Prompt Neutrons from the Spontaneous Fission of Fermium-254†

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The average number of prompt neutrons emitted during the spontaneous fission of fermium-254 has been measured to be 4.05±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,[1–3] 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.[4]

APPARATUS AND METHOD

The apparatus and method have been described in a previous article.[2] Either of two similar parallel-plate ionization chambers could be placed at the center of the liquid scintillator tank, one containing the sample of Cf^{252}, which we use as a secondary neutron standard, and the other the 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 ($T_{\frac{1}{2}}=3.2$ hours for alpha decay).[5]

FERMIUM SAMPLE

The fermium was produced in the Materials Testing Reactor by neutron irradiation of Cf^{252}.[6] Separation of the fermium fraction from einsteinium and californium was achieved with an ion-exchange resin column using ammonium α-hydroxy isobutyrate as the elutant.[7] 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±0.007 spontaneous fission 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 Cf^{252} fissions in the secondary standard fission counter were counted. Using $\bar{\nu}(Cf^{252})=3.82\pm0.12$,[2] we found the over-all neutron-detection efficiency during the measurements to be 60.1±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 was 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 ν observed neutrons.

α	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 $\bar{\nu}(Fm^{254})/\bar{\nu}(Cf^{252})=1.061\pm0.037$ (standard error). With the above value for $\bar{\nu}(Cf^{252})$, the average number of prompt neutrons from the spontaneous fission of fermium-254 is 4.05±0.19.

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