UCRL-1772
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Radiation Laboratory

Contract No. W-7405-eng-48

SPONTANEOUS FISSION OF U^{234}, Pu^{236}, Cm^{240}, AND Cm^{244}

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In a recent communication commenting on the mechanism of fission we called attention to the simple exponential dependence of spontaneous fission rate on Z^2/A and to the effect of an odd nucleon in slowing the fission process.[1] Since it is of interest to test further the simple correlation of the spontaneous fission rate for even-even nuclides with Z^2/A, a further number of such rates have been determined.

The spontaneous fission rates were measured by placing the chemically purified samples on one electrode of a parallel plate ionization chamber, filled with a mixture of argon and carbon dioxide, which was connected with an amplifier followed by a register and a stylus recorder. The results are summarized in Table I.

Table I.* Spontaneous fission rates of U^{234}, Pu^{236}, Cm^{242}, and Cm^{244}.

Nuclide	Fissions/gm-hr	"Half-life" (years)
U^{234}	13 ± 6	$2 \pm 1 \times 10^{16}$
Pu^{236}	$5.8 \pm 2 \times 10^{7}$	$3.5 \pm 1 \times 10^{9}$
Cm^{240}	$1.0 \pm 0.2 \times 10^{11}$	$1.9 \pm 0.4 \times 10^{6}$
Cm^{244}	$1.4 \pm 0.2 \times 10^{10}$	$1.4 \pm 0.2 \times 10^{7}$

*The errors indicated are statistical only and do not include any estimate for possible systematic errors.

The U^{234} was a sample of high isotopic purity obtained by the electromagnetic concentration process, the Pu^{236} was prepared by bombarding highly enriched U^{235} with 18 Mev deuterons according to the reactions

$$U^{235}(d,n)Np^{236} \xrightarrow{\beta^-} Pu^{236},$$

the Cm^{240} came from the bombardment of Pu^{239} with 38 Mev helium ions according to the reaction $Pu^{239}(\alpha,3n)Cm^{240}$, and the Cm^{244} came from the pile neutron bombardment of Am^{243} (containing Am^{241}) by the reactions

$$Am^{243}(n,\gamma)Am^{244} \xrightarrow{\beta^-} Cm^{244}.$$

By the nature of their methods of production, the Cm^{240} and Cm^{244} contained some Cm^{242} whose spontaneous fission had to be subtracted from the total rate in each case. The Cm^{240} also contained some Cm^{241}, but since the fission rate seemed to decay with the half-life of Cm^{240}, the contribution of the Cm^{241} must have been small. This observation on Cm^{241} would agree with the lower rate expected for nuclides having odd nucleons. The result for U^{234} is consistent with the earlier observation of Segrè[2] who reported an upper limit of 30 spontaneous fissions/gram-hour.

These data are included in Fig. 1 which is otherwise identical with the plot in the previous report[1](where references are given), with the exception that odd nucleon nuclides, which apparently all fall above the line, are not included. As can be seen, the new even-even nuclides fit in fairly well with the correlation. However, some even-even nuclides such as U^{234}, and possibly also U^{232} and Th^{230}, exhibit substantial deviations in the direction of slower rates. It is apparent

that more data are needed in order to establish the pattern for even-even nuclides in detail. Nevertheless, it can be definitely stated that the spontaneous fission rates for even-even nuclides seem to define a certain limiting rate, and it seems especially significant that the extrapolation of the line (in Fig. 1) representing this rate to the region of instantaneous rate (that is, half-life of the order of 10^{-20} seconds) gives a value of about 47 for Z^2/A, which corresponds with the predicted limiting value for Z^2/A.

Similar considerations in regard to spontaneous fission rates have recently been published by Whitehouse and Galbraith.[3]

We wish to express our appreciation to Professor J. G. Hamilton, T. M. Putnam, Jr., G. B. Rossi, and the operating crew of the 60-inch cyclotron of the Crocker Laboratory for their help in the bombardments. We would also like to thank the Y-12 Area of the Oak Ridge National Laboratory for supplying the highly purified U^{234} sample. This work was performed under the auspices of the U. S. Atomic Energy Commission.

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[1]G. T. Seaborg, Phys. Rev. 85, 157 (1951).

[2]E. Segrè, U. S. Atomic Energy Commission Declassified Document LADC-975 (May 8, 1951).

[3]W. J. Whitehouse and W. Galbraith, Nature 169, 494 (1952).

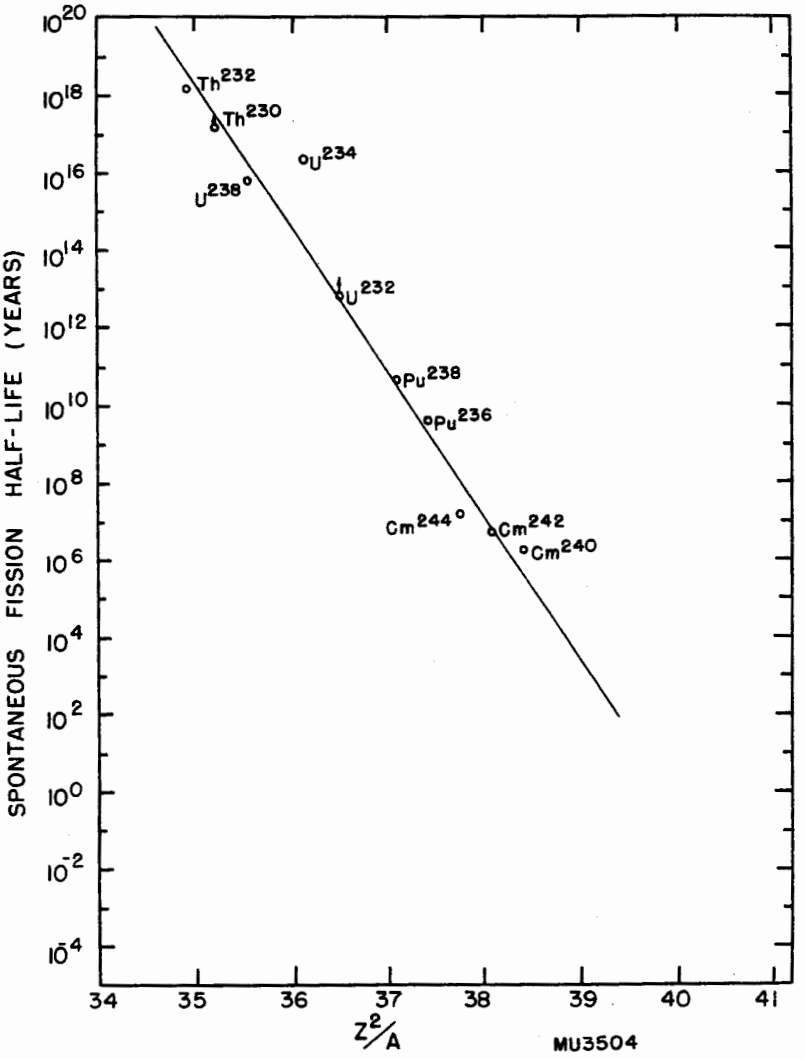

Fig. 1. Plot of spontaneous fission rates of even-even nuclides (δ signifies lower limit to half-life).