(amounting to 0.2 Mev at 18.3 Mev) as an uncertainty in the location of each energy point. An additional source of error in the energy determination arises from the limited accuracy of the range measurement. This has a negligible effect on the location of the high energy points, but becomes important as the energy is reduced by interposition of foils.

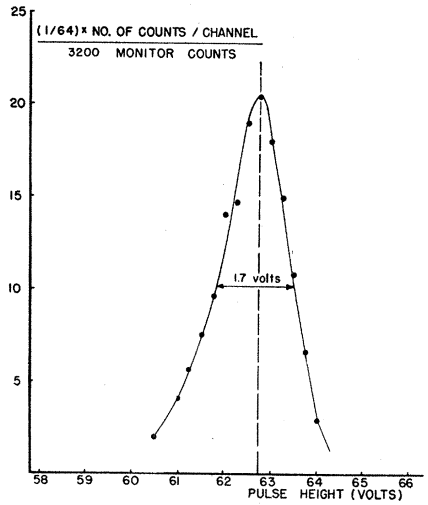

FIG. 2. Profile of pulse-height distribution obtained when a sodium iodide crystal is bombarded with 18-Mev protons scattered by a platinum foil.

Electrical pulses from the photomultiplier tube, which was operated with a battery power supply, were converted into flat-topped pulses having a duration of 1.2 μsec by means of a shorted delay line; they were then amplified with a linear amplifier and analyzed with a single channel differential discriminator having a channel width of 0.6 volt. The linearity of the system was carefully investigated, and correction was made for a small deviation from linearity observed for large output pulses.

A profile of the pulse-height distribution obtained with 18-Mev protons elastically scattered from a thin platinum foil is shown in Fig. 2. The observed distribution is slightly asymmetrical and has a width at half-maximum of 2.7 percent of the peak pulse height. If the estimated energy spread in the incident beam, the channel width of the differential discriminator, and straggling in the scattering foil and the windows are taken into account, the remaining width is approximately 2.3 percent. Our lack of exact knowledge regarding the factors that influence the shape of pulse-height distributions such as this one has been regarded as a source of uncertainty in the location of the peak pulse height for each energy point. In addition, we have regarded as a source of error a small drift (of the order of 0.2 volt) which occurred in the course of the experiment.

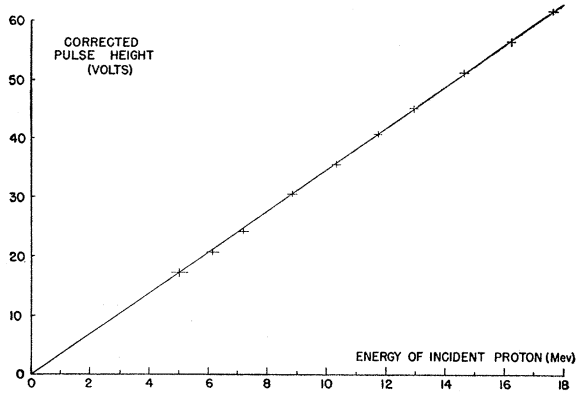

FIG. 3. Experimental relation between pulse height and proton energy in sodium iodide.

The resulting plot of pulse height as a function of energy is shown in Fig. 3. The experimental points are consistent with a straight line passing through the origin. Within an experimental uncertainty of approximately two percent, it is therefore concluded that pulse height and energy are proportional for protons on sodium iodide.

* Supported by the AEC and the Higgins Scientific Trust Fund.
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Excited States of Lithium-6 and Lithium-7†

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(Received May 14, 1952)

EXCITED states of Li^6 and Li^7 have been studied by analyzing the energy spectrum of scattered and disintegration particles emitted on proton bombardment of thin-rolled foils of natural lithium. A 13-inch diameter evacuated scattering chamber with aluminum windows at 30, 60, 90, 120, and 150 degrees to the incident beam was used, and the scattered particles were analyzed by allowing them to strike the surface of a $\frac{1}{8}$-inch thick NaI crystal, as described in the accompanying letter.[1] The bombarding energy was 18 Mev.

