COMPOSITION OF THE ^{7}Li(p,γ) RADIATION BELOW THE 441 keV RESONANCE*

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The only published determinations of the energy of the γ-radiation emitted when lithium is bombarded by protons with energy less than 400 keV have been made by absorption measurements of secondary electrons in aluminium. Gentner (1937) found that the radiation at 90° from a thick lithium target at 300 keV had the same half-value thickness as that at 550 keV, corresponding to about 17 MeV. Tangen (1946), however, reported that the radiation emitted at 0° at both 300 and 400 keV had energy $14 \cdot 5 \pm 0 \cdot 5$ MeV.

The later work of Walker and McDaniel (1948) has shown that the radiation from this reaction consists essentially of two components, at 17·6 and at 14·8 MeV. This note reports a scintillation counter investigation of the ratio of these components at low proton energies. Three other components of lower energy, with combined intensity at resonance amounting to 5 per cent. of the total, have also been identified, by Inall and Boyle (1953), but on the assumption that they remain proportionately small off resonance their effect is neglected here.

A sodium iodide crystal $1\frac{1}{2}$ in. long and $1\frac{1}{2}$ in. in diameter was placed with its centre 3 in. from the lithium target, its axis being on a line from the target at 90° to the direction of the proton beam. A 6260 photomultiplier was coupled optically to it and fed pulses through amplifiers to both a 1009 discriminator-scaler and a single-channel analyser in parallel. The discriminator and the analyser were intercalibrated to ensure that their readings were strictly comparable on the same scale.

The differential pulse-height distribution for thick-target lithium resonance radiation is shown in Figure 1. The continuous spread of the distribution is due to bremsstrahlung escape from the crystal (Campbell and Boyle 1954). The extrapolation to zero pulse height is taken as a straight horizontal line, to eliminate the usual spurious low energy rise.

The assumption is now made that the two components of the radiation give rise to individual pulse-height distributions of the same shape, the maximum pulse height in each distribution being proportional to the photon energy. This assumption is justified by the fact that the greater bremsstrahlung spreading of the 17·6 MeV component is compensated by the natural line breadth of 2 MeV over which the 14·8 MeV component is spread.

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In order to resolve the resultant distribution into the two individual contributions it is necessary to know the value of I_1/I_2, the ratio of intensities of the 17·6 to the 14·8 MeV component. The best published value of this ratio at resonance (in which case both the angular distributions are isotropic) is

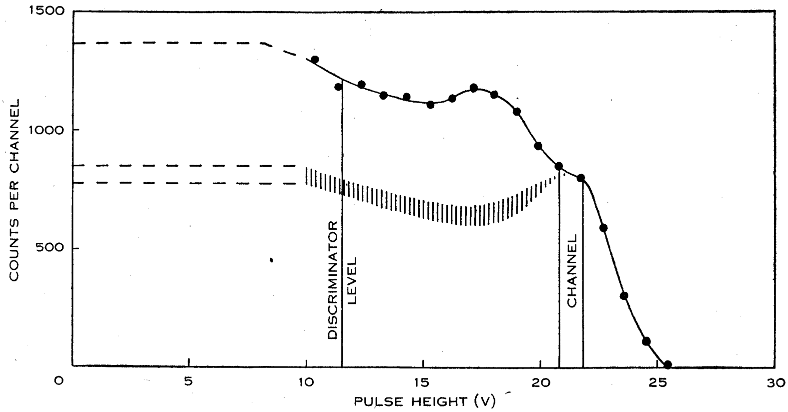

Fig. 1.—Pulse-height distribution at resonance.

1·7±0·2, which is given by Stearns and McDaniel (1951) and includes the earlier work of Walker and McDaniel (1948). The result of a graphical analysis using this value is shown by the broad band in Figure 1, the depth of the hatching indicating the limits set by the uncertainty in I_1/I_2.

