LETTERS TO THE EDITORS

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Evidence for the Polarization of the Protons produced in the D—D Reaction

SEVERAL authors[1,2] have measured the angular distribution of the particles produced in the D—D reaction as a function of bombarding energy in the range 100–400 keV. A theoretical fit to the observations demonstrates the possibility of a strong spin-orbit coupling in the interaction[3]. This coupling may produce polarization of the outgoing protons[4]. The polarization can be detected by observing the azimuthal angular distribution of D—D particles scattered by nuclei in a process involving spin-orbit coupling. An azimuthal anisotropy would be proof of the polarization. Such an anisotropy has been demonstrated in a double-scattering experiment for protons of 3-meV. energy scattered by helium[5]. This provides a valuable analyser for the polarized proton. It was therefore decided to use this method in the search for a polarization of the protons produced in the D—D reaction. A previous attempt to detect polarization of the neutrons by scattering on carbon was vitiated by the background of neutrons produced by scattered deuterons in the accelerator tube.

A beam of 300-kV. deuterons was collimated by two diaphragms of 5-mm. diameter on to a heavy-ice target, thus producing 10^8 protons per second. Protons escaping at an angle of 120° to the deuteron beam were allowed to go through an aluminium window 6·5 mgm./cm.^{2}, and to pass through a scattering chamber (1·2 cm. diameter) containing helium at atmospheric pressure. The scattered protons were detected with a proportional counter (diameter 2 cm., length 7 cm.), filled to a pressure of one atmosphere with argon, at a distance of 2 cm. from the axis of the scattering volume, separated by an aluminium window (2·8 mgm./cm.^{2}). Protons that had passed through an average of 4·0 cm. of helium and which were scattered through an angular range (75°–120° centre of mass) could enter the counter. At the moment of being scattered they had an energy of (2 ± 0·2) MeV. Their energy on entering the counter was 600 keV., which is more than twice the maximum energy of argon recoils from the 2·5-MeV. neutrons. The walls of the counter were lined with lead in order to avoid a background of protons due to an (n,p) reaction which a brass wall counter was found to give.

The whole arrangement of scattering volume and counter could be rotated around the axis of the scattering chamber.

The centre of the scattering volume was 7·5 cm. from the target, which was aligned at 60° to the deuteron beam. The copper target was cooled with liquid air, and heavy ice was formed on it continuously. The size of the copper target was such that displacements of the incident deuteron beam could not cause serious asymmetries in the intensity of the proton beam in the scattering chamber. The measurements were monitored with a neutron recoil counter (filled with methane at 20 atmospheres pressure). The ratio of the intensity of scattered protons to neutron monitor counts was found to be constant within the statistical accuracy of 5 per cent, for any one orientation of the scattering chamber. The proton counting-rate was measured forward and backward in the plane of incident deuteron and emitted proton beams, and in the two positions normal to this plane. The rates observed were:

Forward	1·80 ± 0·07
Backward	2·97 ± 0·11
Normal positions	2·30 ± 0·08, 2·3 ± 0·09

The azimuthal distribution is of the form $\sigma(\theta,\varphi) = \sigma[1 + PA\cos\varphi)$, where φ is the angle between the normals to the scattering planes. The magnitude of A is estimated from the geometry of this experiment and an average value for the analyser efficiency[5] of 87 per cent obtained. The product PA is evaluated from the above data and equation, correcting for the range of φ accepted by the counter. The value of PA is 0·25 ± 0·05. The analyser efficiency A is 0·87 for our geometry, with an uncertainty due to the experimental errors on the data obtained for p—He scattering. Thus the polarization of the D—D protons is (30 ± 6) per cent.

The symmetry of the D—D reaction for proton and neutron emission leads one to expect a similar degree of neutron polarization. Longley, Little and Slye[6] have reported a polarization of (40 ± 20) per cent for D—D neutrons. We cannot make a comparison with our result since they do not indicate the energy of their deuteron beam.

The interest of the availability of a source of polarized neutrons and protons for the investigation of spin-orbit coupling in nuclear scattering and of the interaction of polarized particles with polarized nuclei is obvious.

We are much obliged to Dr. R. J. Blin-Stoyle for suggesting this experiment to us, and for many stimulating discussions. We thank Lord Cherwell for his continued interest. One of us is indebted to Imperial Chemical Industries, Ltd., for a research fellowship, and another to the Department of Scientific and Industrial Research for a maintenance grant.

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Oxford. June 23.

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Weak Echoes from the Ionosphere with Radio Waves of Frequency 1·42 Mc./s.

IT is well known that medium-frequency radio waves (0·5–1·5 Mc./s.) are often very highly absorbed in their passage through the lower ionosphere, so that the amplitude of the echo may fall below the limit of detectability of the usual ionospheric recording equipment. The occasions of greatest absorption occur in the day-time in summer, on certain days of abnormally great absorption in winter and for short intervals during radio fade-outs.

By the use of a new method, we have been able to improve the sensitivity very considerably and have been able to make measurements throughout days of high absorption in winter on a frequency of 1·42 Mc./s. It is the purpose of this communication

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