UNITED STATES ATOMIC ENERGY COMMISSION

AECD-2916

THE RADIOACTIVITY OF Am^{242}

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July 18, 1950

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Date Declassified: August 22, 1950

PRINTED IN U.S.A.
PRICE 5 CENTS

AEC, Oak Ridge, Tenn., 11-13-50--900-A26329

THE RADIOACTIVITY OF Am^{242}

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The neutron irradiation of 475-year Am^{241} results in the production of a pair of isomers,[1,2] Am^{242m} with 16-hr half-life known to decay by β^- emission and a long-lived ground state, Am^{242}, which is also a β^- emitter and has weak alpha branching. Since fairly strong activities can be prepared by pile-neutron irradiation of small quantities of Am^{241}, it became feasible to examine the radiations, particularly those of Am^{242m}, with beta-ray and X-ray spectrometers. When this was done, not only was the β^- transition characterized, but good evidence was obtained that in addition this isomer undergoes appreciable branching decay by isomeric transition and by electron capture.

The electron-capture branching results in the long-lived plutonium isotope, Pu^{242}, which was found with a mass spectrograph upon examination of the plutonium fraction from a sample of americium which had been subjected to long neutron irradiation.[3]

Much of the information on the modes of decay of Am^{242m} was derived from a bent-crystal X-ray spectrometer used to analyze the L X-ray mixture. This instrument and its use in measuring the L-series X-rays accompanying radioactive decay in the heavy-element region are described in another publication.[4] When the irradiated Am^{241} was observed with the X-ray spectrometer, L-series X rays of curium (96), americium (95), plutonium (94), and neptunium (93) were identified, among which the $L\beta_1$, $L\beta_2$, $L\alpha_1$, and $L\gamma_1$ lines were in greatest abundance. The curium, americium, and plutonium X rays decayed with a 16-hr half-life, but the neptunium X-ray intensity did not decrease over a period of several days. The origin of the X rays are presumably as follows: those of curium from an internal-conversion process following the β^- transition, the americium X rays from internal conversion in the isomeric transition of Am^{242m}, the plutonium X rays following electron-capture decay, and the neptunium X rays (which did not decay) following the internal conversion of a γ ray known to exist in the alpha decay[1] of Am^{241}. Table 1 lists the principal X-ray lines observed, their measured energies and relative intensities, and the energies calculated, using the Moseley relation in a manner described elsewhere.[4] The complete X-ray spectra and other decay properties of Am^{242} will be discussed more fully at a later date. It is worth noting, however, that for a particular level vacancy, the ratios of intensities of different lines are about the same (as they should be), and the relative incidence of L_{II}

*Work performed under Contract No. W-7405-Eng-48.

and L_{III} lines is roughly equal both for the plutonium and curium X rays, but those lines from the isomeric transition (americium X rays) show the L_{III}-level X rays to be about five times as abundant as those from the L_{II} level. Selection rules are probably in force here which are responsible for the selection of the L_{III} level (a $p_{3/2}$ state) and for the long lifetime of the metastable state.

The β^--ray spectrum of Am^{242m} was taken with a 255-deg-shaped magnetic field β-ray spectrometer using a resolution of 3 per cent. The Fermi-Kurie plot of the continuous β^- spectrum showed an end point of 628 ± 5 kev. Two sets of L conversion lines were seen, corresponding to gamma rays of 38 and 52 kev, assuming the former to be a plutonium γ ray and the latter to be from americium. In attempting to assign these gamma rays to the several transitions, the differences between L_{II} and L_{III} lines were matched with expected differences of the edges for plutonium, americium, and curium. The assignments on this basis are not conclusive, since the differences in spacing between successive elements are about the same as the experimental uncertainties of electron energies. Tentatively, as indicated above, the 52-kev γ ray is assigned to the isomeric transition and the 38-kev γ ray to the electron-capture transition. This leaves unaccounted for the origin of the X rays of curium, so if the above assignments are to be taken seriously, the conversion electrons following the β^- decay must lie among the Auger electrons. There is some evidence that this is the case.

Table 1--Principal X-ray Lines in Decay of Am^{242m}

X-ray line designation		level transition	Measured energy	Relative intensity (corrected)*	Calculated energy
Pu	$L\alpha_1$	L_{III}-M_V	14.33 ± 0.01	68	14.31
	$L\beta_2$	L_{III}-N_{IV}	17.32 ± 0.02	22	17.29
	$L\beta_1$	L_{II}-M_{IV}	18.34 ± 0.02	54	18.30
	$L\gamma_1$	L_{II}-N_{IV}	21.52 ± 0.05	18	21.43
Am	$L\alpha_1$		14.66 ± 0.02	39	14.66
	$L\beta_2$		†		
	$L\beta_1$		18.90 ± 0.07	8	18.84
	$L\gamma_1$		†		
Cm	$L\alpha_1$		15.01 ± 0.01	100	15.00
	$L\beta_2$		18.13 ± 0.04	36	18.08
	$L\beta_1$		19.48 ± 0.02	107	19.38
	$L\gamma_1$		22.78 ± 0.07	33	22.68

*Estimated corrections for crystal and counter-window absorption and reflection-intensity variation with energy.

†Not resolvable from other lines.

Lead and copper absorption curves showed no hard γ rays or K X rays and only the 50-kev soft γ ray. When compared with the abundance of the conversion electrons, this γ ray appears to be about 50 per cent converted.

From arguments (not all consistent) based on relative abundances of X rays, conversion electrons, and the β^- particles, Am^{242m} appears to decay about 60 per cent by β^- emission, 20 per cent by L-electron capture, and 20 per cent by isomeric transition. All three modes of decay give rise to L-series X rays which, when properly assigned and the abundances are measured, should aid materially in arriving at a decay scheme and in shedding light on the nuclear processes which result in the particular X rays of this interesting nucleus.

The β^- particle of the ground state of Am^{242} has also been measured, but the accuracy of the end point has not yet been determined with desirable accuracy. The value obtained is 580 $\pm$ 30 kev, which is consistent with the supposed 52 kev associated with the isomeric transition of Am^{242m}.

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

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