Internal Conversion Electrons from Sm^{153}-47 Hour

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The internal conversion electron spectrum of 47-hour beta-radioactive Sm^{153} has been investigated with a beta-ray spectrograph. Fourteen lines have been measured in the energy region up to 300 kev, nine of which can be attributed to internal conversions of two gamma-rays of 103 and 69.5 kev energy. Other lines are due to Auger electrons from Eu^{153}, and two weak lines are not assigned.

1. INTRODUCTION

A SUMMARY of data concerning the radioactivity of Sm^{153}-47 hour is given in the Plutonium Project Report.[1] Sm^{153} emits beta-rays with an upper energy limit of approximately 700 kev and gamma-rays of approximately 100 and 600 kev.[2-4] It has also been reported by Wu and Segrè[5] that 47-hour Sm emits x-rays, and Bothe[6] showed that these are characteristic of Eu (63) and therefore follow the beta-ray emission. Finally, Burson and Muehlhause[7] have found the existence of a high coincidence rate between the x-rays emitted from 47-hour Sm.

2. APPARATUS

The beta-ray spectrograph was a 180° focusing type with a maximum radius of curvature of 20 cm. The source, slit system, and photographic plate were mounted in an aluminum tray, which could be inserted, with suitable vacuum- and light-tight seals, in a brass box fitting between the poles of a permanent magnet. The magnet, of the double window yoke type, was formed by slabs of soft iron energized by short Alnico permanent magnets placed between the yoke and pole pieces. The poles were rectangular with sides of 30.5 cm by 51 cm, and the air gap of 7.5 cm had a field of approximately 102 oersteds. The field did not vary by more than 0.2 percent over an area within 4 cm of the pole-face edges. This area amply covered the space in which the electrons were bent to form spectra. The energy range of the spectrograph extended up to 300 kev.

TABLE I. Internal conversion lines from Sm^{153}-47 hour.

$H\rho$ (oersted cm)	E (kev)	Assignment	Gamma-ray energy (kev)
495	21.2	γ_1-K	21.2+48.6= 69.8
627	33.3	$K\alpha_{1,2}-L_{\mathrm{I}}$	
637	34.5	$K\alpha_{1,2}-L_{\mathrm{III}}$	
687	39.9	$K\alpha_{1,2}-M$	
808	54.3	γ_2-K	54.3+48.6=102.9
861	61.1	γ_1-L_{I}	61.1+ 8.1= 69.2
868	62.3	$\gamma_1-L_{\mathrm{III}}$	62.3+ 7.0= 69.3
906	67.2	γ_1-M	67.2+ 1.8= 69.0
916	68.8	γ_1-N	68.8+ 0.4= 69.2
964	75.8	?	
1000	81.2	?	
1087	95.0	γ_2-L	95.0+ 8.0=103.0
1124	101.5	γ_2-M	101.5+ 1.8=103.3
1134	103.1	γ_2-N	103.1+ 0.4=103.5
Weighted means of gamma-ray energies:			γ_1= 69.4 kev
			γ_2=103 kev

The source was prepared by pressing the adhesive side of a 1-mm wide strip of cellulose tape on to the activated Sm_2O_3 powder. The intensity of the source was of the order 0.1 millicurie. The slits were 2 mm wide and subtended an angle of approximately 5° at the source. Good intensity of the conversion lines was obtained using exposures of about one day, for two or three days following activation. The film used was Eastman industrial x-ray.

3. RESULTS AND DISCUSSION

The measured $H\rho$ values of the observed conversion lines are shown in Table I. Some indication of the relative intensities of the lines can be gathered from Fig. 1.

Nine of the lines can be assigned to conversions of two gamma-rays of 69.5 and 103 kev. The absolute error of these energies may be of the order 1 kev. In obtaining these energies the electron work functions pertaining to Eu(63)

[1] Plutonium Project Report, Rev. Mod. Phys. **18**, 513 (1946).
[2] L. Winsberg and others, reference 1.
[3] L. C. Miller and L. F. Curtiss, reference 1.
[4] L. Meitner, Arkiv f. Mat. Astro. Fysik **A27**, 18 (1940).
[5] C. S. Wu and E. Segrè, Phys. Rev. **61**, 203 (1942).
[6] Bothe, Zeits. f. Naturforschung **1**, 179 (1946).
[7] Burson and Muehlhause, private communication.