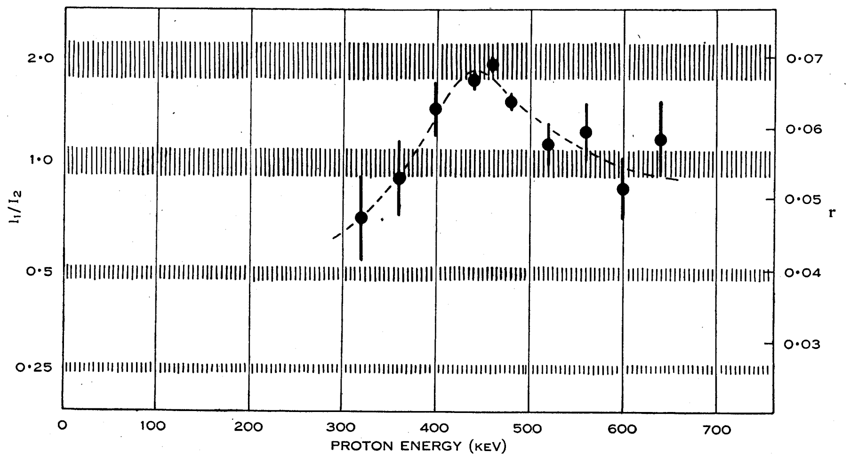

Fig. 2.—Results for thin target.

The discriminator level was set at 11·5 V, where it registered counts due to both γ-components, and the 1-V channel of the analyser was set with its centre at 21·3 V, where it responded almost exclusively to the 17·6 MeV component. From the ratio of the two counts, the areas in Figure 1 to which they correspond, and the known efficiencies of the crystal at the two photon energies, the ratio I_1/I_2 can be determined at other proton energies.

A thin (~10 keV) target of lithium metal was first bombarded by the proton beam, and the ratio r (analyser counts divided by discriminator counts) measured at several beam energies. The results are shown in Figure 2. The ordinate in this figure is a linear scale in r, as shown along the right-hand edge. The left-hand edge is calibrated in I_1/I_2, and the vertical hatching, corresponding to the hatching in Figure 1, is due to the uncertainty in the value of this at resonance. The behaviour of the experimental points, rising to a maximum at the 441 keV resonance and then dropping back to about $I_1/I_2=1$, is in agreement with that observed at 90° between 400 and 600 keV by Devons and Hine (1949). This run therefore acts as a check on the validity of the method.

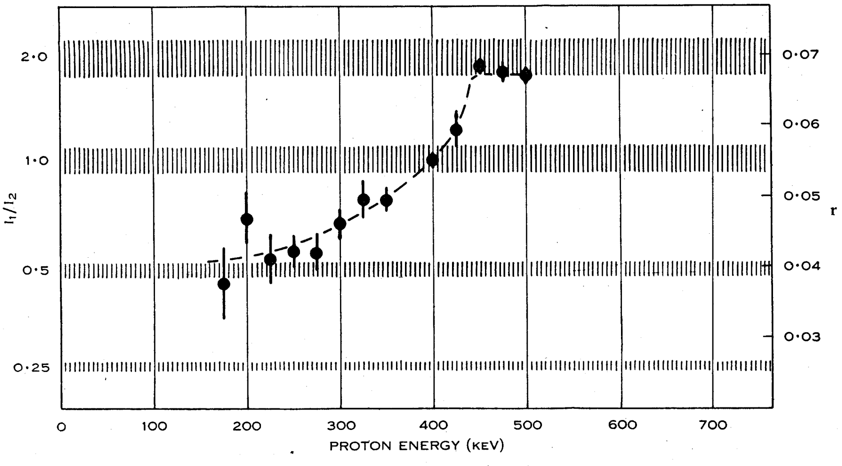

Fig. 3.—Results for thick target.

The results for a thick lithium target at low proton energies are now plotted in Figure 3. Owing to the steeply rising nature of the reaction cross section up to the resonance (Tangen 1946) the thin-target spectrum can be taken to be substantially similar to this.

It is evident from Figure 3 that, as the proton energy is reduced below resonance, the proportion of 17·6 MeV radiation decreases sharply, until at 200 keV it is only about half as intense as the 14·8 MeV radiation.

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