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DECAY PROPERTIES OF THE NEW ISOTOPES ^{243}Cf AND ^{244}Cf

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ERRATUM

TO: All recipients of UCRL-17363
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Subject: UCRL-17363, "Decay Properties of the New Isotopes ^{243}Cf AND ^{244}Cf ,"
Torbjorn Sikkeland, Albert Ghiorso, Jaromir Maly, and Matti J. Nurmi,
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Please change title on cover, title page, and page 1 of UCRL-17363
to read:

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DECAY PROPERTIES OF THE NEW ISOTOPE ^{243}Cf AND ^{244}Cf

Torbjorn Sikkeland, Albert Ghiorso, Jaromir Maly, and Matti J. Nurmia

February 1967

DECAY PROPERTIES OF THE NEW ISOTOPES ^{243}Cf AND $^{244}\text{Cf}^*$

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A new isotope of californium ^{243}Cf has been produced in the bombardments of ^{235}U , ^{236}U , and ^{238}U with ^{12}C ions. At the same time new values for the half-life and α energy observed in the decay of ^{244}Cf were obtained.

The experimental arrangement was identical to that used in the discovery¹ of ^{242}Cf in which various uranium isotopes were bombarded with ^{12}C .

Figure 1 shows a typical α spectrum obtained in the bombardment of ^{236}U with ^{12}C . We shall here discuss in some detail the α group at 7.05 MeV, that in the previous report was tentatively assigned to ^{243}Cf , and the group at 7.21 MeV that was assigned to ^{244}Cf .

1. ^{243}Cf . A least-square analysis of the decay of the α group at 7.05 ± 0.02 MeV in which about 300 events were used gave a half-life of 10.3 ± 0.5 min. The assignment of the emitter to ^{243}Cf was based on the excitation functions of its production in ^{12}C reactions on ^{235}U and ^{236}U . In the former, the shape of the function corresponded to a (^{12}C , 4n) reaction, and in the latter to a (^{12}C , 5n) reaction. We also observed this activity in a $^{238}\text{U}({}^{12}\text{C}, 7n)$ reaction, although here it was partly masked by the tail of an intense group at 7.14 MeV from ^{245}Cf . Indirect experimental evidence that ^{243}Cf also has other decay modes was obtained from cross-section systematics for (^{12}C , xn) reactions as shown in

the following. At a particular value of x , the maximum cross section, σ_x , for such reactions is, to a good approximation, proportional to the quantity $(\bar{\Gamma}_n/\bar{\Gamma}_t)^x$. Here $\bar{\Gamma}_n/\bar{\Gamma}_t$ is the geometric mean of the relative level widths for neutron emission for the nuclides in the cascade of x neutrons. For these nuclides the quantity $\log(\bar{\Gamma}_n/\bar{\Gamma}_t)$ is expected to vary very nearly linearly with \bar{A} , the average mass number of the nuclei in that cascade.² Hence one can set

$$\log \sigma_x = C_x + xC_0\bar{A}, \quad (1)$$

where C_x is a constant dependent only on x , and C_0 is independent of both \bar{A} and x .

These constants were determined from the measured maximum cross sections for (^{12}C , $4n$) reactions with ^{234}U , ^{236}U , and ^{238}U as targets, and for (^{12}C , $5n$) reactions with the targets ^{235}U and ^{238}U . The calculated maximum cross sections for $^{235}\text{U}(\text{}^{12}\text{C}, 4n) \text{}^{243}\text{Cf}$ and $^{236}\text{U}(\text{}^{12}\text{C}, 5n) \text{}^{243}\text{Cf}$ were found to be larger than the measured cross sections for the 7.05-MeV 10-min α activity, by a factor of 9 ± 2 and 12 ± 2 , respectively. The weighted average of these values is 10 ± 2 . Hence, the partial α half-life for this group is 100 ± 20 min, which corresponds to an unhindered α decay.

The energy of the ground-state transition α 's in the decay of ^{243}Cf is predicted³ to be about 7.17 MeV. According to the energy-level diagram of Nilsson,⁴ the odd neutron for the ground state of the nuclide ^{243}Cf is in the state $1/2+[631]$, and that of the daughter ^{239}Cm is in the state $7/2-[743]$, and hence the transition between these two states will be unfavored.

An excited-neutron level, $1/2+[631]$, in the daughter is expected, to which a favored decay will take place. The 7.05-MeV α group apparently is a manifestation of that transition, and the level $1/2+[631]$ in ^{239}Cm then is about 120 keV above the ground state.

It appears from our experiments that other α groups from ^{243}Cf must have intensities less than that of 7.05 MeV. Hence, we conclude the dominant mode of decay of ^{243}Cf to be by electron capture (EC) to ^{243}Bk , and the branching ratio EC/ α to be about 10.

