Natural and Artificial Radioactivity of Potassium

THE question of the origin of the radioactivity of potassium has been much discussed in recent years[1]. The possibility, however, of producing new radioactive isotopes artificially has opened up a new line of attack on this problem. Quite recently Amaldi, D'Agostino, Fermi, Pontecorvo, Rasetti and Segrè[2] have found that, by bombardment of potassium with neutrons, a new radioactive isotope of potassium is produced having a period of 16 hours. Potassium having two stable isotopes, 39 and 41, it is not possible to draw conclusions from these experiments on the mass of the new isotope. The problem can be settled, however, from the fact that the new isotope of potassium can also be produced by bombarding scandium with neutrons. By experiments in this laboratory in which I have been kindly assisted by Hr. Høffer-Jensen, we find that scandium can be converted into a radioactive isotope of potassium. As scandium has only one isotope (45) this conversion must take place according to the equation:

$$_{21}Sc^{45} + {}_0n^1 \longrightarrow {}_{19}K^{42} + {}_2\alpha^4.$$

As the potassium obtained by us has the same period as that found by the Italian workers, we have to conclude that in their experiments it was K^{41} which captured a neutron and was converted into K^{42}. In our experiments we bombarded scandium oxide with neutrons produced by a mixture of beryllium and radium emanation, thus applying Fermi's beautiful method. The scandium oxide was dissolved in hydrochloric acid and, after the addition of 0·15 gm. of sodium chloride and the same amount of calcium chloride, precipitated with ammonia. The calcium present in the filtrate was removed as oxalate and found to be inactive. The remaining sodium chloride, however, was found to be active and to contain the potassium isotopes looked for. This decayed with a period of about 16 hours, emitting very hard β-rays of approximately 1·2 million e.v.

From my comparison of the radioactivity and the atomic weight of potassium fractions obtained by distillation processes (partial separation of isotopes), it follows that the mass of the isotope to which the natural radioactivity of potassium is due can only be 40, 41 or 42. The first mentioned figure is obtained if we accept Baxter's analysis of the fractions, while that of Hönigschmid is only compatible with 41 and 42. Knowing now that the isotope 42 has a short life (16 hours) we are restricted to the alternative 40 or 41.

From measurements with the mass-spectrograph, we know that K^{41} is present in potassium in the extent of 7 per cent. From this figure and the number of β-particles emitted per second by 1 gm. of potassium, it follows that, if the natural radioactivity of potassium is due to K^{41}, it has a period of 10^{12} years. The hypothetical isotope K^{40} should have a much shorter life as this isotope has not been revealed by measurements by the mass-spectrograph. From this fact the upper limit of its period can be stated to be 5×10^{10} years. A lower limit, 10^8 years, is given by the calcium content, potassium content and geological age of old minerals. Presumably when potassium is bombarded by neutrons, K^{39} captures neutrons as well, but since the resulting K^{40} has a long life, its formation cannot be established through measurements of induced activity.

The great difficulty for the theory of β-ray emission, arising from the fact that potassium, in spite of its very long life, emits fairly hard β-rays of a mean energy of about 5×10^5 e.v., has been discussed repeatedly. The discrepancies between theory and experiment would be somewhat lessened if it could be shown that the natural radioactivity of potassium is due to K^{40}, but this difficulty would still remain. It is of interest to note in this connexion that the artificially produced isotope of potassium 42, though having a similar period to thorium B, emits β-rays of more than ten times greater mean energy than the latter. Also, the nucleus of this potassium isotope is thus emitting much harder rays than members of the radioactive disintegration series of similar period.

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[1] cf. G. Hevesy, M. Pahl and R. Hosemann, NATURE, **134**, 377, Sept. 8, 1934.

[2] *Ricerca Scientifica*, **2**, December 1934.

Absorption of Cosmic Particles in Copper and Lead

BY the method of the coincidences between three Geiger-Müller counters of 2·5 cm. diameter and 25 cm. effective length, disposed as in Fig. 1, I have carried out comparative measurements of absorption of the hard component of cosmic particles in copper (atomic weight $(A) = 63 \cdot 57$; atomic number $(Z) = 29$) and in lead ($A = 207 \cdot 20$; $Z = 82$). Lead screens (altogether 9 cm.) were arranged permanently between the counters, in order to exclude softer particles.

The absorbing screens, made of bars of surface area 2·5 cm. × 30 cm., were interposed between the first and second counter: they had the same mass per cm.² of 575 gm./cm.²; the bars of lead were arranged in such a way as to occupy altogether the same height as the copper screen.

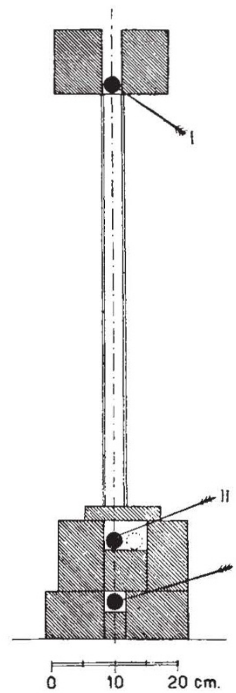

FIG. 1.

The triple coincidences were recorded by an automatic device[1], the resolving power of which, determined according to the double chance-coincidences, was 6×10^{-4} sec.: with this resolving power the expected number of triple chance-coincidences is 0·08 an hour.

The results given in Table 1 were obtained by alternating regularly the measurements taken without absorbing screen between the counters with those taken with the screens of copper and lead.

In the course of these measurements, the triple coincidences with the middle counter displaced laterally 3·2 cm. were also recorded in order to test the reliability of the method. Table II shows that not more than about a tenth of coincidences observed in the preceding case can be attributed to primary particles scattered by the screens or to secondary ones generated near the counters.

From the results reported in Table I there does not appear to be any difference, within the limit