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SPONTANEOUS FISSION OF LIGHT FERMIUM ISOTOPES; NEW NUCLIDES ^{244}Fm AND ^{245}Fm

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SPONTANEOUS FISSION OF LIGHT FERMIUM ISOTOPES;* NEW NUCLIDES ^{244}Fm AND ^{245}Fm

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ABSTRACT

The spontaneous fission half-lives of ^{246}Fm and ^{248}Fm were determined. The new nuclides ^{244}Fm and ^{245}Fm were identified and their decay studied.

In two recent papers[1,2] we presented a discussion of the available data on the spontaneous-fission half-lives of nuclides near the 152-neutron sub-shell. These data, especially the reassignment of the 2.3 - second spontaneous fission activity from ^{254}No[3,4] to ^{252}No, suggest that the fission half-lives of the even-even isotopes of the heaviest elements exhibit a sharp maximum at N = 152 and decrease rapidly at neutron numbers not only above 152 but also below it. The main purpose of this letter is to report new experimental evidence for the latter trend in the case of three light isotopes of fermium.

We have observed a spontaneous-fission branching in the decay of ^{248}Fm and ^{246}Fm using mica to scan a rotating drum, recoil-collection device. These nuclides were produced by bombarding targets of ^{233}U, ^{235}U and ^{236}U with beams of ^{16}O ions and targets of ^{239}Pu and ^{240}Pu with ^{12}C ions. The targets were about 500μg/cm^2 and the beam intensities about 2 μamperes over an area of 0.2 cm^2. The assignment of the fission activities to the above nuclides was made by comparing the half-lives and excitation functions with those of the known alpha activities of ^{248}Fm and ^{246}Fm. The latter were obtained with semi-conductor

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

detectors in the conveyor-gas system described in Ref. 2. In the case of ^{246}Fm the fission branching was large enough to allow simultaneous measurement of the alpha spectrum and the fission events in the conveyor-gas system.

In the course of these experiments, a new alpha activity of 8.15 MeV energy was observed in the bombardments of ^{233}U and ^{234}U with ^{16}O and ^{239}Pu with ^{12}C. Fig. 1 shows the decay curve and half-life obtained for this alpha activity. A comparison of the experimentally observed excitation function for the ^{233}U (^{16}O, 4n) reaction with that computed for compound nucleus formation in a manner described elsewhere[5] is shown in Fig. 2. The activity was assigned to ^{245}Fm on the basis of its production in the cross-bombardments with the expected excitation functions and from alpha decay systematics[2].

Bombardments of ^{239}Pu and ^{240}Pu with ^{12}C ions and ^{235}U and ^{236}U with ^{16}O ions showed the presence of two distinct alpha activities of 8.18 and 7.87 - MeV energy with half-lives of approximately 5 and 30 seconds. These activities were assignable to ^{247}Fm as recently reported by the Dubna group[6].

Finally, a short-lived fission activity was observed in bombardments of ^{233}U with ^{16}O ions. A decay curve and half-life for this activity is shown in Fig. 1. The cross-section for production had the energy dependence expected for the (^{16}O, 5n) reaction as shown in Fig. 2. The activity was not produced in bombardments of the same target with ^{14}N ions. This was taken as indicating the activity is unlikely due to an isotope or isomeric state of an element other than fermium. The above evidence suggests the assignment of ^{244}Fm to this activity.

A summary of the observed properties of these nuclides is given in Table 1. Also shown is a comparison of the maximum values in the production cross-sections

with those calculated according to Ref. 5. Included are the energies at which the maxima occurred. In all cases, the experimental data is in reasonably good agreement with the calculated values. It should be pointed out that an excitation function in only a necessary and not a sufficient condition for the correct mass assignment of spontaneous fission activities and that further experimental work is being carried out.

The systematics of the spontaneous-fission half-lives of the heaviest elements in the light of the present results is shown in Fig. 3. The new data on the fermium isotopes clearly provide further support to the crucial assignment of the 2.3 - second fission activity to ^{252}No. They also serve to illustrate the dramatic effect of the 152-neutron subshell on the fission half-lives of the isotopes of the heaviest elements. This effect is in marked contrast with the relatively weak effect of the subshell on the alpha decay energies and half-lives of the same nuclides.

