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Measurement of the Vector and Tensor Analyzing Powers for Dp-elastic Scattering at the Energy of 800 MeV

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Abstract. The vector A_y and tensor analyzing powers A_{yy} and A_{xx} for dp-elastic scattering were measured at the energy of 800 MeV and at the angular range from 60° to 135° in the center-of-mass system at the JINR Nuclotron. The experimental data are compared with the calculations obtained within framework of relativistic multiple scattering approach.

INTRODUCTION

The study of nuclear reactions involving deuterons has always played an important role in the development of ideas about the structure of the nucleus and the dynamics of nuclear interactions. At the new stage of development of nuclear physics, the study of processes involving the deuteron will undoubtedly help to solve many actual relativistic problems of nuclear physics.

At the present, a lot of data on the deuteron in deuteron induced reactions obtained by electron and hadron beams has been accumulated [1-2].

Over the past decades, several experimental groups have accumulated data on polarization observables in pd - and nd - elastic scattering, as well as in deuteron-breakup reactions on a nucleon [3-6] in a wide energy range (108 – 300 MeV/nucleon). Most of them were associated with testing the two-nucleon (2N) interaction models and detecting the effect of three-nucleon forces (3NF). Currently, there is a number of phenomenological two-nucleon models that describe the experimental data on NN scattering for energies below the pion formation threshold with fairly good accuracy.

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However, these NN forces fail to describe experimental binding energies of few nucleon systems. Inclusion of the three-nucleon forces (3NFs) into the calculations, can remedy the discrepancies between the experimental data and the theoretical calculation [7].

2NF and 3NF effects can be studied using polarized observables in deuteron-proton elastic scattering and deuteron – proton breakup.

In the present work new results on the analyzing powers A_y, A_{yy} and A_{xx} for dp elastic scattering measured at the energy of 800 MeV and in angular range from 60° to 135° are reported. They are compared with the results of theoretical prediction.

EXPERIMENTAL PROCEDURE

The experiment was performed at the Internal Target Station (ITS) at Nuclotron [8], Laboratory of High Energy Physics of Joint Institute for Nuclear Research. ITS is well suited for the study of the d − p interaction reactions at large angles in the center-of-mass system. The experiment consisted of the deuteron beam polarization measurement at the energy of 270 MeV [9] and the analyzing powers measurement at the energy of 800 MeV. Polarized deuterons were provided by polarized ion source SPI (polarized ion source). The linear accelerator LU-20 was used as the injector of Nuclotron.

In current experiment two targets were used (polyethylene film 10 μm sheet and carbon wire). Carbon wire has been used to estimate the background.

A detector support has been placed downstream of the ITS. 39 scintillation counters based on Hamamatsu PMTs were placed in the horizontal and vertical planes. There are eight proton detectors placed on the right, left and up side with respect to the ITS and only four detectors are placed on the bottom side, due to the space limitations. One pair of counters has been used for pp quasi-elastic scattering as the intensity monitor. The detection of the dp elastic scattering events has been done by the coincident measurement of deuteron at the angular range of 60°-135° in the center-of-mass system.

The analyzing powers A_y, A_{yy} and A_{xx} has been measured at sixteen different angles defined by the position of the counters placed in the horizontal and fifteen different angles defined by the position of the counters placed at the vertical planes.

Selection of the dp elastic scattering events has been done by the kinematical coincidence of the scattered deuterons and recoil protons [10].

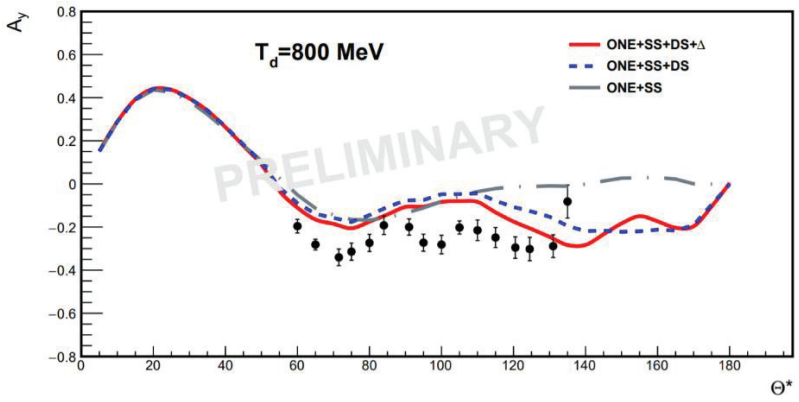
RESULTS OF THE MEASUREMENTS

The angular dependencies of the vector A_y and tensor A_{yy}, A_{xx} analyzing powers in dp elastic scattering at the energy of 800 MeV are presented at Fig. 1. The results obtained at ITS at Nuclotron at the CH_2 target denoted by the full symbols. They are compared with the theoretical calculations performed within the relativistic multiple scattering expansion formalism. The dot-dashed (gray) curve represents the results of those calculations which takes into account one-nucleon exchange (ONE) and single scattering (SS) term. The calculation, witch obtain a double scattering is given by the dashed (blue) curve [11]. The red curve corresponds the calculation with Δ-isobar excitation included [12].

