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PROMPT NEUTRONS FROM THE SPONTANEOUS FISSION OF FERMIUM-254

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### Authors

Choppin, Gregory R.

Harvey, Bernard G.

Hicks, Donald A.

et al.

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Abstract

The average number of prompt neutrons emitted during the spontaneous fission of fermium-254 has been measured to be  $4.05 \pm 0.19$  (standard error).

Introduction

The average numbers of prompt neutrons,  $\bar{\nu}$ , emitted during spontaneous fission have been measured for a number of nuclides,<sup>1, 2, 3</sup> and a general increase with increasing atomic number and weight of the fissioning nucleus has been observed up to and including californium-252. In the experiment reported here the average number of neutrons from the spontaneous fission of fermium-254 has been measured, with a cadmium-loaded liquid scintillator tank of the type developed at Los Alamos as a detector.<sup>4</sup>

Apparatus and Method

The apparatus and method have been described in a previous article.<sup>2</sup> Either of two similar parallel-plate ionization chambers could be placed at the center of the liquid scintillator tank, one containing the sample of  $\text{Cf}^{252}$ , which we use as a secondary neutron standard, and the other the  $\text{Fm}^{254}$ . With a discriminator set so that all fissions were counted, the fission chamber pulses were used to trigger an oscilloscope, and the fission, prompt gamma-ray, and neutron-capture pulses were recorded photographically. Background and californium standard data were taken before and after the fermium run, which was continued through 3.4 half lives ( $T_{1/2} = 3.2$  hours for alpha decay).<sup>5</sup>

### Fermium Sample

The fermium was produced in the Materials Testing Reactor by neutron irradiation of  $\text{Cf}^{252}$ .<sup>6</sup> Separation of the fermium fraction from einsteinium and californium was achieved with an ion-exchange resin column using ammonium  $\alpha$ -hydroxy isobutyrate as the elutant.<sup>7</sup> By measuring the fission rate after the complete decay of the fermium we determined that the sample contained sufficient californium-252 to yield  $0.186 \pm 0.007$  spontaneous fissions per minute. When this background fission rate is subtracted, the measured decay of the sample is consistent with the expected 3.2-hour half life.

### Data and Analysis

The neutrons from 3360  $\text{Cf}^{252}$  fissions in the secondary standard fission counter were counted. Using  $\bar{\nu} \text{Cf}^{252} = 3.82 \pm 0.12$ ,<sup>2</sup> we found the over-all neutron-detection efficiency during the measurements to be  $60.1 \pm 2.1\%$ ; the efficiency had fallen gradually over a period of several months from the original value of 80% because of the slow separation of part of the cadmium compound from the main body of the scintillation liquid.

A total of 870 fissions were recorded from the fermium plus californium sample, giving the distribution of fissions vs numbers of observed neutrons shown in Table I.

Table I

Numbers of fissions with  $\nu$  observed neutrons

$\nu$	0	1	2	3	4	5	6	7
Fissions	42	160	255	265	110	28	8	2

After correcting for the resolution of the apparatus and a background of 0.0050 pulse per fission, as described in Reference 2, and after subtracting the contribution from the californium contamination, we obtained the ratio  $(\bar{\nu}_{\text{Fm}}^{254})/(\bar{\nu}_{\text{Cf}}^{252}) = 1.061 \pm 0.037$  (standard error). With the above value for  $\bar{\nu}_{\text{Cf}}^{252}$ , the average number of prompt neutrons from the spontaneous fission of fermium-254 is  $4.05 \pm 0.19$ .

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