Letters to the Editor

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Alpha-Decay in Isotopes of Atomic Number Less Than 83

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SOME time ago we started work in an attempt to observe alpha-particle decay in isotopes of atomic number less than 83. In the first experiments, thin targets of gold leaf were bombarded with 190-Mev deuterons in the 184-inch cyclotron. Two alpha-decay periods were observed in these targets; one of 0.7 minute half-life and another of 4.3 minutes half-life. The alpha-particle energies were 5.7 and 5.2 Mev, respectively. Chemical separations proved that the 4.3-minute period is due to a gold isotope and suggested that the 0.7-minute period is due to a mercury isotope. The mass numbers of these new isotopes have not been determined. However, the results of excitation functions in the production of the gold isotope by bombarding gold and platinum with protons suggest that its mass number lies in the range 185 to 188. The work on this isotope indicates that the alpha to electron capture branching ratio is of the order of magnitude of 10^{-4}, and that positron activity accompanies the 4.3-minute alpha-period.

Very recently Sm_2O_3, Gd_2O_3 and Dy_2O_3 tagets were bombarded similarly with 200-Mev protons. Several new alpha-decay periods were observed in the gadolinium and dysprosium targets, but significant alpha-activity was absent in the samarium target.

In the gadolinium bombardment there was present an alpha-decay period of approximately 7 minutes half-life and another of about 4 hours half-life, the alpha-particle energies being approximately 4.2 and 4.0 Mev, respectively, as determined with a pulse analyzer apparatus.

In the dysprosium bombardment, three alpha-decay periods were observed, namely ~7 minutes, ~20 minutes, and ~4 hours with alpha-particle energies of 4.2, 4.1, and 4.0 Mev, respectively. Present also was some electromagnetic radiation and a smaller amount of positron activity. With rough assumptions as to counting efficiency and geometry in the counting of the electromagnetic radiation with a Geiger counter, it appears that a minimum value for the ratio of alpha to electron capture is approximately 1 percent for the 4-hour activity.

The relationship between the alpha-particle energies and the half-lifes of these new isotopes places them in a new class. The energies are approximately the same as the alpha-particle energy of Th^{232} which has a half-life of 1.4×10^{10} years. These facts in themselves are proof that these new periods could not have been due to heavy isotope contamination.

Chemical identification of these rare earths has not been completed as yet. However, since the 4.0-hour and 7-minute activities were produced in gadolinium and dysprosium targets and not in samarium, they would appear to be associated with gadolinium or terbium isotopes. Since the 20-minute period was produced only in the dysprosium target it would appear to be an isotope of dysprosium or holmium.

Although it is probably premature to attempt now to interpret these rather limited data, it is tempting to suggest a difference between the alpha-emitting isotopes of the gold region and those of the rare earths. As has been pointed out on numerous occasions[1] it should be possible to observe artificial alpha-activity in sufficiently neutron deficient isotopes in the region between the rare earths and lead. The alpha-emitting isotopes of the gold region might be "normal" examples of this since they are observed to decay with short electron capture half-lives, and with small alpha to electron capture branching ratios. In this case alpha-particle decay would be largely the consequence of considerable neutron deficiency. The higher alpha to electron capture branching ratio of the new rare earth isotopes is probably due to (a) a more moderate degree of neutron deficiency giving rise to longer electron capture half-lives, and (b) exceptionally high alpha-particle energies giving rise to shorter alpha-half-lives. These new rare earth periods might, therefore, be correlated with the stable configuration of 82 neutrons[2] in such a way as to acquire the necessary extra alpha-disintegration energy. Just as the isotopes having neutron numbers in the range 127–130 of the region above lead (for example $_{84}Po^{211}$, $_{84}Po^{212}$, $_{84}Po^{213}$, or $_{85}At^{215}$) decay by unusually high energy alpha-particle emission as a consequence of their decay to or near the stable configuration of 126 neutrons,[3] so might isotopes such as $_{65}Tb^{149}$ or $_{66}Dy^{150}$ and those differing by a few neutrons (such as $_{65}Tb^{148}$, $_{65}Tb^{150}$, $_{66}Dy^{151}$, or $_{67}Ho^{153}$, etc.) decay by relatively high energy alpha-particle emission as a consequence of their decay to or near the stable configuration of 82 neutrons. Such isotopes would, therefore, be attractive possibilities for the assignment of these new rare earth periods. It would be more consistent with this view to assign the long-known natural radioactivity of samarium to $_{62}Sm^{147}$ (and/or $_{62}Sm^{148}$) rather than to $_{62}Sm^{152}$ (present best tentative assignment),[4] but, on the other hand, other stable configurations with a larger number of neutrons[5] may also be important.

