# LETTERS TO THE EDITORS

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NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 555.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

## Fission of Thorium by Neutrons

SINCE March 1938, we have been engaged in the study of artificial radioactivity induced in thorium by fast neutrons. We have already reported[1] the production of uranium Y, which was obtained in the course of this investigation.

At that time we had examined the barium and lanthanum fractions from activated thorium and obtained nearly all the periods which Meitner, Strassmann and Hahn[2] found in their study of the artificial radioactivity of thorium, and which Hahn and Strassmann[3] and other authors later identified with those for fission products of uranium and thorium, although our agreements were not exact in some cases and some other periods were obtained in our experiments.

We did not, however, follow closely these lines of investigation, since our attention was directed to a radioactive substance, which was precipitated with bismuth and lead as carriers from hydrochloric acid solution by hydrogen sulphide. We spent much time on the chemical identification of this substance. Its chemical properties were not easy to ascertain, but it was still more difficult to understand the nuclear reactions concerned. Chemical properties suggested that either 'transuranic' or elements of lower atomic

number than bismuth were involved, but both these alternatives were difficult to accept at that time. Then, however, came Hahn and Strassmann's discovery of fission processes, and the problem became easier, at least in principle.

From this point of view we have been working on the chemical identification of elements for several months, but have not come yet to final conclusions. In the meantime, results on similar work were published by Bretscher and Cook[4] and by Meitner[5], but exact identification of elements was not given. Although our experiments are still in a very preliminary stage, we should like to give here the results so far obtained, since we are obliged to interrupt our work for some time.

Thorium nitrate, carefully freed from mesothorium as well as from other disintegration products except radiothorium, was exposed to fast neutrons which were produced by bombarding lithium with 3 Mv. deuterons of several microamperes from our cyclotron. The exposure ranged from one to five hours, after which the sample was subjected to chemical separations. Examination of radioactivity showed the production of the following active substances: Bi, Hg, Sb, Sn and Ag. Besides these elements, the following fractions were found to be radioactive: alkali fraction, halogen fraction, Mo-fraction, Se + Au-fraction, Cu + Cd-fraction. Identification of elements in these fractions requires further investigation.

We tested for radioactive lead and arsenic and proved their definite absence. Our chemical separations, however, took at least two or three hours and all radioactivities of short periods must have escaped our detection.

We tried similar experiments also with uranium, and so far have obtained the following radioactive precipitates: Bi, Hg, Ag, Sb + Sn, and Cu + Cd-fraction.

More thorough identification of radioactive elements both from thorium and uranium, and determination of their periods will be made in the future. Chemical procedures and details of the experiments will be given elsewhere.

We should like to acknowledge the assistance given by Messrs. N. Saito and N. Matuura in connexion with the chemical separations.

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[1] Nishina, Y., Yasaki, T., Kimura, K., and Ikawa, M., NATURE, **142**, 874 (1938).
[2] Meitner, L., Strassmann, F., and Hahn, O., *Z. Phys.*, **109**, 538 (1938).
[3] Hahn, O., and Strassmann, F., *Naturwiss.*, **26**, 756 (1938); **27**, 11 (1939); **27**, 89 (1939).
[4] Bretscher, E., and Cook, L. G., NATURE, **143**, 559 (1939).
[5] Meitner, L., NATURE, **143**, 637 (1939).

## Induced β-Activity of Uranium by Fast Neutrons

In the course of experiments on the fission of uranium by fast neutrons,[1] besides fission products the uranium fraction showed a $\beta$-activity with a period 6.5 days.

This activity was induced appreciably only by fast neutrons obtained by bombarding lithium with 3-Mev. deuterons from our cyclotron. The experimental procedure was as follows.

A few grams of uranium oxide, $U_3O_8$, carefully purified and freed from its disintegration products were exposed to fast neutrons for more than fifty hours. After the exposure, a uranium fraction ($U_3O_8$) was separated and purified from all possible elements produced by fission as well as from its own disintegration products. The most care was given to the removal of lanthanum from the sample, the procedure taking as long as one day. The activity of the irradiated uranium was compared with that of a nonirradiated sample, in order to subtract the growing $\beta$-activity due to disintegration products of uranium. The difference thus obtained shows a 6.5-day period. This activity is probably due to $U^{237}$ produced from $U^{238}$ through loss of a neutron, as in the case of the production of UY from thorium.[2] If this is the case, we have here a member of the missing radioactive family $4n+1$.

