terms of the energy loss of photons in the Sun's gravitational field (McCrea 1954; Papapetrou 1956), the above effect cannot be explained in these terms.

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ANGULAR DISTRIBUTION OF α-PARTICLES FROM ^{7}Li(d,α)^{5}He†

By A. C. RIVIERE‡ and P. B. TREACY‡

Introduction

The deuteron bombardment of ^{7}Li can result in the production of two α-particles and a neutron by one of the following processes:

$$\begin{aligned} {}^7\mathrm{Li}+{}^2\mathrm{H}\rightarrow{}^9\mathrm{Be}^*&\rightarrow{}^4\mathrm{He}+{}^5\mathrm{He},\quad {}^5\mathrm{He}\rightarrow n+{}^4\mathrm{He} && (a)\\ &\rightarrow n+{}^8\mathrm{Be},\quad {}^8\mathrm{Be}\rightarrow{}^4\mathrm{He}+{}^4\mathrm{He} && (b)\\ &\rightarrow n+{}^4\mathrm{He}+{}^4\mathrm{He} && (c). \end{aligned}$$

It is possible to distinguish between (*a*) and (*b*) by means of groups present in the spectrum of particle energies. A mono-energetic α-particle group has been observed (Ajzenberg and Lauritsen 1955), which can only be due to a two-body break up of ^{9}Be leaving ^{5}He in the ground state. Two neutron groups have been observed (Ajzenberg and Lauritsen 1955), corresponding to the formation of ^{8}Be in the ground and first excited states. No substantial evidence exists for reaction (*c*).

The angular distribution of the mono-energetic group in the α-particle energy spectrum with respect to the deuteron beam has been measured previously (Treacy 1951) at a bombarding energy of 900 keV and found to be isotropic to within an experimental error of 10 per cent. Using this information, the calculations in a recent study (Riviere 1956) of reaction (*a*) at the same

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deuteron energy were made on the assumption that deuterons of zero angular momentum only were involved.

The purpose of the present experiment was to obtain a more accurate measurement of the angular distribution of the α-particle group with respect to the beam. It was hoped that by studying emission at small angles to the beam some evidence might be found for the presence of small peaks in the angular distribution which would indicate direct "knock-on" effects in the reaction mechanism.

Experimental Method

To obtain the angular distribution of the group, the energy spectrum of the α-particles emitted over a small solid angle from the target was observed at various angles with respect to the beam.

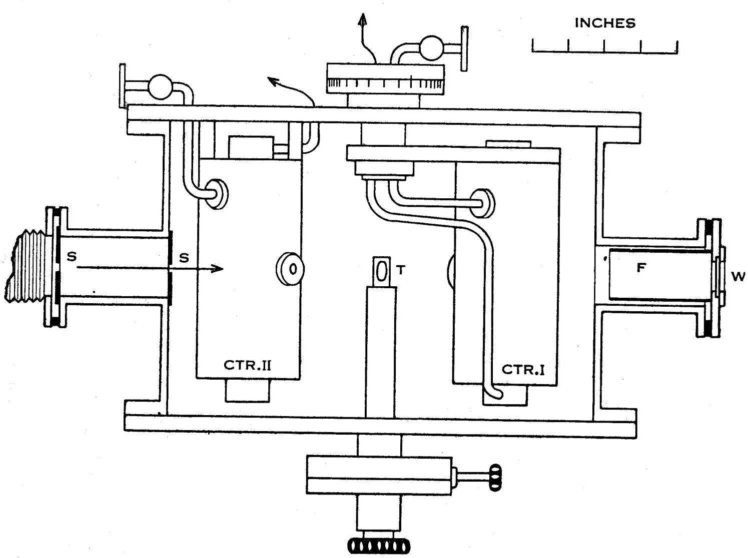

Fig. 1.—A schematic drawing of the experimental equipment.