2. ^{244}Cf . This nuclide was produced in $^{235}\text{U}(^{12}\text{C}, 3n)$, $^{236}\text{U}(^{12}\text{C}, 4n)$ and $^{238}\text{U}(^{12}\text{C}, 6n)$ reactions. In the last system the 7.14-MeV alphas from ^{245}Cf , produced simultaneously, interfered with the α spectrum from ^{244}Cf . In the bombardment of ^{236}U with 69-MeV ^{12}C , the yield of ^{245}Cf was about two orders of magnitude less than that of ^{244}Cf , and this system was used to study the decay properties. The decay of 2000 events of ^{244}Cf was followed over 8 half-lives and a least-square-fit analysis gave a half-life of 19.4 ± 0.6 min.

In separate experiments, the energy spectrum of the α 's from ^{244}Cf was studied in greater detail, with the 7.070-MeV α 's from ^{217}At and the 7.680-MeV α 's from ^{214}Po used as calibration sources.

With 2.5 keV/ch, the group at 7.21 MeV was resolved into two, one at 7.214 MeV and the other 40 ± 4 keV lower. The ratio of the intensity of the former group to that of the latter was 3.0 ± 0.3 . Apparently the former consists of α 's from a ground-state transition and the latter of α 's from a transition to the $2+$ rotational level associated with the ground state. The FWHM of the group at 7.214 MeV was measured to be 21 keV.

^{244}Cf has been reported to emit alphas with an energy of $7.17 \pm .01$ MeV and a half-life of 25 ± 3 min.⁵

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‡ On leave of absence from the Department of Physics, University of Helsinki, Finland.

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Fig. 1. Alpha spectrum from eight 20-min bombardments of $500 \mu\text{g}/\text{cm}^2$ of ^{236}U with about 80 MeV ^{12}C of intensity $6 \mu\text{A}/\text{cm}^2$ (+6 ions).

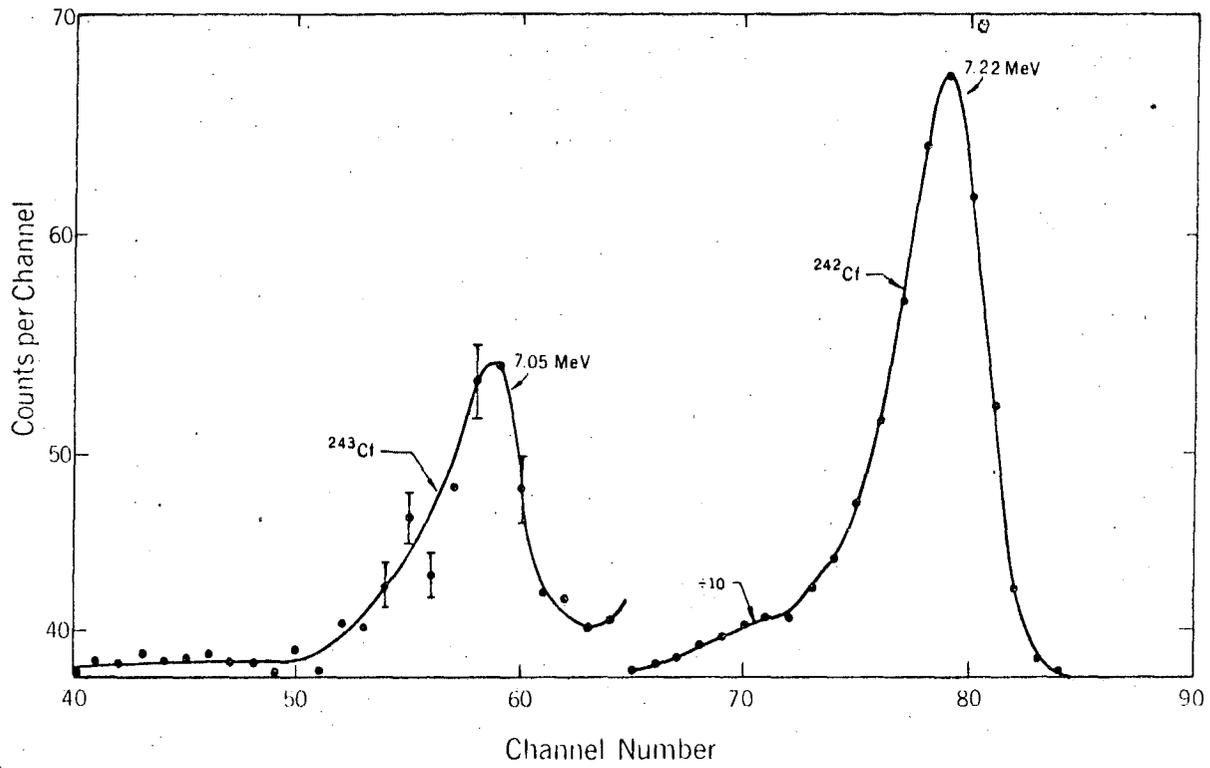


Fig. 1

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