Scattered particles with sufficient range to penetrate 24 mg/cm^2 of aluminum were found to consist of groups of protons scattered elastically and inelastically from Li^7 and Li^6 and three groups of deuterons from the reaction $Li^7(p, d)Li^6$. Protons and deuterons were differentiated from each other by their characteristic decrease in energy on interposing thin aluminum foils in the scattered beam. Using the observed relation between particle energy and laboratory scattering angle, one can then make an unambiguous identification of the particular nuclear reaction leading to each observed particle group.

Proton energies were calculated by comparison with protons scattered elastically from platinum on the assumption that pulse height and energy are proportional for protons on NaI.[1] Q values were computed from these energies after making correction by use of Smith's data[2] for the loss of energy in windows and air path. Mass defects and relativistic change of mass with velocity were taken into account. The uncertainty in the resulting Q values as quoted below includes the uncertainty in the energy of the incident beam,[1] as well as the possible error resulting from the procedure used in locating peak pulse heights, but it does not include a

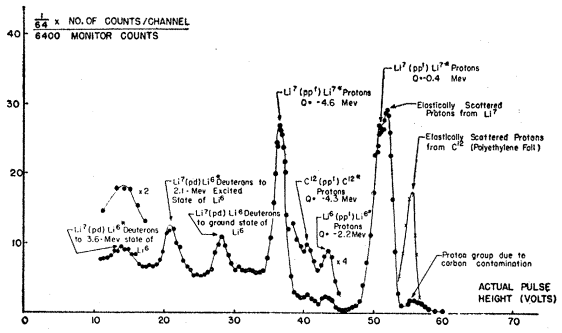

FIG. 1. Differential discriminator analysis of pulse spectrum observed at 60° in the laboratory system with a channel width of 0.6 volt. A broad group of protons is not resolved at this angle of observation from the group of deuterons which leave Li^6 in the ground state. Inelastically scattered protons leaving Li^7 in the well-known state at 0.48 Mev are not quite resolved from the elastic group, but contribute to its width.

systematic error that would be caused by a deviation from exact proportionality between pulse height and proton energy in NaI.

In the absence of a direct calibration of the response of sodium iodide to deuterons, deuteron energies were computed by using the known[3,4] Q value for the reaction $Li^7(p, d)Li^6$ leading to the ground state of Li^6 and assuming proportionality between deuteron energy and observed pulse height.

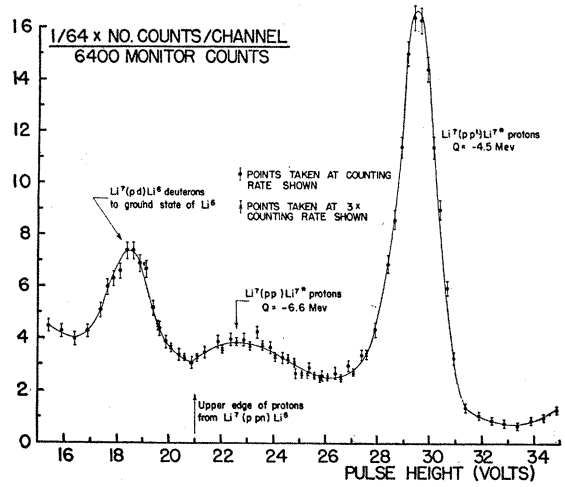

FIG. 2. Low energy portion of the spectrum observed at 90° showing the broad proton group corresponding to a 6.6-Mev state in Li^7. This group is also observed at 30°, 120°, and 150° in the laboratory system, and it appears to have a width approximately twice as large as our experimental resolution at this energy (0.3 Mev). Vertical bars indicate standard deviations of the experimental points.

The spectrum of particles observed at 60° in the laboratory system is shown in Fig. 1. Figure 2 shows part of the spectrum observed at 90°. We have also obtained a differential discriminator spectrum at 120° and oscilloscope photographs of the spectra at 30° and 150°.