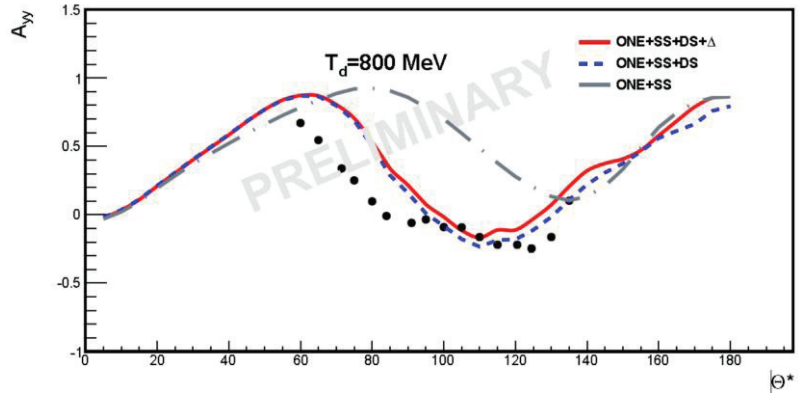
It can be seen in (Fig. 1a) that the vector analyzing power has negative values at all angles and none of the models reproduce the behavior of the A_y quantitatively. This can be associated with insufficiently accurate inclusion of 3NF into the calculations. The tensor analyzing power A_{yy} in dp - elastic scattering (Fig. 2b) has large values at small angles in the center-of-mass system (> 80°). The tensor analyzing power A_{xx} has large negative values at angles up to 75° (Fig. 1c).

It is shown that the model which includes only one-nucleon exchange and single scattering is suitable for describing the behavior of tensor analyzing power A_{xx} at all angular range but does not repeat the behavior of Ay and A_{yy}. Inclusions in the theory of double scattering and Δ-isobars improve the description of A_{yy} experimental data obtained at central scattering angles.

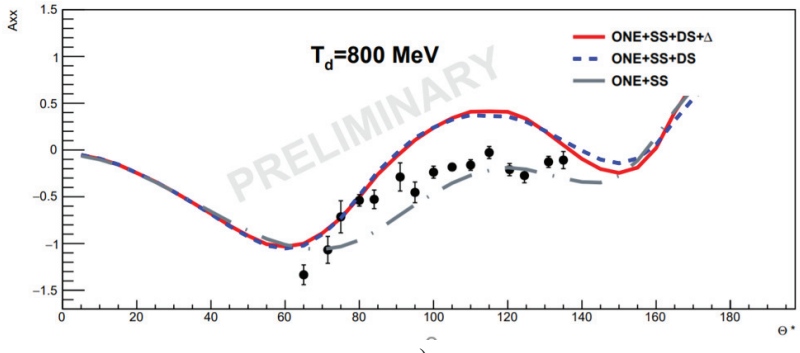
In the next step, the angular dependences of the vector and tensor analyzing powers will be obtained for the deuteron-hydrogen reaction. The graphical cuts on the correlation of the energy losses for deuteron and proton obtained at CH_2 target (Fig.2a) and the projection at the X – axis (Fig.2b) have been done. The same cuts were applied to the Carbon spectra. After that, the C_{12} normalization coefficient will be obtained by using the least square method. Then the procedure of CH_2 – C subtraction will be performed.



a)

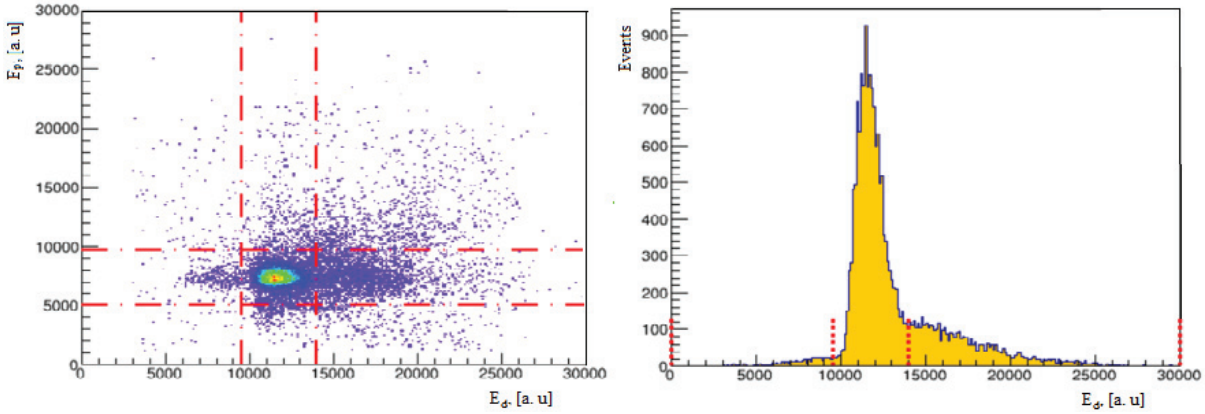


b)



c)

FIGURE 1. Angular dependencies of the vector A_y (a) and tensor A_{yy} (b), A_{xx} (c) analyzing powers for the dp elastic scattering at 800 MeV. The curves are described in the text.



a) b)

FIGURE 2. The procedure of CH_2 – C subtraction. a) The correlation of the energy losses in plastic scintillators for proton and deuteron (ADC spectra). The solid lines represent a graphical cut for the selection of dp-elastic scattering events; b) The projection of ADC spectra at the X – axis.

CONCLUSIONS

The vector A_y and tensor A_{yy}, A_{xx} analyzing powers for the dp elastic scattering have been measured for the first time on Internal Target Station of the JINR Nuclotron at the energy of 800 MeV and in the angular range from 60◦ to 135◦ in the center-of-mass system. The obtained data are compared with theoretical predictions obtained using relativistic multiple scattering model.

Some deficiencies in the description of the analyzing powers at the energy of 800 MeV require the consideration of additional mechanisms, for instance, 3NFs. Since present 3NFs models cannot improve the agreement with the data obtained at this energies, new models of 3NF's should be considered.

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