Inelastic Scattering of 14-MeV. Neutrons by Lithium-7

THE nuclear-level scheme for lithium-7 given in the review article on light nuclei by Ajzenberg and Lauritsen[1] indicates levels at 0·478, 4·61, 6·56 and 7·46 MeV. excitation. The level at 7·46 MeV. corresponds to a resonance in the $^6Li(n,^3H_1)^4He$ reaction at a neutron energy[2] of 0·25 MeV., but neither (p,p'), nor (d,d'), nor (α,α') scattering experiments have revealed inelastically scattered particle groups corresponding to this level[3].

We have studied the inelastic scattering of fast neutrons by lithium-7, using a photographic plate loaded with natural lithium. In this work advantage was taken of the fact that the levels of interest are unstable with respect to alpha-particle and triton emission. The loaded plates (Ilford 200 μ E_1 with 32 mgm. per c.c. loading) were exposed to 14·1-MeV. neutrons produced by the $^3H_1(d,n)^4He$ reaction, and the plates were searched for the occurrence of alpha-particle and triton pairs of tracks produced by the reaction :

$$^7Li(n,n')^{7*}Li(t)^4He\ ; \quad Q = -2{\cdot}465\ \text{MeV}. \qquad \text{(i)}$$

The scattered neutron was not detected in this experiment. The only measurements made were of the energy released to the alpha-particle and triton when the recoiling and excited lithium-7 nucleus decayed within the emulsion. By suitable processing of the plates, good discrimination was obtained between the alpha-particle and triton tracks. The events appeared as a thick and a thin pair of tracks having a common point of origin, and were easily recognized against a background of recoil protons and single alpha-particles arising from other emulsion constituents. Measurements were made on the ranges and angles of emission of the alpha-particle and triton tracks with respect to the incoming neutron direction.

Provided that the interpretation of the event is correct, these data are sufficient for the calculation of the excitation energy $\varepsilon(^7Li)$ of the states of lithium-7 involved in the reaction and, in addition, the energy E_N of the incoming neutron. The expressions obtained for both these quantities involve the same factors, and the value of E_N deduced provided a sensitive test of the accuracy of the individual measurements and of the correctness of the identification of each event. Only those events which inferred an incoming neutron energy within prescribed limits on either side of 14·1 MeV. were accepted.

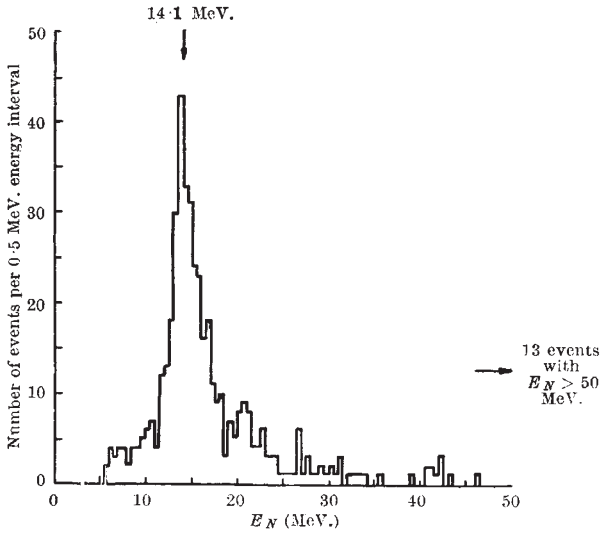

Fig. 1

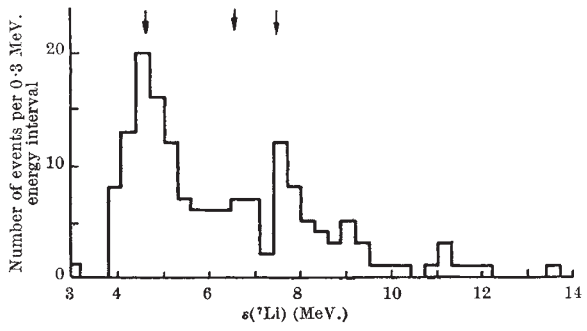

Fig. 2

The frequency distribution of E_N values calculated from the data obtained from measurements on 427 events is given in Fig. 1. The peak occurs at an energy of 14·0 ± 0·25 MeV. and has a half-width at half-height of 1·5 MeV.

Fig. 2 gives the distribution obtained for $\varepsilon(^7Li)$ measured in MeV. above the ground-state, assuming the Q value given for reaction (i). Only events satisfying the acceptance limits for E_N (11–18 MeV.) have been included, and this has eliminated many events due to reactions other than (i) which produce heavily ionizing and lightly ionizing particle-pairs of the type measured. Suitable corrections have been applied to remove the background of such events which could have produced E_N values within these limits. In particular, Fig. 2 has been corrected for a considerable background of events due to the reaction :

$$^7Li(n,t)^5He(n)^4He\ ; \quad Q = -2{\cdot}465\ \text{MeV}. \qquad \text{(ii)}$$

The background corrections applied made little difference to the shape and position of the groups in the $\varepsilon(^7Li)$ distribution in the range 0–9 MeV., although the fully corrected distribution given has been reduced to a total of only 167 events. Most of the events removed appeared in the uncorrected $\varepsilon(^7Li)$ distribution in the range 9·2–13·5 MeV., and these events, when recalculated according to reaction (ii), fell into two groups representing helium-5 excitation energies of 0 ± 0·3 MeV. and 2·4 ± 0·6 MeV. A distribution of $\varepsilon(^7Li)$ values corrected on the assumption that only the ground-state of helium-5 is involved in reaction (ii) shows a prominent peak at 9·25 ± 0·25 MeV. which may represent a new level in lithium-7.

In Fig. 2 the prominent group at 4·6 ± 0·25 MeV. is identified with the level in lithium-7 at 4·61 MeV. (see ref. 1). The smaller group at 7·5 ± 0·25 MeV. is identified with the expected level at 7·46 MeV., and the group of events between 6 and 7 MeV. is presumably due to the broad level reported[3,4] at 6·56 MeV.

D. L. ALLAN
Atomic Energy Research Establishment,
Harwell,
Nr. Didcot, Berks.

[1] Ajzenberg and Lauritsen, *Rev. Mod. Phys.*, **24**, 330 (Oct. 1952).
[2] Hughes *et al.*, *A.E.C.U.*, 2040 (1952).
[3] Franzen and Likely, *Phys. Rev.*, **87**, 667 (1952).
[4] Gove and Harvey, *Phys. Rev.*, **82**, 658 (1951).