A schematic drawing of the equipment used is shown in Figure 1. Two similar proportional counters are mounted inside a large cylindrical evacuated chamber which has the target (*T*) at its centre. One counter (*Ctr. I*) can be set so as to observe particles emitted at any angle between 0 and 148° to the beam with an angular resolution of 0·5° included, and the other (*Ctr. II*) is of similar aperture and fixed so as to observe particles emitted at 150° to the beam. Each counter consists of a vertical cylindrical cathode 3 in. in diameter with a 0·005 in. diameter tungsten wire supported axially as the anode. Particles enter the counters through thin aluminium windows equivalent to 4·0 cm of air. The window apertures each subtend a solid angle of 0·0055 steradian at the centre of the target and are tapered at an angle of 10° to reduce small-angle scattering of the accepted particles. The windows are also arranged so that the anode wire cannot be seen from any part of the target; the axis of a ray drawn from the centre of the target through the centre of the window passes the anode wire at a distance of 0·375 in. The gas filling consists of a mixture of commercially pure argon with an addition of 3 per cent. nitrogen to stabilize the gas gain.

The pulses from each counter are amplified by standard linear amplifiers. The output pulses from the counter II amplifier are increased in height by the addition of a fixed pedestal voltage which is greater than the maximum pulse size to be expected from the counter I amplifier. The two sets of pulses are then mixed and the whole recorded by a pulse height analyser. If two particles are detected simultaneously, one in each counter, then only the larger pulse to reach the mixing unit will be recorded. This pulse will in all cases be the one with pedestal from the counter II amplifier. With the counting rates used in this experiment no significant error is introduced by this preference.

The mono-energetic α-particle group from the reaction ^{7}Li(p,α)^{4}He was observed and the width at half height of this group as recorded on the analyser was equivalent to three channels, corresponding to a resolution of about 10 per cent. at the peak.

The target was made by the electro-deposition of a thin layer of metallic ^{7}Li from a solution of the metal chloride in pyridine and the metal was then allowed to oxidize in the air. The target backing consisted of nickel foil equivalent to 2 mm of air, and the layer of lithium was deposited over a circle 0·5 in. in diameter. The orientation of the target with respect to the beam was always such that α-particles detected in the counters were emitted at an angle which was less than 55° to the normal to the plane of the foil. The target holder could be rotated about a vertical axis. Provision was made for its withdrawal from the chamber without breaking the vacuum by means of the valve shown schematically in Figure 1. Changes of target thickness consequent on rotation were automatically compensated by always using counter II as a monitor.

The 900 keV deuteron beam was defined by two 0·25 in. diameter apertures (S) before entering the chamber and these apertures ensured that the beam struck the centre of the target. The two apertures, the target, and the window on counter I were visually aligned to determine the zero error of the graduated scale used to set the position of counter I. The beam was trapped by the Faraday cage (F) insulated from the chamber so that the target current could be recorded. The quartz window (W) allowed the direct beam to be seen when the target was lowered and hence permitted visual alignment of the beam.

Experimental Results

Three series of measurements were made, in each of which the α-particle energy spectra were recorded at eleven angles from 0 to 148°. A typical spectrum is shown in Figure 2. Curve A is that part due to the detection of particles in counter I and curve B is due to counter II. A pedestal equivalent to 40 channels has been added to all pulses contributing to curve B.

In a particular run an average curve B was selected and all others compared to it since they were of the same shape. Each curve A was different for each angle θ, since the centre-of-mass motion produces a different observed energy for the group depending on the value of θ. The following method was used to analyse the *A* curves. The extrapolated end point *a* and the centre of the peak *b* were determined. The distance *X* from the point *a* to the ordinate at *b* was

