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ENERGY DEPENDENCE OF NEUTRON POLARIZATION IN THE REACTION D(d, n)He^3

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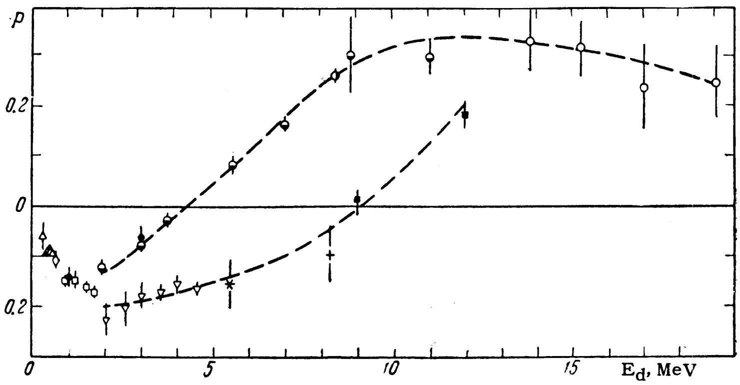
The polarization of neutrons from the D(d, n)He^3 reaction is measured for an emission angle of 40°(l. s.). The deuteron energy is 3 MeV. The results obtained are in good agreement with the data of Dubbledam and Walter[1] and do not confirm the experimental results of Baicker and Jones[5].

NEUTRONS obtained from a nuclear reaction are usually polarized. The degree of polarization depends on the type of reaction, the bombarding particle energy, and the emission angle of the neutrons from the source. The reaction D(d, n)He^3 is very widely used, so that its properties have been thoroughly studied both experimentally and theoretically. Several experimental studies of the polarization of neutrons obtained from this reaction have been reported. The studies cover an incident deuteron energy range from a few hundred keV up to 15-20 MeV. While the general features of the dependence of the neutron polarization on the energy of the incident deuterons are clear in the low energy region (below 2 MeV), at higher energies the data in the literature do not agree as to the nature of the energy dependence. Above 2 MeV the experimental data are grouped into two distinct sets showing two different energy dependences. According to one set of data[1-3], the polarization decreases markedly with increasing deuteron energy above 2 MeV, changes sign near 4 MeV, and reaches 30-35% at about 10 MeV. According to the other set[4-7], the neutron polarization remains negative up to 9 MeV. Such large discrepancies are hard to explain, since the results of several independent investigations are included in each set of data: the second set of investigations[4-7] were carried out by various techniques, and the first set[1-3] utilized a more refined method of polarization study which excluded spurious asymmetry due to the experimental geometry, by means of a solenoid to rotate the neutron polarization vector. In all the experiments cited, He^4 was used as an analyzer. Minor differences in the angle of emission of the neutrons from the source also cannot explain the observed discrepancies.

In the present investigation we have measured the polarization of neutrons produced in the D(d, n) He^3 reaction at a laboratory angle of 40°. 2.97-MeV deuterons from a Van de Graaff generator bombarded a thick deuterium target. Neutrons emitted from the target at 40° were scattered in a helium analyzer. The center of the helium scatterer was 150 cm from the deuterium target. The angle subtended by the scatterer was approximately 3°. Instead of counting the neutrons scattered by the helium, we counted the helium recoil nuclei corresponding to these neutrons. The scatterer-detector consisted of five parallel-connected, angle-sensitive counters filled with He^4 gas at 1 atm. The helium recoil nucleus counting rate was measured at laboratory angles of ± 22.5°, corresponding to center-of-mass neutron scattering angles of ± 135°. Operation of the detector-analyzer was checked on polarized and unpolarized neutrons. Movement of the detector from one azimuth angle to the other was accomplished remotely. The neutron background was measured by placing in the path of the neutron beam a paraffin absorber which reduced the direct neutron flux by approximately two orders of magnitude. Insertion and removal of this absorber was also done remotely.

In the experiment, pulses were selected whose height was at least 80% of the height corresponding to the maximum range of the helium recoil nuclei at an angle of 22.5°. This criterion resulted in selection of pulses from tracks approximately parallel to the counter axis. The neutron scattering angles corresponding to the recoil nuclei tracks were defined by the orientation of the recoil tracks. To correct for the finite dimensions of the counters, the polarization function $P_2(\theta)$, representing the polarization of the neutrons by the scatterer, was calculated as a weighted mean value from the differential cross section for scattering of 5.54 MeV neutrons by helium[9]. The behavior of the polarization $P_2(\theta)$ was obtained on the basis of the theoretical dependence of neutron polarization on neutron energy[10]. The value obtained for the polarization of neutrons leaving the target at 40°



Neutron polarization in the reaction D(d, n)He^3 as a function of incident deuteron energy, according to the results of different authors: ⊖ –[1] (45° c.m.); ◑ –[2] (40° lab); o –[3] (30° lab); + –[4] (47° c.m.); ▽ –[5] (40° lab); * –[6] (40° lab); ■ –[7] (30° lab); □ –[10] (49° lab); ◇ –[12] (50° lab); △ –[13] (47° lab); ▲ –[14] (51° lab); ● – present work.

is $P_1(40°) = -0.062 \pm 0.019$ (the indicated error is statistical). The sign of the polarization corresponds to the accepted convention[11].

The figure shows the polarization value found, together with the results of other experiments. It can be seen that our result agrees well with those of Dubbledam and Walter[1], thereby lending weight to the upper curve, and differs substantially from the data of Baicker and Jones[5].

The same figure gives a value for the polarization of neutrons emitted at 49° (lab) at a deuteron energy of 1 MeV. These measurements were made with a cascade generator, using a similar technique.

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