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PROMPT NEUTRONS
FROM THE SPONTANEOUS FISSION OF FERMUM-254

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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, $\bar{v}$, emitted during spontaneous fission have been measured for a number of nuclides,\textsuperscript{1,2,3} 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.\textsuperscript{4}

Apparatus and Method

The apparatus and method have been described in a previous article.\textsuperscript{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\textsuperscript{252}, which we use as a secondary neutron standard, and the other the Fm\textsuperscript{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).\textsuperscript{5}
Fermium Sample

The fermium was produced in the Materials Testing Reactor by neutron irradiation of \(^{252}\text{Cf}\). Separation of the fermium fraction from einsteinium and californium was achieved with an ion-exchange resin column using ammonium \(\alpha\)-hydroxy isobutyrate as the eluant. 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 \(^{252}\text{Cf}\) fissions in the secondary standard fission counter were counted. Using \(\text{v} \text{Cf}^{252} = 3.82 \pm 0.12,\) 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 \(v\) observed neutrons

<table>
<thead>
<tr>
<th>(v)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fissions</td>
<td>42</td>
<td>160</td>
<td>255</td>
<td>265</td>
<td>110</td>
<td>28</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>
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 \( \frac{\bar{\nu} \text{Fm}^{254}}{\bar{\nu} \text{ Cf}^{252}} = 1.061 \pm 0.037 \) (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 \( 4.05 \pm 0.19 \).

Acknowledgments

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References

2. D. A. Hicks, J. Ise, Jr. and R. V. Pyle, submitted to the Physical Review (Phys. Rev. 101 (1956)). References to earlier work were included in this article.