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Half-Life of $^{137}Ba^{m}$

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ABSTRACT

We investigate the half-life of the radioactive isotope $^{137}Ba^{m}$. We measured the activity of three samples through use of a Geiger-Muller counter. Activity was measured for approximately 10 minutes per sample, and approximately 3 half-lives were observed for each sample. Our results indicate a half life of 147.9±4.2s, deviating from the accepted result of $t_{1/2}$ =153.1±0.06s by 3.4%.

Subject headings: radioactivity, half-lives, $^{137}Ba^{m}$

1. Introduction

Radioactive decay is a well-established phenomenon in which isotopes lose energy as a result of nuclear instability. This activity can be measured by Geiger-Muller detectors, which detect voltage fluxuations of a wire suspended in a gaseous mixture.

Activity of an isotope is often expressed in half-life ($t_{1/2}$), which is the period of time under which half of a radioactive substance will undergo a decay. Although radioactive decay is, by definition, a statistical, quantum mechanical process, when dealing with samples that contain thousands of atoms the half-life of these substances are often observed to be very predictable. This decay takes the form of

$$lnA(t) = -\lambda t ln(A_0) \tag{11}$$

where A(t) is the activity of the radioactive substance as a function of time, A_0 is the initial activity of the substance, and λ is the decay constant. Thus, half-life is defined as

$$t_{1/2} = ln(2)/\lambda. \tag{15}$$

The isotope $^{137}Ba^{m}$ is a known emitter of γ radiation with an accepted half-life of 153.1±0.06s(National Nuclear Data Center). After undergoing a decay, the substance becomes a stable form . We report in this paper our measurements of the half-life of $^{137}Ba^{m}$.

2. Experimental Procedure

Samples of $^{137}Ba^{m}$ were obtained from a ^{137}Cs isotope generator using a 0.9% NaCl in 0.04 M HCl eluting solution. Activity was measured using of a SpecTech ST-150 Nuclear Lab Station Geiger-Muller detector. The operating voltage of the detector was determined using an unknown γ -emitter with a 5.3 year half-life. Ideal operating voltage for the instrument was found to be 600V.

Trial 1 and Trial 2 were performed on two separate samples on the same date. Trial 3 was performed two days later with another sample. Background for the first two trials averaged 0.7 Bq. Trial 3 had a background average of 0.8 Bq.

Activity was measured for 30 second intervals with 10 seconds to record data between each measurement. Measurement intervals were measured on the instrument, and the delay intervals were measured on a stopwatch. The samples were measured until approximately three half-lives had passed.

3. Results

The logarithm of these results was computed and fit to a linear least squares equation. The data for Trial 2 is plotted in Figure 1. We determined the half-life of $^{137}Ba^{m}$ to be 147.9±4.2s.

4. Discussion

Deviation from the accepted value could largely be accounted for by timing inconsistencies. Delay between the end of a measurement, the start of the stopwatch, and the beginning of the next test could easily have an error of + 1 s per measurement. Our results show a bias towards taking a longer interval of time than measured due to operator and instrumentation delay.

As this is a statistical process, some variation can be expected, especially with low

activity.

Some variation was observed in background activity, as shown on Table 1. However, these values were often at least an order of magnitude lower than measured counts of the samples, and therefore had little effect on the final result.

5. Conclusions

We performed a three sample measurement of the half-life of $^{137}Ba^{m}$. Trials were conducted using $^{137}Ba^{m}$ samples eluted from a ^{137}Cs source. A half-life of 147.9±4.2swas found, deviating from the accepted value of 153.1±0.06s(National Nuclear Data Center) 3.4%. Sources of error include timing inconsistencies and statistical issues.