In view of these new data it can be seen that alpha-decay in the lighter elements is more prevalent than hitherto recognized, and therefore these investigations are being continued. This letter is intended only as a very preliminary report and more complete results will be reported at some future date.

We wish to thank James Vale and the crew of the 184-inch cyclotron for their assistance in carrying out the work.

This work was performed under the auspices of the U. S. Atomic Energy Commission.

[1] See, e.g., T. P. Kohman, Phys. Rev. **76**, 448 (1949). This contains a rather complete list of references to other publications on this subject.
[2] See, e.g., Maria G. Mayer, Phys. Rev. **74**, 235 (1948).
[3] Perlman, Ghiorso, and Seaborg, Phys. Rev. **75**, 1730 (1948).
[4] A. J. Dempster, Phys. Rev. **73**, 1125 (1948).
[5] N. Feather, Nature **162**, 412 (1948).

Betatron-Produced Sources of High Specific Activity: Copper 62*

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THIN metallic foils have been activated, employing a probe technique, by bombardment with a 22-Mev betatron. Specific activities in excess of 5 millicuries of Cu^{62} positron activity per gram have been obtained with 2-mm strips of half-mil copper foil (approximately 11 mg/cm²). These sources were employed to measure the positron spectrum by means of a 180-degree type magnetic spectrometer. The technique of activation is shown in Fig. 1. The electron beam, of small cross section, was caused to strike a lead converter, the resulting beam of x-rays in turn activating the folded foil. The presence of the converter greatly enhanced the strength of the activity since gamma-cross sections are of the order of 400 times larger than electron cross sections.[1] The specific activities thus obtained were more than a thousand times greater than those realized when the betatron is employed in the conventional manner with an x-ray donut. The procedure

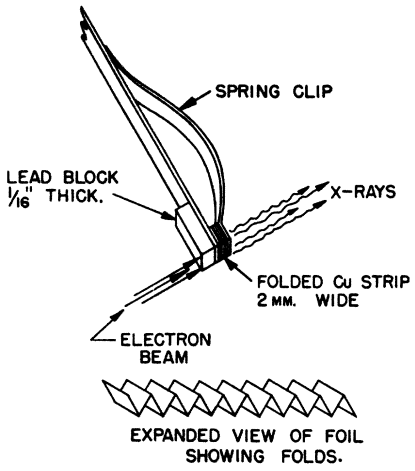

FIG. 1. Technique of activation of the foils.

took advantage of the tiny cross section of the beam at the probe, resulting in a high concentration of x-ray quanta in that region. After irradiation the foils, which had been cut to size prior to bombardment, were removed through an air lock, unfolded, and inserted in the spectrometer.

Figure 2 shows a Kurie plot of preliminary work with the 10-minute positron activity of Cu^{62}. Several sources were required because of the short decay time, and the major error arose from the normalization of the samples. The spectrometer had a resolution of about 1.25 percent. The field of the spectrometer was continuously monitored by comparing, with a null method, the e.m.f. generated by a rotating coil between the pole faces with that by a coil rotating in the gap of a standard permanent magnet. The latter was calibrated by means of the photoelectrons ejected from a 20 mg/cm² uranium foil by the gamma-rays of Co^{60}. The values of Lind *et al.*[2] for the Co^{60} lines were used. Two sets of measurements were obtained with a path radius of 10 cm, and one at 8 cm. The endpoints, respectively, were 2.88, 2.84, and 2.78 Mev. A mean was chosen to be 2.83±0.05 Mev. This figure is greater than that quoted by Crittenden.[3]

