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MEASUREMENT OF THE ASYMMETRY OF QUASI-ELASTIC SCATTERING OF POLARIZED 635 ± 12 MEV PROTONS BY ^{6}Li NUCLEI

Надеждин В.С., Петров Н.И., Сатаров В.И. **E1 - 7559**

Измерение асимметрии квазиупругого рассеяния поляризованных протонов с энергией 635±12 МэВ ядрами лития-6

Измерена асимметрия квазиупругого рассеяния поляризованных протонов с энергией 635±12 МэВ ядрами Li^6 для несимметричной компланарной геометрии, соответствующей углу рассеяния $\theta = 57^\circ$ в системе центра масс падающего и ядерного нуклонов.

При импульсах остаточного ядра, не равных нулю, измеренные величины асимметрии квазиупругого рассеяния отличаются от величины асимметрии свободного pp-рассеяния.

Сообщение Объединенного института ядерных исследований
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Nadejdin V.S., Petrov N.I., Satarov V.I. **E1 - 7559**

Measurement of the Asymmetry of Quasi-Elastic Scattering of Polarized 635 ±12 MeV Protons by Li^6 Nuclei

The asymmetry of quasi-elastic scattering of polarized 635 ± 12 MeV protons scattered by Li^6 nuclei has been measured for the nonsymmetric complanar geometry corresponding to the scattering angle $\theta = 57^\circ$ (c.m.s.) of the incident and nuclear nucleons.

With residual nuclear nonzero momenta the measured values of the asymmetry of quasi-elastic scattering differ from that of the free pp scattering asymmetry.

Communications of the Joint Institute for Nuclear Research.
Dubna, 1973

I. Introduction

The method of the distorted wave impulse approximation which is a basis for theoretical interpretation of direct nuclear reactions at intermediate energies gives only semi-quantitative description of data on the differential cross sections of quasi-elastic proton scattering by nuclear protons [1,2]. The insufficient knowledge of the mechanism of the (p,2p) process does not allow one to make the method more accurate yet in order to achieve good quantitative agreement of theoretical predictions with experimental results. Therefore, to obtain new experimental information sensitive to the (p,2p) reaction mechanism is very important.

It is considered that the study of polarization effects [3,4] may give necessary information including data on the spins of the excited states of residual nuclei.

However, these effects for the (p,2p) reaction have not been, in fact, studied. Only some papers * have been published describing measurements of quasi-elastic scattering of polarized protons for the nonsymmetric geometry corresponding to the zero momentum of the residual nuclei. These experiments made it possible to find out that within errors the measured asymmetry values close to with the corresponding value of free pp -scattering.

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* See, e.g., ref. [5].

In order to continue the series of studies [5] at the end of 1972 the authors of the present paper began measuring the dependence of the asymmetry quasi-elastic polarized proton scattering by light nuclei upon the momentum of residual nuclei for the complanar, non-symmetric experimental geometry.

Below are described preliminary data for ^{6}Li nuclei obtained in the first series of runs.

II. Experimental Conditions

The asymmetry was measured by using the coincidence conjugated telescopes which detected both the protons. Each telescope consisted of four scintillation counters. The first three counters were switched in coincidence and the fourth one was switched in anti-coincidence. The energy range of detected protons was chosen by means of copper moderators placed between the second and the third scintillation counters as well as between the third and the fourth ones of each telescopes. The angles at which the telescopes were placed were taken so that the momentum transferred to the residual nucleus was parallel or antiparallel to the polarized beam direction. The scattering angle in c.m.s. of the incident and travelling nuclear protons was 57° in all cases.

The target was 2.0 g/cm^{2} thick and contained 90% of ^{6}Li isotopes. The full 635 ± 12 MeV polarized proton beam incident on the target was 5.10^{6} particles/sec. The proton polarization of the beam was 42.5%. The beam was polarized by scattering the internal beam on a ^{9}Be target to the left.

Due to the large energy spread of protons in the incident beam it was impossible to separate the ground and the excited ($E_s = 18$ MeV) states of the ^{5}He residual nucleus. But in our series of runs the contribution of incident proton scattering by nucleons of the S -shell

of the ^{6}Li nucleus was reduced by a selection of moderators.

The apparatus resolution on the residual nuclear momentum was on average $P_r = \pm 30$ MeV/c.

III. Experimental Results

For each momentum value of the residual nucleus the asymmetry was determined by means of the measured reaction yields for the "left-hand" and "right-hand" positions of conjugated telescopes. In order to check the apparatus for the false asymmetry the asymmetry of polarized proton scattering by hydrogen was measured at an angle of 90° in the centre-of-mass system. The asymmetry in this case was found to be $a(90^{\circ}) = -0.018 \pm \pm 0.015$, i.e. close to zero.

