Ranges of Particles Emitted in the Disintegration of Boron and Lithium by Slow Neutrons

I HAVE determined the ranges of particles emitted during disintegration of ^{10}B and ^{6}Li by slow neutrons, using a boron or lithium-coated ionization chamber connected with a Hoffmann electrometer. The ranges were deduced from the position of angles on the curves representing the ionization as a function of the pressure. The chamber filled with air was a brass cylinder of 8 cm. inner diameter and 10 cm. height. In the case of boron, pure finely powdered boron mixed with some water was distributed over the inner walls of the chamber; the density of the layer after evaporation of water was 2×10^{-3} gm./cm.^{2}. In the case of lithium, lithium hydroxide made insoluble by heating at a high temperature was spread over the surface in an analogous manner with the same density as before. About 10 millicuries of polonium mixed with beryllium were used as source of neutrons, and the chamber was surrounded with a large cylindrical block of paraffin wax for slowing down the neutrons.

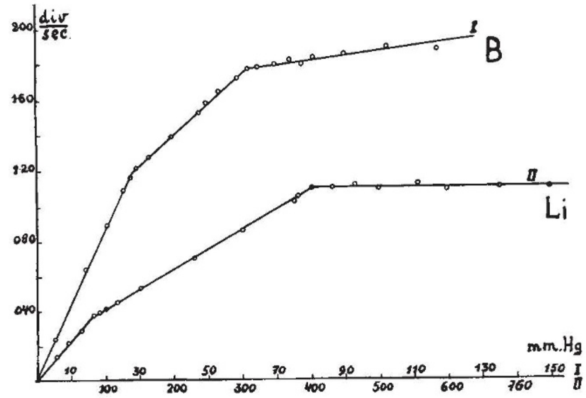

FIG. 1.

In order to evaluate the effect due to slow neutrons, measurements were made at each pressure (*a*) with neutrons filtered through a sheet of cadmium $0\cdot5$ mm. thick, (*b*) without cadmium. The difference $b - a$ is due to slow neutrons only.

These differences are plotted against the pressure of air on Fig. 1. The angles corresponding in the case of boron (Curve I) to α-particles and ^{7}Li nuclei, and in the case of lithium (Curve II) to α-particles and ^{3}H nuclei are well apparent. They occur respectively at the following pressures:

Disintegration of boron: α, 62 mm.; ^{7}Li, $27\cdot6$ mm.
Disintegration of lithium: α, 82 mm.; ^{3}H, 408 mm.

Owing to the shape of the chamber, the paths of particles *in vacuo* were of unequal length, and it was therefore necessary to define a 'mean effective length of path'. To do this, the apparatus was calibrated in the following way. To the boron powder a few drops of an extremely weak solution of polonium were added, and the substance spread over the walls in exactly the same manner and quantity as before. The ionization pressure curve gave 293 mm. for the position of the angle, which gives 10 cm. as the 'effective mean length of the path' of the particles. Using this value, I obtained the following values for the ranges:

Disintegration of boron: α, $8\cdot18$ mm.; ^{7}Li, $3\cdot64$ mm.
Disintegration of lithium: α, $10\cdot8$ mm.; ^{3}H, $53\cdot6$ mm.

The ranges for α-particles correspond to the energy $E_{\alpha\mathrm{B}} = 1\cdot43 \times 10^6$ e.v. and $E_{\alpha\mathrm{Li}} = 1\cdot93 \times 10^6$ e.v. respectively[1].

Owing to the conservation of quantity of movement, the total kinetic energy of the emitted particles is equal to $\frac{m' + m_\alpha}{m'} \times E_\alpha$, E_α being the energy of the α-particles, m' the mass of the nucleus emitted simultaneously with the α-particles (namely, ^{7}Li in the case of boron and ^{3}H in the case of lithium). If the disintegration is not followed by any γ-ray emission, this kinetic energy represents the total energy, E_B and E_Li, released in the nuclear processes under examination. Assuming this to be true, I find $E_\mathrm{B} = \frac{11}{7}E_{\alpha\mathrm{B}} = 2\cdot24 \times 10^6$ e.v., and $E_\mathrm{Li} = \frac{7}{3}E_{\alpha\mathrm{Li}} = 4\cdot5 \times 10^6$ e.v.

Using the following atomic masses[2], $n = 1\cdot0091$, $^{3}\mathrm{H} = 3\cdot0171$, $^{4}\mathrm{He} = 4\cdot0039$, $^{6}\mathrm{Li} = 6\cdot0167$, $^{7}\mathrm{Li} = 7\cdot0180$, $^{10}\mathrm{B} = 10\cdot0161$, I find $E_\mathrm{B} = 0\cdot0033$ mass units, or $3\cdot07 \times 10^6$ e.v., and $E_\mathrm{Li} = 0\cdot0048$ mass units, or $4\cdot48 \times 10^6$ e.v. The agreement is excellent in the case of lithium, while in the case of boron the discrepancy is greater than could be attributed to errors in the determinations of ranges. If instead of the experimental velocity-range relation given by Blackett and Lees, we use the numbers calculated from the theories of Bethe and of Bloch[3], then the agreement is in both cases within probable experimental errors. It may also be noticed that Curve I for boron shows a slight increase even at pressures at which the ionization should be constant. This increase may correspond to an unknown mode of release of energy, perhaps related to the existence of γ-rays of boron, reported by Kikuchi, Aoki and Husimi[4].

The cross-section of the boron nucleus for capture of a slow neutron was found to be eight times greater than the cross-section of the lithium nucleus.

My thanks are due to Prof. L. Wertenstein for his interest in this work.

J. ROTBLAT.

Atomic Physics Laboratory,
Free University of Poland,
Warsaw.
June 27.

[1] Blackett and Lees, **134**, 658 (1931).
[2] Oliphant, NATURE, **137**, 396 (1936).
[3] M. Curie, "Radioactivité", tables (1935).
[4] NATURE, **137**, 745 (1936).

Kikuchi Lines from Etched Copper Crystal

IT is well known that a cross-grating pattern of spots is produced when a fast electron beam is incident, at a small angle, on the etched surface of a single crystal. Two explanations have been given of this phenomenon. Thomson[1] showed that the effect would arise if the electrons passed through small projections on the surface, while Germer[2] attributed it to distortion of the crystal lattice. When etched single crystals of zincblende and galena were studied by Tillman[3], he found Kikuchi lines to be present in addition to the cross-grating and, as has been pointed out previously[4], the presence and sharpness of Kikuchi lines may be taken as a criterion of the degree of perfection of the crystal lattice.

It has been found that an etched single crystal of copper gives Kikuchi lines along with a cross-grating of spots (Fig. 1). The crystal was cut from a freshly prepared single-crystal rod which had been carefully protected from any distortion. Subsequent specimens,