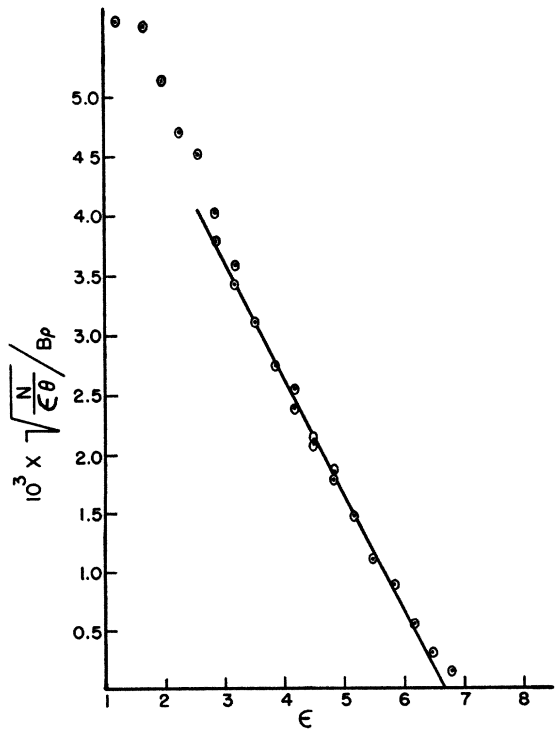

FIG. 2. Kurie plot of Cu^{62} positrons.

* Aided by the joint program of the ONR and AEC.
[1] Skaags, Laughlin, Hanson, and Orlin, Phys. Rev. **73**, 420 (1948).
[2] Lind, Brown, and DuMond, Phys. Rev. **76**, 591 (1949). The figure there quoted erroneously for the lower energy line was corrected by private communication from DuMond.
[3] E. C. Crittenden, Jr., Phys. Rev. **56**, 709 (1939).

Energy of an Excited State of Li^7

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IN a recent unpublished note, H. Primakoff and E. Feenberg suggested the possibility of the existence of two closely spaced excited states in Li^7. This hypothesis[1] appears necessary because of the selection rules in the Be^7 decay and the $B^{10}(n, \alpha)Li^{7*}$ reaction. The first step made to test this hypothesis was to compare the energies of the radiations emitted in the transitions $Li^{7*} \rightarrow Li^7$ for different methods of producing Li^{7*}. Many measurements of the energy of the radiation following the transition $Be^7 \rightarrow Li^{7*}$ have been reported,[2] but some of the energies reported for this radiation are sufficiently different from the energy of the gamma-radiation following the transition $B^{10}(n, \alpha)Li^{7*}$ reported by Elliott and Bell,[3] to allow the possibility of the existence in the Li^7 of two excited states, reached, one by the K-capture in Be^7 and the other by the emission of an alpha-particle by the compound nucleus B^{11}. The purpose of the present work is to restrict the possible existence of these excited states to a very narrow band by measuring the energy of the gamma-radiation following the transition $Be^7 \rightarrow Li^{7*}$ by comparing this energy with the energy of the gamma-radiation emitted by Au^{198}. This method was used by Elliott and Bell to determine the energy of the radiation following the transition $B^{10}(n, \alpha)Li^{7*}$. The source was prepared by bombarding an internal target of lithium metal in the Washington University cyclotron with 9-Mev deuterons for 17,000 microampere hours. The Be^7 was then chemically separated from the lithium following a procedure suggested by Dr. G. Friedlander[4] the final product about 5 mgs of beryllium acetate (about 5 mgs of beryllium carrier were added) was sealed in a glass tube. A source of Au^{198} obtained from the Oak Ridge pile was sealed in an identical tube. The energies of radiations emitted by the two sources were compared in a 180° beta-ray spectrometer[5] by comparing the energy of the photoelectrons produced in an uranium radiator of 50 mg/cm², and 1 mm wide. The measurements were made in the following order: measurement of the gold line, then the lithium line, gold again, then lithium again. These measurements were executed one immediately after the other. The bracketing of the lithium measurement between two measurements of the gold line, and the repetition of the lithium measurement showed that the field measuring device (flip coil connected to a galvanometer) did not vary during the experiment. The reference point for the measurement of momentum was taken at the peak of photoelectron lines. It should be noted that any point on the photoelectron lines could be taken as a reference since each of the four measured lines should be identical by virtue of the fact that the source was always located at the same position relative to the uranium radiator and that the same radiator was always used. Values obtained for the momentum in arbitrary units were (see also Fig. 1):