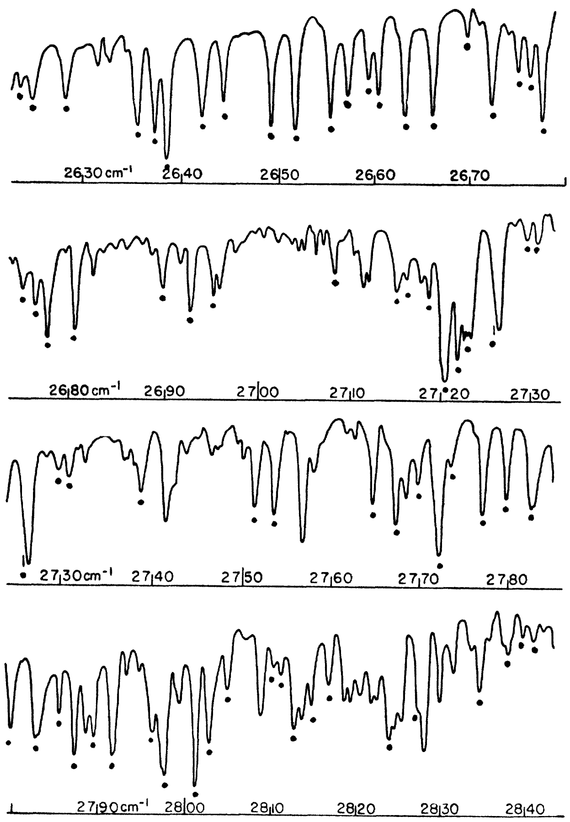

FIG. 1. Some lines of HDO in the solar spectrum near 3.7μ.

For a more thorough investigation of the HDO laboratory spectrum, it is planned to use an absorption cell of the multiple-reflection type with a path length of at least four meters. By using such a long path length, the ratio of D_2O to HDO can be reduced considerably without lessening the intensity of the HDO absorption.

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Neutrons from the Bombardment of Li^6 by Deuterons*

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WHEN lithium enriched in the mass six isotope became available through the AEC, it was felt worth while to examine the neutrons from the following reactions:

$$Li^6+H^2\rightarrow Be^7+n^1+3.30\text{ Mev} \quad (1)$$

$$Li^6+H^2\rightarrow He^4+He^3+n^1+1.68\text{ Mev.} \quad (2)$$

The yield curve for neutrons from these reactions has already been reported.[1]

In the present experiments the neutron energy spectrum has been analyzed from cloud-chamber photographs of recoil protons in the direction of the deuteron beam. A target of $Li_2{}^6SO_4$, 375 μg per cm^2 (about 150 kev at the bombarding energy used) was irradiated with 595-kev deuterons from the Rice Institute Van de Graaff generator. The low bombarding energy was chosen to minimize the neutrons from deuteron bombardment of carbon contamination on the target and on the tube wall in the analyzing magnet.

The neutron energy was determined from the range of the recoil protons in a Wilson cloud chamber filled with CH_4 and C_2H_5OH at 2 atmos. pressure. The cloud chamber was 17 cm from the target in the direction of the deuteron beam, the sensitive volume subtending a maximum angle of 16° at the target. Only tracks within 10° of the direction of the incident neutrons were accepted. Tracks shorter than 8 mm (corresponding to a 1-Mev recoil) were not counted because of the difficulty of determining their direction.

From some 6000 photographs, 1100 acceptable tracks were found. The number of tracks lying within 250-kev intervals are plotted in the histogram of Fig. 1. The curve in Fig. 1 gives the relative neutron spectrum and was obtained from the histogram by dividing by the neutron-proton scattering cross section.[2]

To extend the energy measurements to lower values, the chamber was filled with H_2 and C_2H_5OH at 2 atmos. These tracks were not so sharp as before, and only tracks longer than 1.3 cm (500 kev) were counted. With the same geometry as before, 160 tracks were measured for neutron energies below 1500 kev. The energy distribution, corrected for cross section and fitted to the higher energy spectrum, is shown by the open circles in Fig. 1.