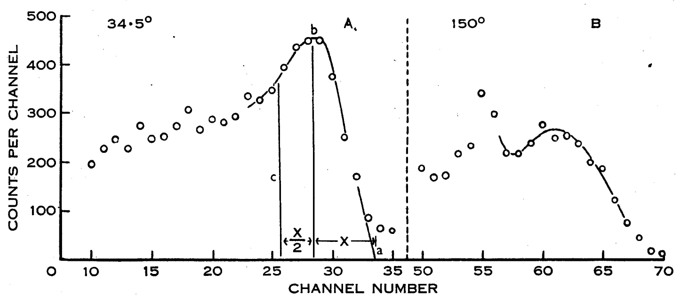

Fig. 2.—A typical pulse height analyser spectrum taken for θ=34·5°. Curve *A* and curve *B* are due to the detection of particles in counters I and II respectively. All pulses from counter II are increased by a pedestal equivalent to 40 channels.

measured and an ordinate *c* drawn at a distance $3X/2$ from *a*. The sum of the numbers of counts in the channels lying between *a* and *c* was then used as a measure of the ^{5}He peak. This value was normalized using the ratio of the height of the corresponding curve *B* to the chosen standard curve *B* for the run.

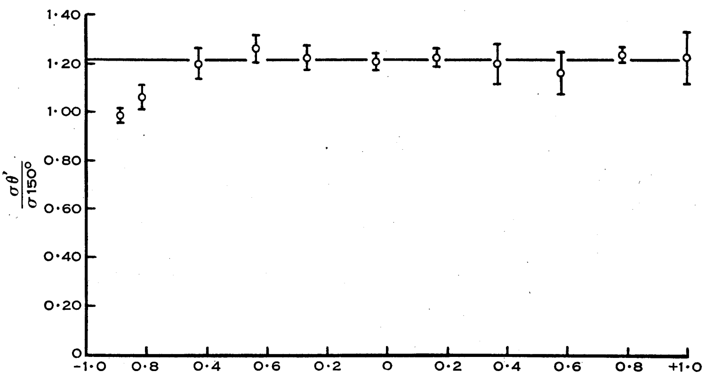

Fig. 3.—The experimental results obtained from three series of measurements. Here θ′ is the angle of emission in the centre-of-mass system, and the results are corrected for centre-of-mass motion.

The resulting numbers were then normalized so that the mean of all runs for the angle θ=150° was unity; here 148° was assumed as being sufficiently close to 150° to normalize to the 148° measurement.

The means of all three series of measurements were corrected for centre-of-mass motion effects, and the results are presented in Figure 3 where θ′ is the angle between the emitted particle and the beam in the system with the centre-of-mass at rest. A straight line has been drawn on Figure 3 to represent an isotropic distribution. The points obtained at the largest angles are seen to lie well below the line. These two spectra were recorded for an increased gain in the counter I amplifier to spread the counts over a larger number of channels, and this may have introduced an error.

We conclude that the angular distribution of the α-particles contributing to the formation of the ground state of ^{5}He in reaction (*a*) is isotropic at a deuteron energy of 900 keV to within an experimental error of 2 per cent. There is no evidence for a "knock-on" reaction to within this accuracy. The most simple explanation of the result is that primarily *s*-wave deuterons are responsible for the reaction. The necessary spin assignments under this assumption are discussed by Riviere (1956).

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SOLUTION OF FLOW PROBLEMS IN UNIDIMENSIONAL LAGRANGIAN HYDROMAGNETICS*

By R. E. LOUGHHEAD†

Introduction

A problem of considerable interest in many branches of astrophysics is that of the subsequent behaviour of a current which at an initial time $t=0$ is largely concentrated within a given region of an ionized gas of infinite extent. In particular, it has been suggested by Alfvén (1950) that a high current discharge in an ionized gas is likely to constrict because of the electromagnetic attraction between parallel currents and that this constriction effect may be involved in the formation of solar prominences. Similar considerations may also be of importance in studies of magnetic fields in the spiral arms of the Galaxy.

The solution of an initial value problem of this type is greatly complicated by the non-linear character of the hydromagnetic equations governing the motion of the ionized gas. However, in the simple case of the unidimensional motion of an ionized gas in which the magnetic field is everywhere at right angles to the direction of motion of the fluid, a numerical solution can be carried through using a finite difference scheme along the lines proposed by the author

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