We are indebted to Tom Bowman for his help in the target preparations and the Hilac crew for excellent machine operation.

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Figure Captions

1. Decay curves for spontaneous fission of ^{244}Fm and alpha decay of ^{245}Fm.

2. Experimental (points) and calculated (solid lines) excitation functions for production of ^{244}Fm and ^{245}Fm from bombardment of ^{233}U with ^{16}O ions.

3. Systematics of the spontaneous-fission half-lives of the heaviest elements.

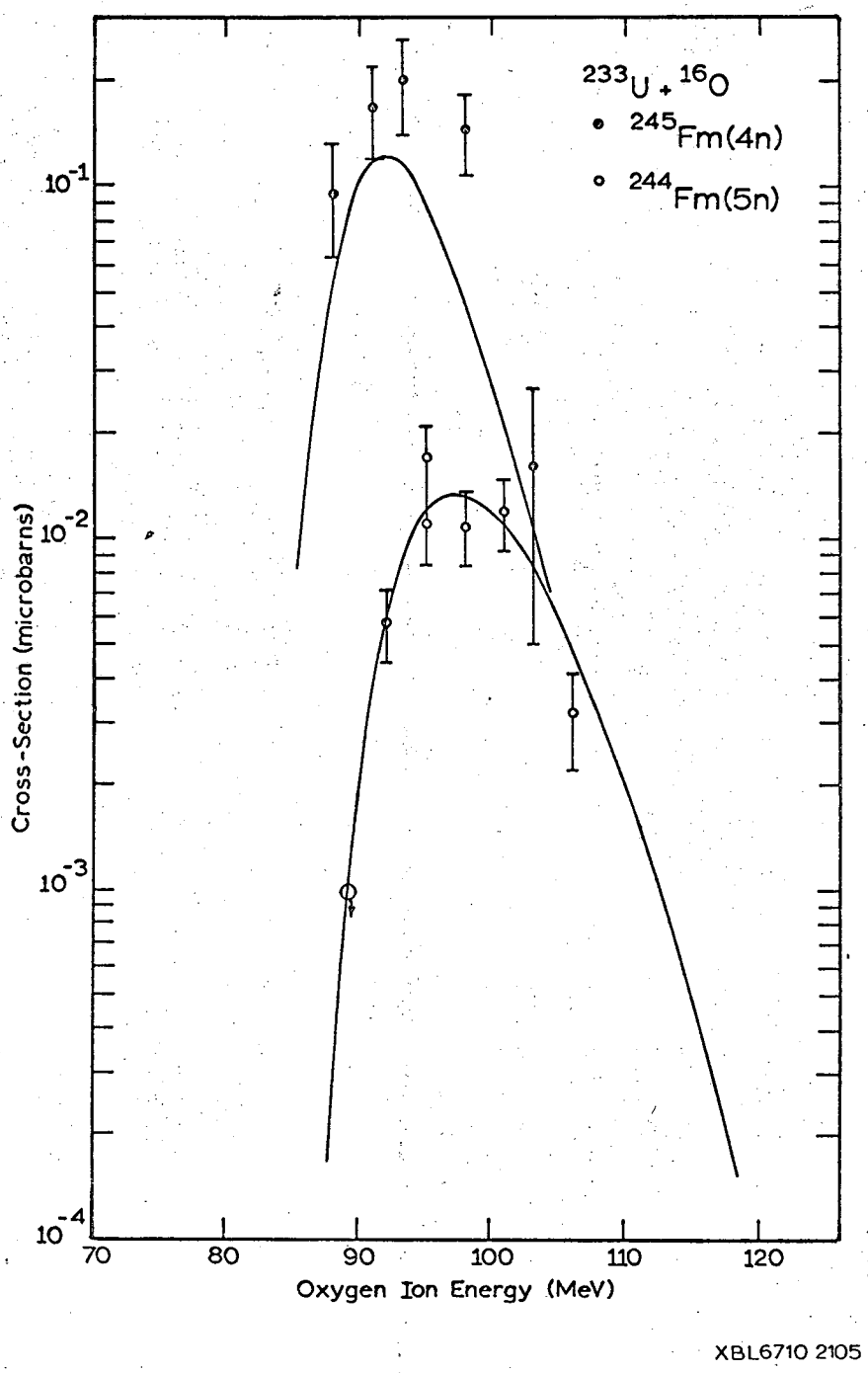
$^{233}U + ^{16}O$
$^{245}Fm(4n)$
$^{244}Fm(5n)$
Cross-Section (microbarns)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
70
80
90
100
110
120
Oxygen Ion Energy (MeV)
XBL6710 2105