In order to determine whether or not the 435-kev state of Be^7 reported by Brown, Chao, Fowler, and Lauritsen[3] appears in this reaction, the tracks corresponding to neutrons in the 3- to 4-Mev energy range have been analyzed in smaller energy intervals. The number of tracks in 100-kev intervals is shown in Fig. 2. The asymmetric shape of the spectrum and the one high point at 3.35 Mev (400 kev below the energy of neutrons from the formation of Be^7 in the ground state) may be interpreted as an indication that this 435-kev state in Be^7 is formed in this reaction. Although it is not definite from Fig. 2 that this excited state does appear in this reaction, one might conclude that if it is formed, only about 30 percent or less of the disintegrations result in the excited state.

Using the peak of the curve at 3.75 Mev in Fig. 2, as the energy of the neutrons from the formation of Be^7 in the ground state, the Q-value calculated for the reaction is 3.27 Mev.

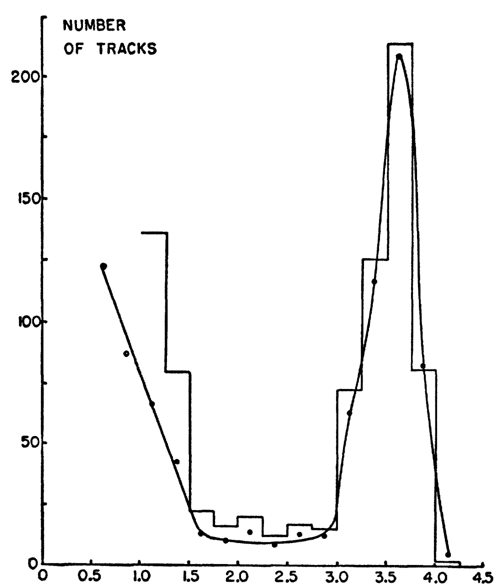

FIG. 1. Number of recoil tracks in 250-kev intervals. Smooth curve has been corrected for $n-p$ scattering cross section. Solid circles refer to data in CH_4 and open circles to data in H_2. Point at 1.12 Mev is common to both sets of data.

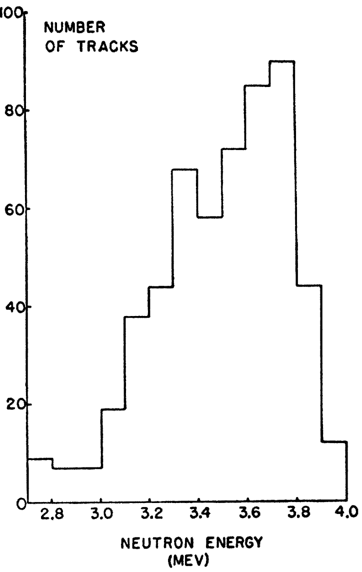

FIG. 2. Number of recoils in 100-kev intervals.

The neutrons below 1.5 Mev show a continuous distribution in energy and so may be attributed to reaction (2). Although the shape of the curve was not determined below 0.5 Mev, it appears that somewhat fewer than one-half of the neutrons come from reaction (1), if the angular distributions of the competing reactions are the same.

Mandeville, Swann, and Snowdon[4] have determined the neutron energy spectrum for these two reactions by measuring the recoil proton tracks in photographic emulsions. They used a bombarding energy of 900 kev and measured the neutrons emitted at an angle of 90° to the deuteron beam. Their data indicate that about two-thirds of the neutrons come from reaction (1), if the angular distributions of both reactions are assumed to be the same. These two experiments together indicate that either the angular distributions of the neutrons from the two reactions are not the same or that the relative yields of the reactions change with the bombarding energy.

* This work was supported by the Research Corporation and by the Joint Program of the ONR and AEC.
† AEC fellow.

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Neutron Groups from the Reaction $Li^7(p, n)Be^7$

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RECENT reports[1–4] indicate the existence of at least one excited state in Be^7 within 1 Mev of the ground state. Therefore, the reaction $Li^7(p, n)Be^7$ should give rise to at least two groups of neutrons of different energies depending upon whether the reaction leads to Be^7 in the ground state or in an excited state.