The random coincidence background between the telescope did not exceed 5% and 20% from the coincidence counts for the telescope positions corresponding to the direction of the residual nucleus momenta along the beam and against it. The measured asymmetry dependence is shown in Fig. 1. The absciss is the projection of the momentum P_r of residual nuclei. The ordinate is the measured asymmetry in per cent. The triangle in this figure is the measured asymmetry for free pp -scattering with the same scattering angle in c.m.s.

As is seen from Fig. 1, with the zero momentum of the residual nucleus the measured asymmetry remains the same as in ref. [5] and it coincides within errors with the measured asymmetry for free pp -scattering. But with the momentum deviation by ± 50 MeV/c from zero the asymmetry varies greatly. It increases with positive momentum projections and decreases with negative ones. The observed asymmetry dependence upon the residual nuclear momentum is difficult to explain by

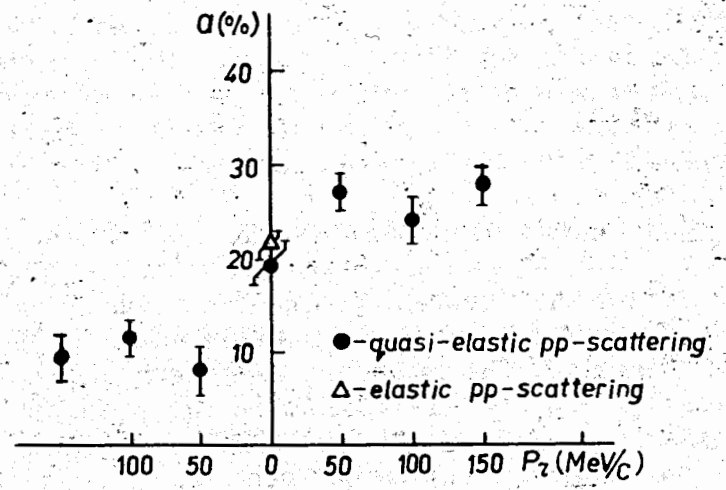

Fig.1. The asymmetry of quasi-elastic scattering of polarized protons on the ^6Li nucleus.

measurement errors since for positive and negative projections of the momentum the deviations from asymmetry for the zero momentum of the residual nucleus are of systematic nature. For positive projections all the measured asymmetry values are larger, and for negative projections are smaller than those for the zero momentum. It is evident that with a more accurate resolution on the residual nuclear momentum we could observe a still greater change of asymmetry values in the momentum range from zero to 50 MeV/c.

Thus, the experiment made it possible to establish that the asymmetry of quasi-elastic scattering of polarized protons by ^6Li nuclei with the nonzero residual nuclear momenta differs essentially from that of free pp -scattering. This difference demonstrates the effect of nuclear structure upon the quasi-elastic proton scattering by nuclei. This means that when studying polarization effects it is possible to obtain new experimental information on the mechanism of direct nuclear reactions.

In particular, it follows from the obtained results that the polar diagram is not applicable for describing the quasi-elastic proton scattering by nuclei even in the region of low momenta transferred to the residual nucleus.

Recently Dr. Th.Maris proposed at the Vth International Conference on High Energy Physics held in Uppsala (1973) to perform an experiment on quasi-elastic scattering of polarized protons in the asymmetric geometry in order to establish the character of spin-orbital coupling of nuclear nucleons. He indicated in his report that if the momenta of the residual nucleus were fixed in the plane of quasi-elastic scattering, then due to the combined effect of the spin-orbital coupling and the nuclear absorption a situation arises identical to the appearance of the effective nucleon polarization of the nucleus-target in the direction perpendicular to the scattering plane. This effective polarization of the target results in the appearance of the additional asymmetry which causes the dif-

ference of the measured asymmetry values from that for free pp -scattering with nonzero momentum of the residual nucleus.

In our case the additional asymmetry arises due to the effective $P_{3/2}$ proton polarization of the ^6Li nucleus.

The general pattern of the asymmetry dependence upon the momentum projection of the residual nucleus measured in our experiment is in agreement with the evaluations of the differential cross sections of quasi-elastic scattering of the totally polarized 215 MeV protons by protons of the $P_{3/2}$ shell of the ^{16}O nucleus which have been given in Dr. Th.Maris's talk.

The experiment is till under way.

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