Fig. 2

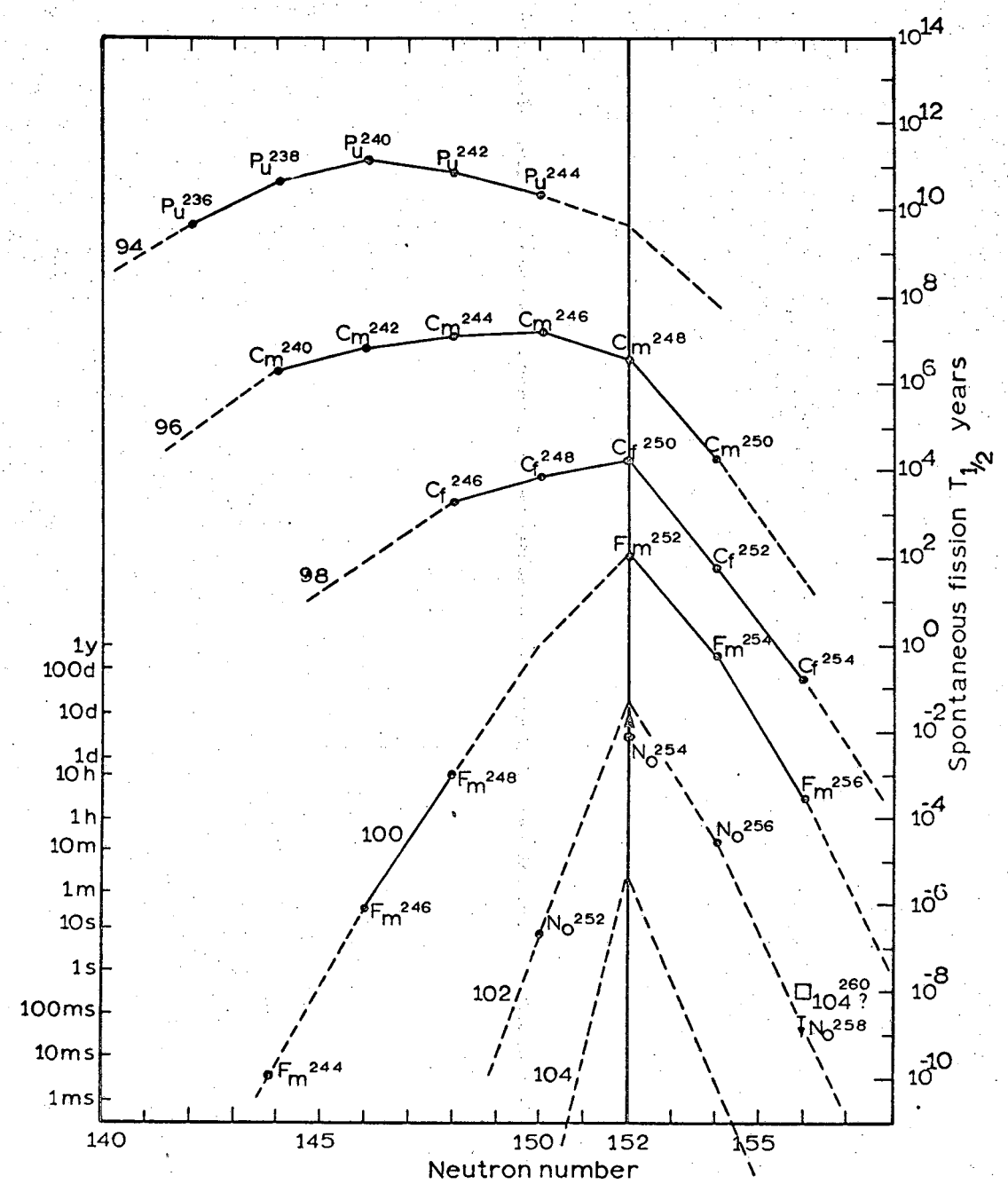

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Fig. 3