Photographic plates (Ilford C2 emulsions 50μ thick) have been exposed to neutrons produced in this reaction by protons with energies of 2.705 and 3.120 Mev from the Argonne electrostatic accelerator. By studying the recoil protons in the emulsions the energies of the neutrons can be found. The photographic plates were mounted at 0° to the proton beam and 10 cm from the 10-kev thick metallic lithium target.

After processing the plates, the tracks were measured in a microscope with an oil immersion objective. Tracks were considered to be acceptable for measurement if they showed no detectable dip into the emulsion and if they deviated from the incident neutron direction by an angle less than arctan $\frac{1}{5}$. This procedure leads to a larger acceptable range of solid angles for the short tracks than for the long tracks. This will accentuate the intensity of a group of neutrons arising from an excited state relative to the group arising from transitions leading to the ground state of Be^7.

The energies of the recoil protons were determined from their ranges by using the Ilford range-energy curves.[5] The neutron energy is found from the recoil proton energy E_p by the use of the relation $E_n = E_p/\cos^2\theta$ where θ is the angle between the incident neutron direction and the recoil proton.

Figure 1 shows a histogram of the number of neutrons in a 25-kev range for each of the incident proton energies. The letter A locates the center of gravity of the main group of neutrons and B the center of gravity of a clearly resolved group arising from an excited state in Be^7. The centers of gravity were found by first subtracting a constant background of two tracks from each block in the histogram and then locating the center of gravity in the usual fashion. For the 2.705-Mev data A is found to be at 937 kev and B at 472 kev. For the 3.120-Mev data, A is at 1364 kev and B is at 896 kev. In the forward direction the neutrons in the main groups should have energies of 1.000 and 1.423 Mev, respectively. In each case the center of gravity of the group A is found 63 kev below its calculated position in terms of the accelerator calibration, but the energy difference between the two values of A is 427 kev which is a remarkable coincidence and indicates that the Ilford range-energy curve used is quite good. Since the value of B from the 3.120-Mev data is relatively close to that of A from the 2.705-Mev data, one would expect to find a reliable value for the separation of the B state from the ground state if the 3.120-Mev data is used. The energy difference from A to B in the 3.120-Mev data yields a value of 428±20 kev for the level separation. The 2.705-Mev data cannot be expected to yield a very reliable result since the B group now corresponds to proton recoils of approximately 5μ in length. In this region the slope of the range-energy curve is changing rapidly so relatively large errors may be expected. The A to B difference in this case yields a value of 408±35 kev for the height of the corresponding excited state of Be^7 above the ground state. The points labeled C indicate the expected location of the 205-kev group reported by Grosskreutz and Mather[1] and the point D indicates their 745-kev group. The latter group cannot be excited at 2.705 Mev bombarding proton energy.

To compare the relative intensities in the various groups, one must correct for the following: (1) different accepted solid angles for different track lengths; (2) different probability of leaving the

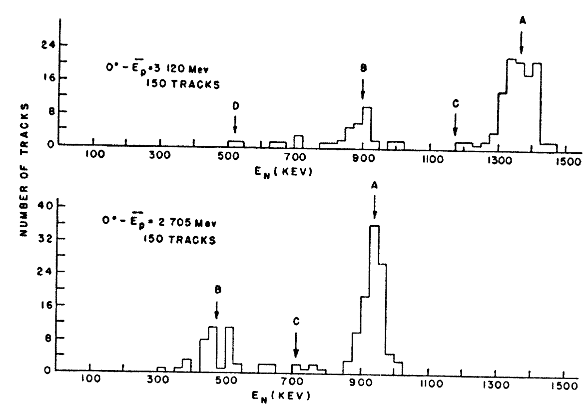

FIG. 1. Neutron groups from the reaction $Li^7(p, n)Be^7$. Note that the relative intensities of the neutron groups have not been corrected.