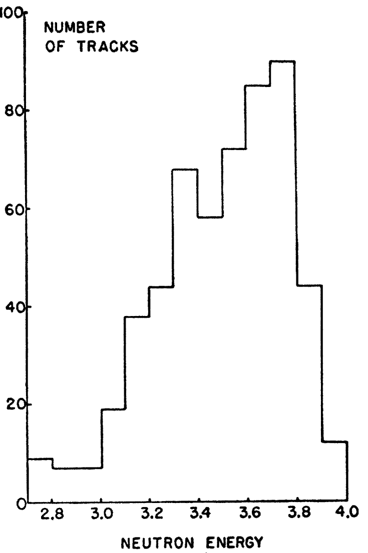

FIG. 2. Number of recoils in 100-kev intervals.

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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[2] Bailey, Bennett, Bergstralh, Nuckolls, Richards, and Williams, Phys. Rev. 70, 583 (1946).
[3] Brown, Chao, Fowler, and Lauritsen, Phys. Rev. 78, 88 (1950).
[4] Mandeville, Swann, and Snowdon, Phys. Rev. 76, 980 (1949).

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

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February 7, 1950

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

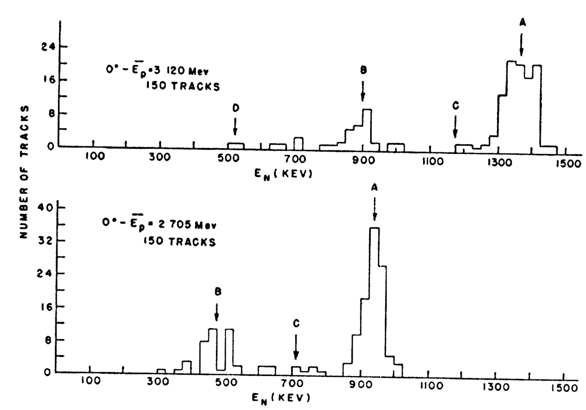

FIG. 1. Neutron groups from the reaction $Li^7(p, n)Be^7$. Note that the relative intensities of the neutron groups have not been corrected.

emulsion for different track lengths; (3) variation of (n, p) scattering cross section with energy.

Table I shows the total correction factor that must be applied

TABLE I. Correction factors for neutron groups.

Neutron group / Proton energy	Main group ground state A	205 kev C	428 kev B	745 kev D
2.705 Mev	1	0.55	0.25	—
3.120 Mev	1	0.67	0.38	0.16

to each of the groups before determining their relative intensities.

Using the correction factors of Table I the intensity of the 428-kev group relative to the main group is 0.08 ± 0.02 for both sets of data. If there is a group at D there are only two tracks in the data which could correspond to this group. The relative intensity is found to be less than one percent. It is difficult to decide whether there is a group corresponding to the points marked C. The number of tracks that can be assigned reasonably to such a group in each case is no more than could be considered to be background. In each set of data there are about six tracks that may be considered to be in such a group. The relative intensity would be five percent of the main group if all of these did arise from a level at 205 kev in each set of data.

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The $3\nu_3$-Band of Telluric CO_2 in the Solar Spectrum*

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OBSERVATION of the lines of the $3\nu_3$-band of telluric CO_2 that appear in the solar spectrum is possible only when the earth's atmosphere is very dry. Numerous strong lines of the 0 2 1, 1 0 1, 1 2 0, and 2 0 0 bands of H_2O occupy the same wave-length region. One of the results of guest investigator arrangement between the Mount Wilson and Palomar Observatories and the McMath-Hulbert Observatory, for the direct-intensity recording of the solar spectrum, is a spectrophotometric tracing made on an exceptionally dry day (December 20, 1949), at Mount Wilson, California. The weakened H_2O absorption unmasks many lines of the $3\nu_3$-band of CO_2.