The sign of the $\beta$-rays was shown to be negative and consequently we suspected the production of a radioactive element of atomic number 93, the chemical properties of which are probably homologous to rhenium. From the decay curve it is clear that its period must be very long, if it exists. To search for such an element, the irradiated uranium oxide, which was freed from fission products as well as its own disintegration products as above mentioned, was left for about 7 days, and was then dissolved in nitric acid. The solution, after an addition of perrhenic acid, was treated with ammonium sulphide and then acidified with sulphuric acid. The precipitated rhenium sulphide, after the removal of contaminated sulphur by carbon bisulphide, was examined for $\beta$- and $\alpha$-activities. Neither of them could be found within the error of our experiments. We may thus conclude, as in the case of 23-minute uranium,[3] that the 6.5-day uranium decays also into a very long-lived 93 element. The detailed accounts of the experiments will be given elsewhere.

The above investigations were carried out as a part of the work of the Atomic Nucleus Sub-Committee of the Japan Society for the Promotion of Scientific Research. We acknowledge the assistances given by our laboratory colleagues in connection with the irradiation of samples and by Messrs. N. Saito and N. Matuura regarding the chemical separations.

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[1] Y. Nishina, T. Yasaki, H. Ezoe, K. Kimura and M. Ikawa, Nature **144**, 547 (1939); Nature, in press (1940).
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IN THE PRESENT CIRCUMSTANCES, PROOFS OF "LETTERS" WILL NOT BE SUBMITTED TO CORRESPONDENTS OUTSIDE GREAT BRITAIN.

## Fission Products of Uranium produced by Fast Neutrons

IN continuation of our experiments on the fission of uranium by fast neutrons, we have been studying decay periods of various isotopes. In this communication we give the results on silver and cadmium isotopes.

The uranium oxide, $U_3O_8$, carefully purified and freed from its disintegration products just before the experiments, was exposed to fast neutrons produced by bombarding lithium with 3 Mev. deuterons of several microamperes from our cyclotron, as described in our earlier note[1]. The exposure ranged from a few hours to some fifty hours, according to the object of the experiments. From the irradiated sample, silver was separated as iodide or chloride, cadmium as sulphide. Each fraction, carefully freed from the known fission products of uranium such as barium, lanthanum, antimony, tellurium, iodine, molybdenum, etc., was examined for its activity.

The decay curves of the silver fraction, which were obtained from samples exposed for some fifty hours, showed two periods, 7·5 days and 3 hours. The former activity is probably identified with $^{111}Ag$ [2,3] and the latter with $^{112}Ag$ [3].

The decay curves of the cadmium fraction, which was obtained from long exposures, showed apparently three periods, fifty minutes, several hours and 2·5 days. The first activity is possibly an isotope reported by Dodé and Pontecorvo[4]. The second one was proved to be $^{117}Cd$ by the identification of indium activity produced through its series transformation in the following way. Cadmium sulphide from a sample irradiated for 3 hours was dissolved in hydrochloric acid three hours after the initial separation of cadmium. The solution, after an addition of indium nitrate, was treated with an excess of ammonia. The precipitated indium hydroxide was filtered off and examined for the activity. Its half-period was found to be 2·1 hours, which is due to the known isotope of indium $^{117}In$ [5]. We thus conclude that the activity of the cadmium fraction is due to $^{117}Cd$, the half-life of which turns out according to our measurements to be about 5·5 hours.

Similar procedure was taken with the 2·5-day activity. The cadmium sulphide from an irradiated sample of long exposure was left for about twenty hours before dissolution in hydrochloric acid, until the cadmium isotope $^{117}Cd$ and its daughter product died away. The indium fraction obtained in the same way as above was examined for activity, and a half-life of 4·5 hours was obtained, which we identify with the known radioactive isomer of the stable indium isotope $^{115}In^*$ [5]. As a consequence, we conclude the 2·5-day activity to be due to a cadmium isotope $^{115}Cd$.

It should be mentioned that Be + D neutrons from our cyclotron, and also neutrons slowed down by paraffin, do not appreciably produce silver and cadmium activities as above mentioned. The details of the experiments will shortly be given elsewhere.

The above investigations were carried out as a part of the programme of the Atomic Nucleus Sub-Committee of the Japan Society for the Promotion of Scientific Research. We acknowledge the assistance given by our laboratory colleagues in connexion with the irradiation of samples and by Messrs. N. Saito and N. Matuura regarding the chemical separations.

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