

Li⁹—New Delayed Neutron Emitter*

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AN investigation has been made of a new delayed neutron activity from targets bombarded in the Berkeley 184-inch cyclotron beam. When the daughter product of a beta-decay is neutron unstable, the neutron comes out immediately. Because the decay in neutron intensity is then the same as that of the beta-particle, this process is usually referred to as delayed neutron emission. Only one other delayed neutron emitter, N¹⁷, is known¹ outside of the fission products.

Deuteron bombardment of Be and of elements immediately above it, and proton bombardment of B and of elements immediately above it, give rise to such neutrons displaying a decay in intensity with a 0.168-sec half-life.

The targets were 1½-in. diameter cylinders of approximately 3-in. length, placed in the external beam of the cyclotron. A BF₃ ion chamber embedded in paraffin surrounded the target. A low noise triode preamplifier was used which was coupled into a standard linear amplifier, giving an over-all gain of 5×10⁶. The neutron detection efficiency for RaBe neutrons was 5 percent.

The half-life measurement was made by irradiating the target for several seconds, shutting the cyclotron off, and recording the decaying neutron activity by photographing the pulses displayed on an oscilloscope. The activity was followed over more than 5 half-lives, and a complete record of the position of each event in time was secured on the film. The resolution of the equipment was 10 μsec. About 500 pulses per cycle were obtained with a boron target under deuteron bombardment. The results of these measurements give a half-life as shown in Fig. 1 of $T_{1/2} = 0.168 \pm 0.004$ sec. The cross section for this reaction for deuterons on boron is approximately 4 millibarns.

The elements from Li through N were surveyed for this activity, using both protons and deuterons. The relative yields/atom for the various elements are:

| | Li | Be | B | C | N | Ratio B/Be |
|-----------|------|------|-----|----|---|------------|
| deuterons | <2 | 45 | 100 | 10 | 3 | 2.2 |
| protons | <2.5 | <2.5 | 100 | 13 | 5 | >40. |

A Cu target was also used as one type of background determination. The relative copper to boron yield/atom ratio was less than 1 percent. From the above table it is seen that the relative yield under deuteron bombardment is appreciable beginning with Be, while under proton bombardment the yield is not significant until

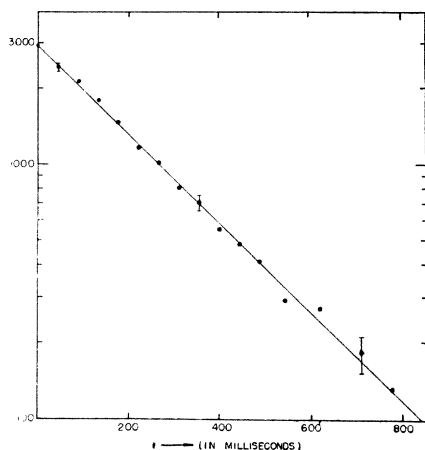


FIG. 1. Neutron decay.

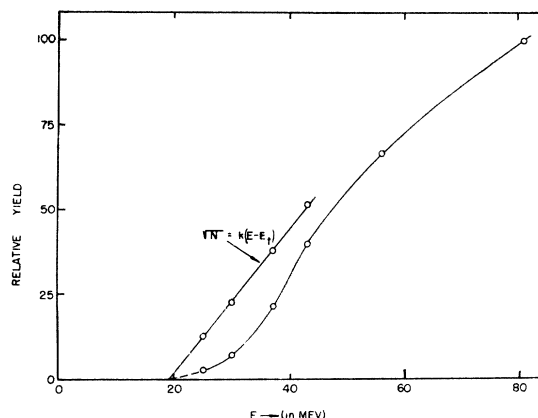
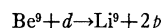


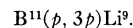
FIG. 2. Excitation function.

boron is used. That is, within the accuracy allowed by the background; this activity is induced by deuterons on Be, but not by protons. An examination of the isotope chart indicates the most likely reaction to be

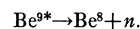


under deuteron bombardment.

The fact that under proton bombardment the lightest element to yield the neutrons is boron is also consistent with the Li⁹ assignment, assuming



The Li⁹ decay scheme is assumed to be



Evidence for an excited level in Be⁹ which is unstable to neutron emission has been given by Davis and Hafner.² The Be⁸ breaks up immediately into two alphas, and, the possibility of investigating the neutron-alpha-coincidence as a corroboration of this decay scheme is being considered.

Li⁹ and the above decay scheme hold an analogous position in the isotope chart to that of N¹⁷. A mass calculation of Li⁹ by Barkas³ permits a threshold for this reaction to be estimated as ≈ 18.5 Mev. Experimental data on this point were secured by moving a Be target in along the radius of the cyclotron gap with a deuteron beam. The excitation function is shown in Fig. 2. Theoretical indications that this function is of the form $N = k_1(E - E_t)^2$ are further substantiated by the fact that a straight line is a good fit to the experimental points replotted as $\sqrt{N} = k(E - E_t)$. The threshold determined from this intercept is 19 ± 1 Mev, which is in agreement with the calculated threshold. The Li⁹ mass indicates that an electron energy of ~ 11 Mev is quite likely. An attempt to measure a high energy electron in coincidence with the neutron has not yet been successful.

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¹ L. Alvarez, Phys. Rev. **75**, 1127 (1949).

² K. E. Davis and E. M. Hafner, Phys. Rev. **73**, 1473 (1948).

³ W. H. Barkas, Phys. Rev. **55**, 691 (1939).

Beta-Ray Spectrum of K⁴⁰

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THE beta-ray spectrum of K⁴⁰ has been measured by observing the distribution in size of the light flashes which are generated in a crystal of KI-Tl by the natural radioactivity of the