing powers in dp-elastic scattering at large angles in c.m.s. in the energy range from 0.3 up to 2.0 GeV at the Nuclotron Internal Target Station. For the scientific program of the DSS project it is also necessary to develop the efficiency polarimetry for deuteron and nucleon beams at intermediate and high energies at the Nuclotron.

1. EXPERIMENT

Analyzing powers for the dp-elastic scattering at the energies 880 and 2000 MeV were measured with the newly-constructed polarimeter at the Internal Target Station (ITS) of Nuclotron in June 2005. Polarized deuterons were provided by the polarized-ions sources POLARIS. The 10 μm CH_2 foil was used as a proton target. Additionally, the measurements with carbon target were made to estimate the background originating from quasi-free scattering on carbon. Prior to the analyzing powers measurement at 880 and 2000 MeV, the beam polarization measurement was carried out at 270 MeV [1], where well-established data on the analyzing powers exist. A detailed description of the experiment can be found in [2].

2. RESULTS

The dp-elastic events were selected by using the energy losses correlation and time-of-flight difference for the scattered deuteron and recoil proton. A detailed description of the dp-elastic events selection at the energies of 270, 880, and 2000 MeV can be found in [3].

The beam polarization was determined by using asymmetry of the dp-elastic scattering yields and known analyzing powers of the reaction. The values of the vector (tensor) deuteron beam polarizations obtained at 270 MeV are 0.216 ± 0.014 (0.605 ± 0.025) and 0.208 ± 0.012 (-0.575 ± 0.02) for the spin modes «2–6» and «3–5» of PIS POLARIS, respectively.

The results on the analyzing powers A_y, A_{yy}, and A_{xx} in dp-elastic scattering at 880 MeV are compared with several theoretical predictions in Fig. 1. The solid, dash, and dash-dotted lines are the results of the Faddeev calculations [4] using CD-Bonn nucleon–nucleon potential, of the relativistic multiple scattering calculation [5] using CD-Bonn deuteron wave function (DWF), and of the optical potential calculation [6] with the dibarion DWF, respectively. One can see that Faddeev and relativistic multiple scattering models give a good description of the data except for A_{xx}. On the other hand, Faddeev calculations fail to reproduce the cross section at the angles larger than 90°, while the relativistic multiple scattering calculations give much better agreement with the data at the angles between 60 and 130°.

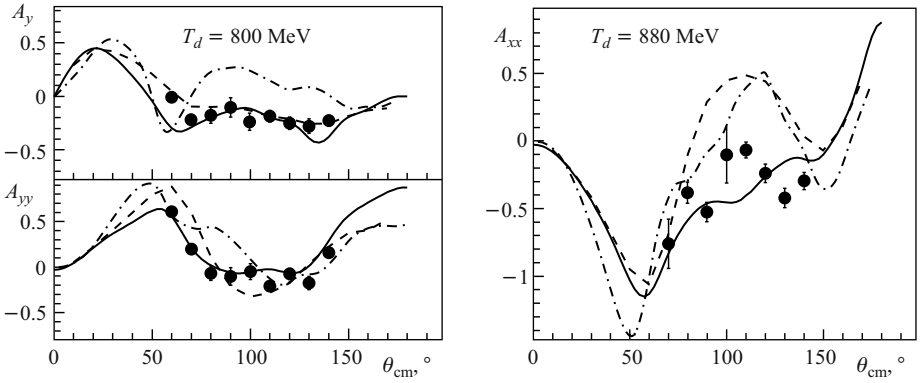

Fig. 1. Vector A_y, tensor A_{yy} and A_{xx} analyzing powers in dp-elastic scattering at 880 MeV. The lines are the predictions of different models [4–6] (explained in the text)

The results on the vector A_y and tensor A_{yy} analyzing powers at fixed angles in c.m.s are plotted as a function of transverse momentum p_T in the left and right panels of Fig. 2, respectively. The open and solid symbols represent the data obtained at RIKEN, Saclay, ANL, and at Nuclotron, respectively. The values of A_{yy} change the sign at $p_T \sim 600{-}650$ MeV/c as in the case of deuteron inclusive breakup. The negative sign of A_{yy} is observed at large p_T. Vector analyzing power A_y has small negative values at low p_T, but it achieves large positive values at p_T higher ~ 700 MeV/c. The change of the sign is also observed for A_y at $p_T \sim 600{-}700$ MeV/c at large scattering angles in the c.m. It would be interesting to perform the further precise measurement to understand the reason of such a behavior.

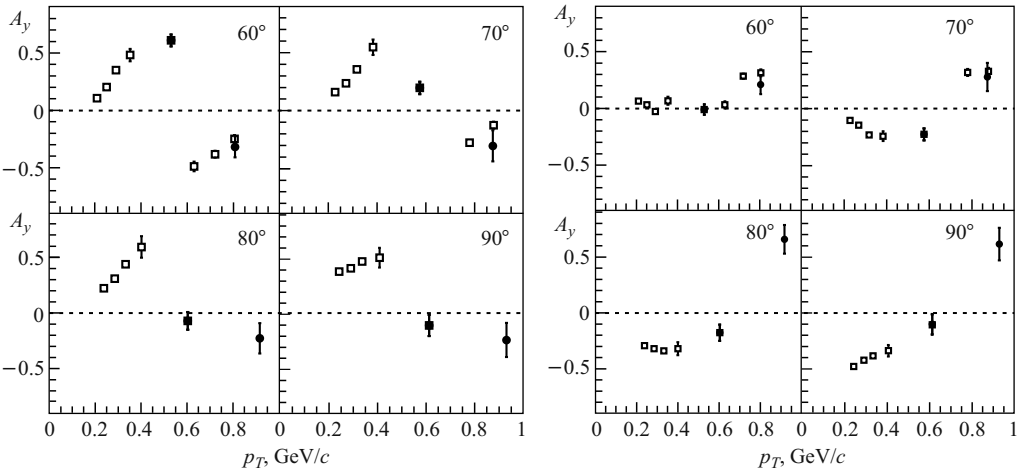

Fig. 2. Vector A_y (left panel) and tensor A_{yy} (right panel) analyzing powers in dp-elastic scattering obtained at fixed angles of 60, 70, 80, and 90° in the c.m. as a function of transverse momentum p_T. The open and solid symbols are the data obtained at RIKEN, Saclay, ANL, and at Nuclotron, respectively

CONCLUSION

• New polarimeter based on the asymmetry measurement in dp-elastic scattering has been constructed at internal target at Nuclotron (JINR). It allows one to measure vector and tensor components of the deuteron beam polarization simultaneously.

• The final results on the analyzing powers A_y, A_{yy}, and A_{xx} in dp-elastic scattering at the energies of 880 and 2000 MeV are obtained.These data are important for the preparation of the future experiments at LHEP–JINR at Nuclotron.

The authors would like to express their gratitude to the Nuclotron accelerator staff. We thank L. S. Azhgirey, Yu. S. Anisimov, E. Ayush, A. F. Elishev, V. I. Ivanov, L. V. Karnjushina, J. Kliman, Z. P. Kuznezova, A. P. Laricheva, A. G. Litvinenko, V. Matousek, M. Morhach, V. G. Perevozchikov, I. Turso, H. Witala, and V. N. Zhmyrov for the help during the preparation and performance of the experiment. This work has been partly supported by the Russian Foundation for Basic Research (Grants No. 10-02-00087a).

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