Figure 3 summarizes the observed reactions between protons and Li^7. The second excited state in Li^7 is located at 4.56±0.10

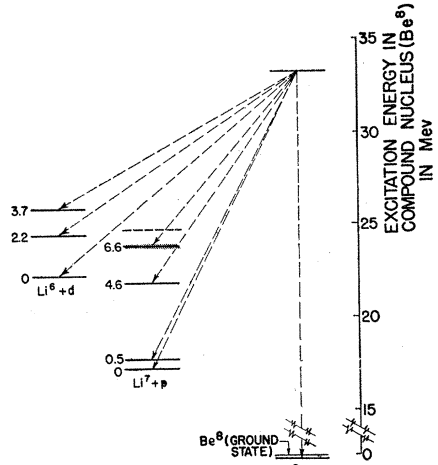

FIG. 3. Schematic representation of all particle groups observed in this experiment which result from the interaction of 18.3-Mev protons with Li^7.

Mev above the ground state, in substantial agreement with the results of Gelinas, Class, and Hanna,[5] and Gove and Harvey.[6] In addition, we observe a broad group corresponding to a new level in Li^7 at 6.56±0.12 Mev. The possible existence of this level has been suggested by Bashkin and Richards.[7] We have not observed a proton group corresponding to a level in Li^7 at 7.54 Mev, as reported by Blair[8] and others,[9,10] although a weak group corresponding to this energy might not be detected above a background which presumably consists of protons from $Li^7(p, pn)Li^6$. (The maximum energy of the continuous distribution arising from this reaction corresponds to an excitation energy in Li^7 of 7.25 Mev.)

The observed deuteron groups suggest levels in Li^6 at 2.2±0.2 and 3.7±0.2 Mev. The first of these was also detected through a weak inelastically scattered proton group from Li^6 (Fig. 1) giving a better value of 2.18±0.12 Mev for the level position, in agreement with a recent determination.[11] The 3.7-Mev level in Li^6 is presumably identical with the state responsible for the gamma-ray observed by Day and Walker[12] in $Be^9(p, \alpha)Li^6$.

A group of α-particles from $Li^7(p, \alpha)\alpha$ was observed with a 12.5 mil thick NaI crystal placed inside the vacuum of the scattering chamber. Comparison with Po−α pulses and use of Taylor's calibration[13] for NaI indicates that these particles arise from the direct break-up of the compound nucleus Be^8.

† Research supported by the AEC and the Higgins Scientific Trust Fund.
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Radiative K-Capture in A^{37}†

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(Received June 30, 1952)

IN 1940, Morrison and Schiff[1] predicted the existence of a weak continuous high energy gamma-ray spectrum accompanying K-capture. The energy distribution of this spectrum was calculated for allowed transitions to be

$$(\omega_k/\omega_C)dk=(\alpha/\pi)(W/mc^2)^2(1-\epsilon)^2\epsilon d\epsilon,$$

where $\epsilon=k/W$. W is the energy available for capture and k is the energy of the gamma-ray. The ratio of the total number of gamma-rays to the total number of K-captures is given by

$$\frac{\omega_R}{\omega_C}=\int_0^W\frac{\omega_k dk}{\omega_C}=\frac{\alpha}{12\pi}\left(\frac{W}{mc^2}\right)^2.$$

Up to the present time, the only confirming evidence for this gamma-radiation has been the work of Bradt[2] and Maeder and Preiswerk[3] on Fe^{55}.

Since the ratio ω_R/ω_C is proportional to W^2, radiative K-capture should be more easily observed in A^{37} than in Fe^{55}, for W is 816

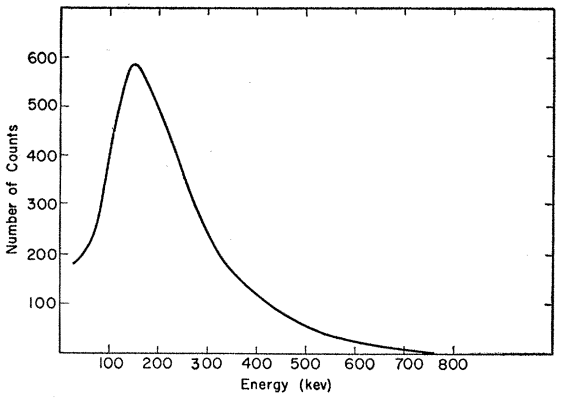

FIG. 1. Pulse-height analysis of A^{37} gamma-radiation.