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Neutron-Induced Disintegration of Li^6 and Li^7†

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A study has been made of the $Li^6(n,dn)He^4$ and $Li^7(n,tn)He^4$ reactions over the energy region 5 to 14 Mev. The cross sections are very large and, as a consequence, normal Li may have important applications as a shielding material for fission and fusion reactors.

A DETAILED analysis has been made of the systematics involved in the production of deuterons and tritons from Li^6 and Li^7, respectively, as a function of neutron energy in the region 5 to 14 Mev.[1] Aside from the cross sections for the above reactions, measurements were made of the spectral and spatial distributions of the charged-reaction products.

Separated isotopes of Li were incorporated in Ilford C2 emulsions which were then exposed to known fluxes of monoenergetic neutrons. Examination of the processed emulsions revealed a profusion of two-prong "stars," most of which could, on the basis of energy and momentum considerations, be identified as arising from the above-mentioned reactions.

The angular and energy distributions of the charged particles permitted evaluation of the energy and angular distributions of the emitted neutrons. The energy distributions show that many of the reactions proceed by way of a two-stage process through known levels in the Li nuclides, i.e.,

$$Li^6+n \rightarrow Li^{6*}+n'; \quad Li^{6*} \rightarrow He^4+d$$
$$Li^7+n \rightarrow Li^{7*}+n'; \quad Li^{7*} \rightarrow He^4+t.$$

All of the reaction products appear to have isotropic angular distributions in the center-of-mass system, indicating that the reactions proceed via a compound nucleus as opposed to direct interaction. Figure 1 displays the number of observed events as a function of excitation energy of the Li nuclides, assuming a two-stage process. The 2.2-Mev level in Li^6 and the 4.6-Mev level in Li^7 are always well resolved.

Figure 2 gives the energy dependence of the cross sections for the disintegration of Li^6 into an alpha particle and deuteron, and Li^7 into an alpha particle and triton. The values of these cross sections are seen to be comparable to the geometrical cross sections for the Li nuclides. The high probability for Li^6 and Li^7 to break up in the manner above outlined, coupled with

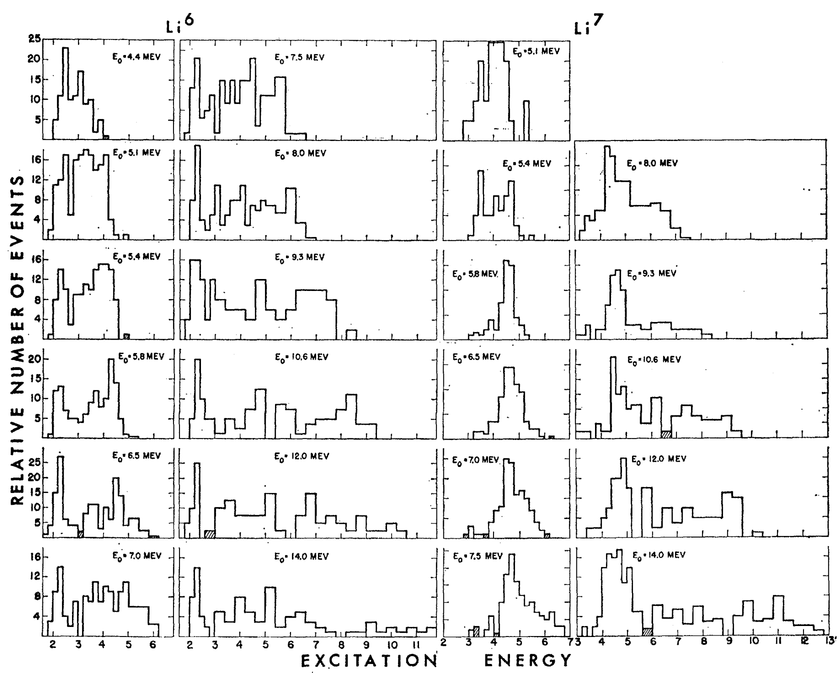

FIG. 1. Number of observed disintegrations vs excitation energy of Li^6 and Li^7.

† Work done under the auspices of the U. S. Atomic Energy Commission.
[1] G. M. Frye, Jr., Phys. Rev. 93, 1086 (1954).

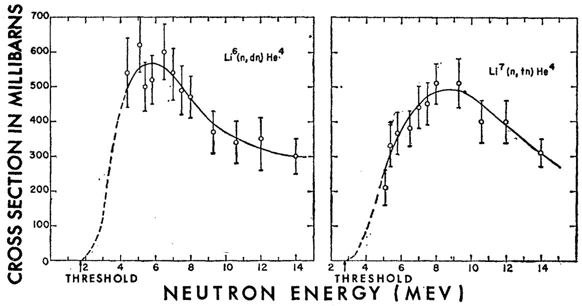

FIG. 2. Energy dependence of the cross section for the $Li^6(n,dn)He^4$ and $Li^7(n,tn)He^4$ reactions.

the consideration that other reactions are energetically possible, supports the hypothesis that Li^6 and Li^7 can be described in terms of a two-body cluster model,[2] in which Li^6 appears as an alpha particle and deuteron and Li^7 as an alpha particle and triton.

The extraordinarily large cross sections for the above reactions have other and more pragmatic implications.

(1) LiH should be extremely useful as a light-weight reactor shield. This follows from the fact that the ratio of geometrical cross section to weight of a nucleus is proportional to $A^{-1/3}$, while the atomic density of LiH is not unfavorable. Also the small mass of Li places its elastic cross section in a favorable light from the standpoint of slowing down neutrons. Once the neutrons are thermalized in a LiH shield, they would be captured by Li^6 without gamma-ray production.

(2) Normal Li might be quite appropriate as a "blanket"[3] for controlled thermonuclear devices. This "blanket" would serve the dual function of neutron shield and tritium producer—the fast neutrons would produce tritium in Li^7, and the thermalized neutrons would produce tritium in Li^6. It would thus be possible to breed more tritium than is consumed in a fusion reactor which utilized the d-T reaction.

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[2] G. C. Phillips, Bull. Am. Phys. Soc. **4**, 99 (1959); G. C. Phillips and T. A. Tombrello, Nuclear Phys. **19**, 555 (1960) and **20**, 648 (1960); L. D. Pearlstein, Y. C. Tang, and K. Wildermuth, Nuclear Phys, **18**, 23 (1960), Phys. Rev. **120**, 224 (1960), and Phys. Rev. **123**, 548 (1961).

[3] K. O. Hinterman and R. Wideröe, *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy* (United Nations, Geneva, 1958), Vol. 32, p. 440; D. J. Rose and M. Clark, Jr., *Plasmas and Controlled Nuclear Fusion* (Massachusetts Institute of Technology Press, Cambridge, Massachusetts, 1961).