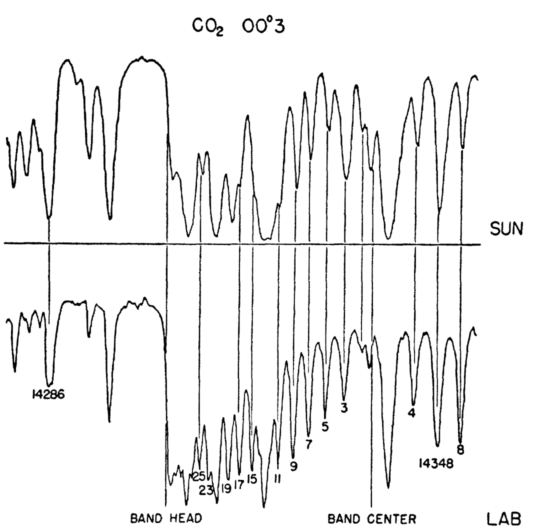

FIG. 1. The $3\nu_3$-band of CO_2 in the solar spectrum, with laboratory comparisons.

The top half of Fig. 1 is a part of this record; the bottom half is a laboratory comparison. The intensity increases upward from the straight line below each tracing. Broken lines connect corresponding features of the two tracings and indicate the positions of the band head and band center. The numbers 14,286 and 14,348 are the wave-lengths in angstroms of the absorption lines immediately above them. Beneath the CO_2 lines in the laboratory tracing are the upper quantum numbers for the lines in the short wave-length branch, and the lower quantum numbers for the lines in the long wave-length branch of the band.

14,308A(H_2O) and 14,313A(H_2O) complicate the strong CO_2 band head at 14,305A in the solar spectrum, and the line at 14,338A(H_2O) obscures the band center. On all tracings obtained up to December 20, 1949, H_2O lines completely mask the analogous isotopic ($C^{13}O_2^{16}$) band head at 14,700A.

We wish to acknowledge continued financial aid from the McGregor Fund of Detroit.

* Report on work supported in part by Contract N6onr-232-V with the ONR.

A Precise Determination of the Energy of the Cs^{137} Gamma-Radiation*

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February 16, 1950

FOR the absolute calibration of nuclear spectrometers, it has become common practice to make use of the photo-electrons ejected from a radiator or the internal conversion electrons resulting from a gamma-ray of known energy. Since the shape of photo-lines depends somewhat on the position of the source relative to the radiator and also on the thickness of the radiator, the use of an internal conversion line appears to be preferable. Although the energy of the Au^{198} gamma-ray has been measured with great precision,[1] the relatively short half-life provides a calibration source of only temporary utility. It is felt that the conversion electrons from the 0.66-Mev gamma-ray which follows the disintegration of Cs^{137} provide a much more suitable calibration standard. The 33-year half-life makes possible the preparation of an essentially permanent laboratory source of monoenergetic electrons. There is also the advantage that the conversion line lies at a higher energy and is completely separated from the main nuclear beta-spectrum. In an attempt to establish Cs^{137} as a calibration standard, the energy of the internal conversion electrons has been carefully determined by direct comparison with that of the 0.4112-Mev gamma-ray of Au^{198}.

The measurements were made with the 40-cm radius of curvature, 180 degree focusing, shaped magnetic field spectrometer.[2] A composite source of Au^{198} and Cs^{137} was prepared on a 0.00025-in. Al backing. The source was 0.25 cm wide and 2.5 cm high and was spread with the aid of insulin. An electrically grounded source of mechanical permanence was thus obtained. The scattering from the aluminum backing causes only a slight broadening of the lines and does not affect the energy determinations which are made in terms of the extrapolation of the high energy edges. The source thickness was estimated to be 0.03 mg/cm² of Au^{198} and 0.1 mg/cm² of Cs^{137}.

Figure 1 shows a typical momentum distribution curve of the electrons which are internally converted in the K shells of Hg^{198} and Ba^{137}. For these measurements, the detecting slit was 0.40 cm wide and the distance between the center of the source and the center of the slit was $2\rho=80.58$ cm. In determining the energy