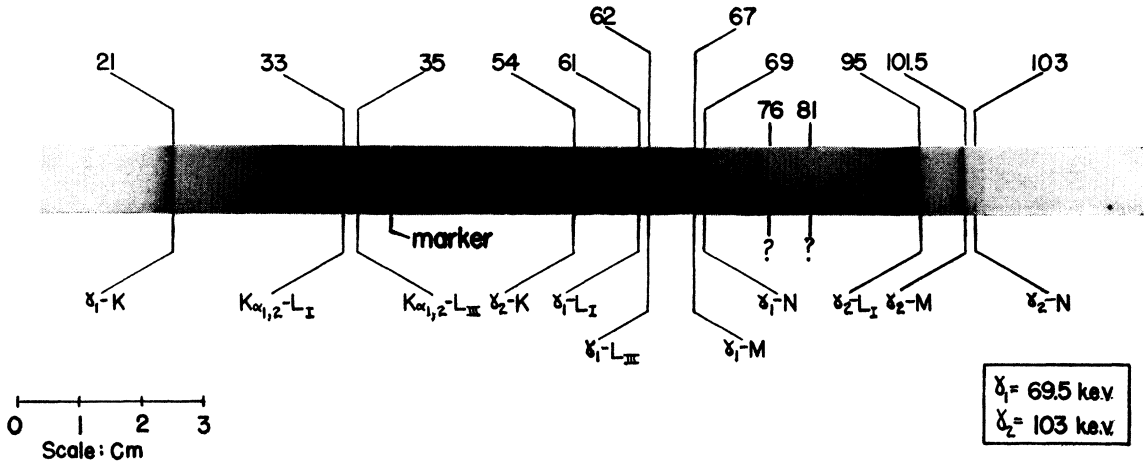

FIG. 1. Internal conversion electrons from Sm^{153}-47-hr.

have been used. It can be shown, in fact, that conversion of these gamma-rays in Sm(62), or in any element other than Eu, is inconsistent with the value of the magnetic field of the spectrograph.

The x-ray critical absorption energies can be used to obtain an accurate evaluation of the magnetic field. Once an assignment of the conversion lines has been made from an approximate value of the field, the accurate x-ray energy level values can then be used to calculate accurately the value of the field which will bring the gamma-ray energies derived from the K, L, M, N conversions into agreement. Check measurements of the well-known UX_1 conversion line at 92.5 kev[8,9] have also been made. Using the derived field of 101.8 oersteds, an energy of 92.0 kev was obtained for this line.

Other lines present in the Sm^{153} conversion spectrum are Auger lines arising from the internal conversion of Eu(63) x-rays. These lines at 33.3, 34.5, and 39.9 kev, although composite, show sharp edges where the more intense $K\alpha_1$ components are converted. Two other weak lines at 76 and 81 kev are unaccounted for. They appear, however, to be characteristic of Sm^{153}-47 hour.

There is no indication of conversion lines that might arise from combinations of the two observed gamma-ray lines, i.e., in the regions of $(103+69.5-K)$ and $(103-69.5-L)$.

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[8] L. Meitner, Handbuch der Physik **20** (1933).
[9] Bradt and Scherrer, Helv. Acta Phys. **19**, 307 (1946).

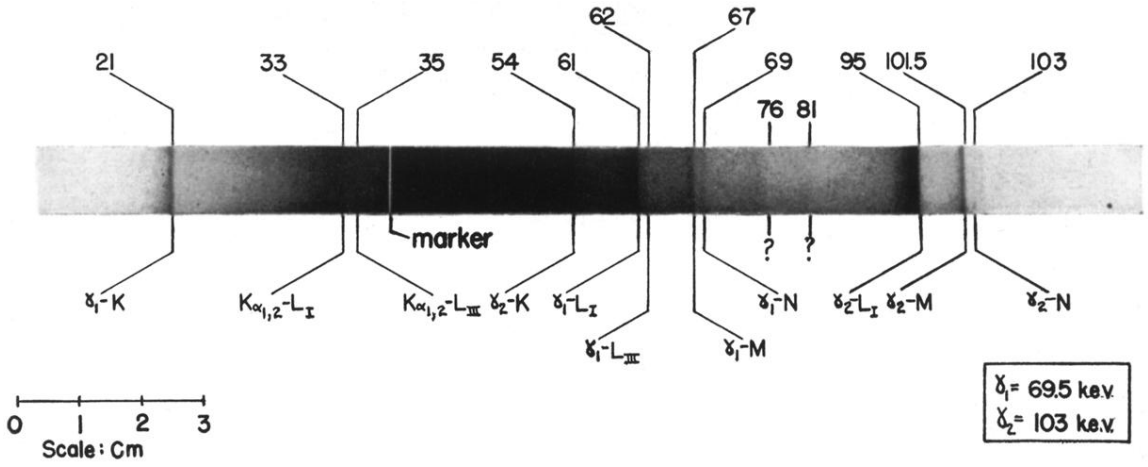

FIG. 1. Internal conversion electrons from Sm^{153}-47-hr.