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REFERENCES

National Nuclear Data Center, information extracted from the Chart of Nuclides database, http://www.nndc.bnl.gov/chart/

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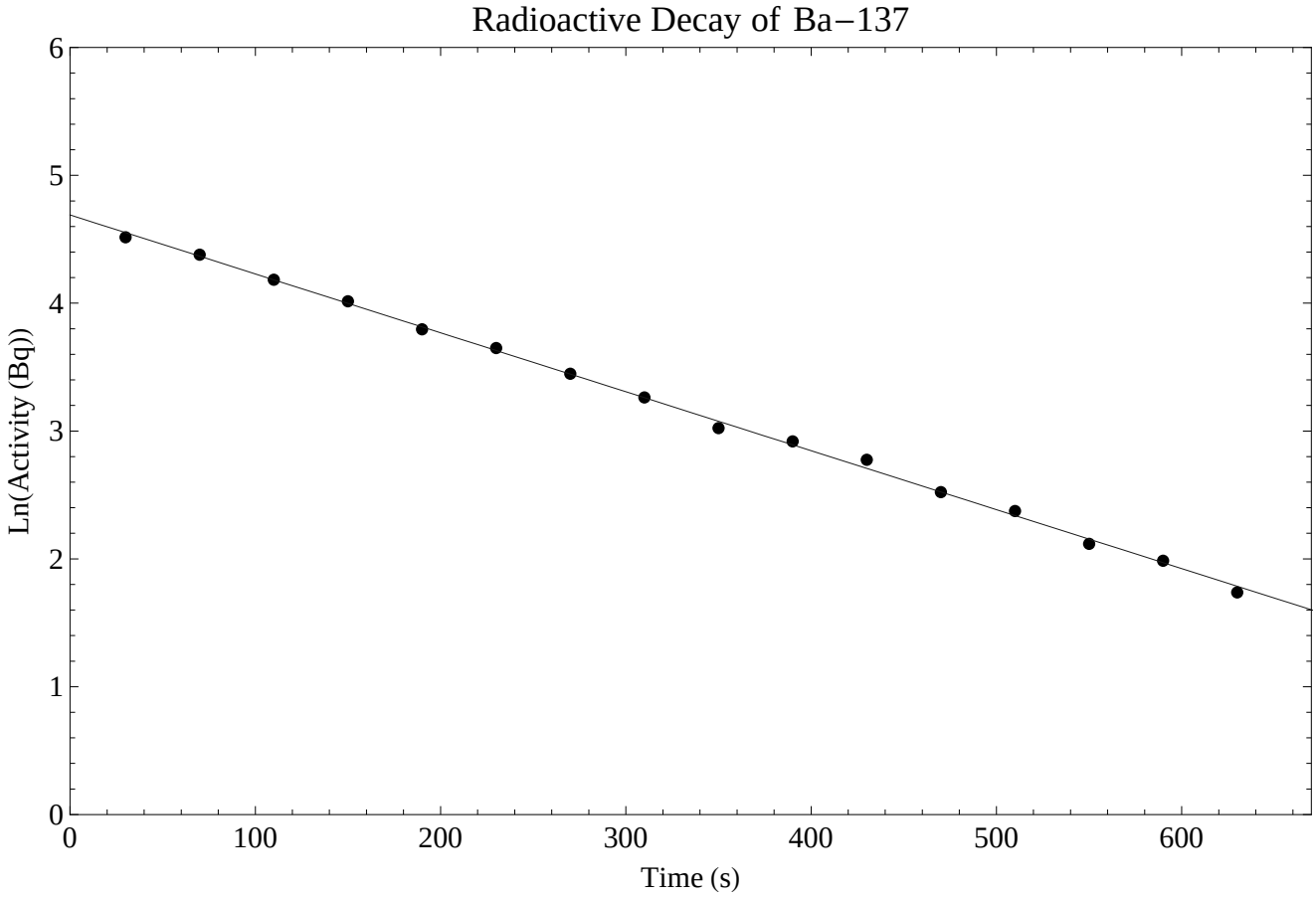

Fig. 1.— Results from Trial 2, overlaid with a least squares line fit. Data has been adjusted to account for background radiation. The fit has a slope of -0.0046 Bq/s.

Table 1: Background Radiation Measurements

Test	Day 1 (cts)	Day 2 (cts)
1	48	63
2	65	79
3	72	73

Note. — Background data taken before each trial was performed. Three background tests were averaged together each day experimentation was performed. Day 1 corresponds to Trial 1 and Trial 2, and Day 3 corresponds to Trial 3.