POLARIZATION OF 6.5-MeV DEUTERONS ELASTICALLY SCATTERED ON TITANIUM, IRON, AND NICKEL

L. V. GUSTOVA, Yu. A. NEMILOV, and L. A. POBEDONOSTSEV

Submitted to JETP editor August 1, 1962

J. Exptl. Theoret. Phys. (U.S.S.R.) 44, 100-102 (January, 1963)

The angular dependence of the asymmetry of deuterons scattered on Ti, Fe, and Ni was investigated. The scattering asymmetry of all three elements was found to be practically the same. It is therefore concluded that in polarization phenomena involving 6.5-MeV deuterons, only the total number of nucleons in the nucleus is important.

THE problem of the polarization of deuterons in the elastic scattering on spin-zero nuclei has already previously been considered theoretically (see [1-3]). The azimuthal scattering asymmetry can be written in the form

$$I = I_0 (A + B\cos\varphi + C\cos^2\varphi).$$

The coefficients A, B, and C are determined by the phase shifts, and in the final analysis by the characteristics of the levels of the compound nucleus.[4-6] This formula differs from the analogous expression for nucleons by the presence of the term $C\cos^2\varphi$. To determine the ratios of the coefficients B/A and C/A it is necessary to carry out intensity measurements of the deuterons scattered not only "left" and "right" (at angles $\varphi = 0°$ and $\varphi = 180°$), but also "up" and "down" ($\varphi = 90°$ and $\varphi = 270°$). The problem of the polarization of deuterons by nuclei with non-zero spin has not yet been considered theoretically.

We have carried out experiments on the secondary scattering of deuterons. Figure 1 is a schematic diagram of the instrument. 6.5-MeV deuterons were obtained from the cyclotron of the Radium Institute.

The results of the first experiments convinced us that the neutron and gamma-ray background present a considerable obstacle in measurements of the deuteron polarization. It was observed that the chief sources of background are the collimating diaphragms of the primary beam, the Faraday cup, and also the primary-scattering target, if it is prepared from a substance with small Z (for instance, C^{12}). Because of this, the distance from the collimating diaphragms to the target, and from the target to the Faraday cup was made as large as possible; this allowed the setting up of additional screening.

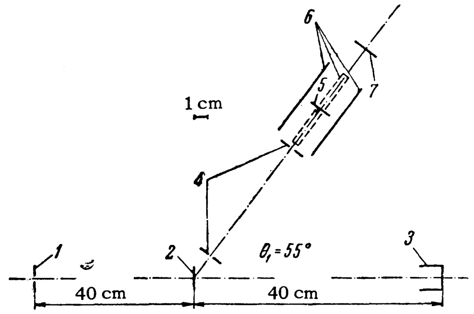

FIG. 1. Diagram of the setup: 1 – primary-beam diaphragm, 2 – primary-scattering target, 3 – Faraday cup, 4 – scattered-beam collimator, 5 – secondary-scattering target, 6 – recording films, 7 – additional film.

The angle of primary scattering in our measurements was fixed: $\theta_1 = 55°$. The angle of secondary scattering θ_2 was determined from geometrical considerations, and could vary between 27–75°. Secondary deuterons were registered by a photographic film with a 50-micron thick Ya-2 emulsion.

The secondary-scattering chamber contained a photographic film (7 on Fig. 1), on which the primary scattered beam produced a sharply defined black spot. The coincidence of the center of this spot with the geometrical center of the secondary-scattering chamber served as proof of the correct adjustment of the instrument. The intensities I(90°) and I(270°) were equal in all our measurements, and this served as additional proof of correct adjustment. An experiment was also carried out in which a 6-mg/cm² gold foil served as the second target. On account of the overwhelming role of the Coulomb scattering on gold at our deuteron energies, there should have been in this case no asymmetry in the secondary scattering; this assumption was confirmed by our results. We obtained the asymmetry in secondary scattering on

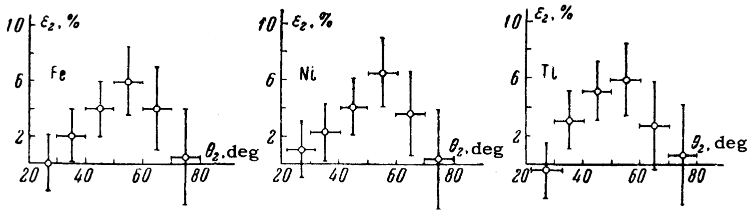

FIG. 3. Angular dependence of the asymmetry coefficient ϵ_2 for various nuclei.

titanium, iron, and nickel. In all the experiments identical targets were used for the secondary and primary scattering. All targets were about 2-mg/cm^2 thick, and consisted of a natural mixture of isotopes. Since there are no theoretical calculations for nuclei with nonzero spin, we expressed the scattering asymmetry in terms of ϵ_1 and ϵ_2 which were defined as follows:

$$\varepsilon_1 = \frac{I(0°) - I(180°)}{I(90°) + I(270°)}, \quad \varepsilon_2 = \frac{I(0°) + I(180°)}{I(90°) + I(270°)} - 1.$$

The introduction of such expressions is convenient, because in the case of scattering on nuclei with zero spin they take on a definite physical meaning: $\epsilon_2 \neq 0$ indicates the presence of "quadrupolarization," whereas when $\epsilon_2 = 0$, then $\epsilon_2 = B/A = P_1P_2$ where P_1 is the polarization of the beam in the scattering on the first target, and P_2 is the polarizing ability of the second target.

Natural iron contains 91% Fe^{56} with zero spin, and it is therefore possible to apply to it the available theoretical considerations.

The results of our measurements are shown in Figs. 2 and 3. As can be seen from a consideration of the obtained curves, almost identical dependences of the quantities ϵ_1 and ϵ_2 on the secondary-scattering angle are observed for all three elements. Such uniformity makes one think that the properties of the specific nuclei do not manifest themselves in polarization phenomena in deuteron scattering; instead there appear characteristics averaged over all nuclei with close values of Z. This appears to be natural, since in deuteron scattering the compound nucleus is relatively highly excited. For this reason it would seem that the polarization of the deuterons in the scattering should be most sensibly considered on the basis of the optical model of the nucleus.

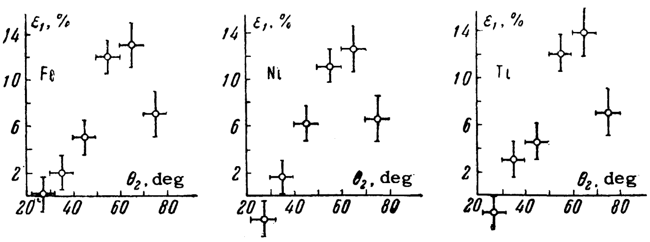

FIG. 2. Angular dependence of the asymmetry coefficient ϵ_1 for various nuclei.

[1] L. I. B. Goldfarb and I. R. Rook, Nucl. Phys. **12**, 494 (1959).

[2] R. I. N. Phillips, Proc. Phys. Soc. **75**, 317 (1960).

[3] G. R. Satchler, Nucl. Phys. **21**, 116 (1960).

[4] O. D. Cheĭshvili, JETP **30**, 1147 (1956), Soviet Phys. JETP **3**, 974 (1956).

[5] O. D. Cheĭshvili, Soobshcheniya AN Gruz SSR (Communications of the Georgian SSR Acad. Sci.) **19**, 23 (1957).

[6] L. D. Dul'kova, JETP **39**, 1008 (1960), Soviet Phys. JETP **12**, 701 (1961).

Translated by Z. Barnea
18