The standard deviation of the experimental points from either curve is 0.6 micron, which corresponds approximately to an energy of 0.3 Mev. This energy is the maximum deviation from the value of $Q_m = -6.63$ Mev allowed for the selection of stars for remeasurement in this check of the range-energy relation.

$R_1(Li^8)$ agrees, within our experimental error, with the points of Barkas,[21] whose criterion for the end of the Li^8 track was that of method (1). Although Gilbert[25] states that his results agree with those obtained by Barkas, his criterion for the end of the Li^8 track was that of method (2). In the experiments of Barkas and Gilbert the Li^8 tracks were surface ones and the range was measured from the point at which the Li^8 ion entered the emulsion; whereas in the present experiment all the tracks originated and ended in the emulsion.

$R_2(Li^8)$, although still somewhat above them, is closer than $R_1(Li^8)$ to the low-energy experimental points of Faraggi,[22] Cüer and Lonchamp,[26] and Neuendorffer, Inglis, and Hanna.[27] The semitheoretical curve of Wilkins, which was fitted to the two low-energy points of Faraggi, agrees quite well with the results of method (2), whereas that of Lonchamp[28] is somewhat low.

Equations (1) and (2) apply at 30% relative humidity. Although these results are for boron-loaded emulsion, the correction to normal emulsion is less than 1% at 30% relative humidity.[20] Therefore no correction was made.

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Alpha and Spontaneous Fission Half-Lives of Plutonium-242*†

J. F. Mech, H. Diamond, M. H. Studier, P. R. Fields, A. Hirsch, C. M. Stevens, R. F. Barnes, D. J. Henderson, and J. R. Huizenga
Argonne National Laboratory, Lemont, Illinois

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Measurements on Pu^{242} samples, highly enriched by neutron irradiation, resulted in the alpha half-life value of $(3.88\pm0.10)\times10^5$ years and in the spontaneous fission half-life value of $(7.06\pm0.19)\times10^{10}$ years.

I. ALPHA AND MASS MEASUREMENTS

THE alpha half-life of Pu^{242} has been reported previously as 5×10^5 and 9×10^5 years.[1,2] We have recently redetermined this value by a combination of alpha energy and mass spectrographic analyses of plutonium samples enhanced in Pu^{242}.

This plutonium was principally Pu^{242} by mass and was made available through long neutron irradiation of Pu^{239} in the Materials Testing Reactor (MTR) at Arco, Idaho. More precise measurements of the spontaneous fission decay rate and more accurate evaluation of the alpha half-life were possible, since interfering plutonium activities are largely removed in the irradiation process.

Two plutonium samples were irradiated in the MTR with approximately 1.0×10^{22} and 1.2×10^{22} neutrons/cm², samples 1 and 2, respectively. After irradiation the plutonium was purified by chemical methods described elsewhere.[3,4] The isotopic compositions of these plutonium samples were determined mass spectrometrically and are compiled in Table I. Alpha pulse analyses of these samples are presented in Table II.

TABLE I. Mass spectrometric analyses of plutonium in mole percent.

Pu isotope	Sample 1	Sample 2
238	0.216±0.004	0.16 ±0.02
239	0.087±0.002	0.068±0.004
240	2.02 ±0.02	0.633±0.006
241	1.31 ±0.01	0.308±0.006
242	96.33 ±0.02	98.77 ±0.03
244	0.037±0.002	0.052±0.004

* The α half-life was reported previously as Argonne National Laboratory Report ANL-5348.
† Based on work performed under the auspices of the U. S. Atomic Energy Commission.
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TABLE II. Alpha pulse analyses in percent.

Pu isotope	Sample 1	Sample 2
238	81.71±0.3	82.50±0.24
239+240	10.09±0.24	4.89±0.17
241+242	8.20±0.22	12.60±0.09

The alpha half-life of Pu^{242} was calculated by comparison to the known half-life of Pu^{240} (6580 years)[5] by use of the following mathematical relation:

$$T_{\frac{1}{2}}(Pu^{242}) = T_{\frac{1}{2}}(Pu^{240}) \times \frac{\text{mole percent } Pu^{242}}{\text{mole percent } Pu^{240}} \times \frac{\text{percent } \alpha \text{ activity } Pu^{240}}{\text{percent } \alpha \text{ activity } Pu^{242}}.$$

The alpha particles of Pu^{239} and Pu^{240} have similar energies as do those of Pu^{241} and Pu^{242} and therefore were not resolved. This required only a small correction since these interfering activities are present in low abundance. In sample 1, the intensity of the Pu^{239} alpha is 1.2% of the Pu^{239} plus Pu^{240} alpha activity. The Pu^{241} alpha (α half-life 3.5×10^5 years)[2,6] contributes 1.2% of the Pu^{241} plus Pu^{242} alpha activity. The data from Tables I and II, when substituted into the above formula with appropriate corrections for the extraneous alpha activity and the decay of Pu^{241}, yield the alpha half-life value of $(3.87\pm0.15)\times10^5$ years for Pu^{242}. A similar calculation yields 86±3 years for the half-life of Pu^{238}. For sample 2, 2.85% of the Pu^{239} plus Pu^{240} activity was due to Pu^{239} while the correction for Pu^{241} is almost negligible. Pu^{242} and Pu^{238} alpha half-lives of $(3.88\pm0.15)\times10^5$ and 86±11 years were calculated from the data. The average value for Pu^{242} is then $(3.88\pm0.10)\times10^5$ years. The calculated value of 86±3 years for Pu^{238} is consistent with earlier measurements.[7]

II. SPONTANEOUS FISSION MEASUREMENTS

Some of the plutonium of sample 2 was electrodeposited onto a 1.5-inch stainless steel disk from a nitric acid ammonium oxalate solution under the conditions described by Ko.[8] The alpha activity on the disk was measured at $(1.644\pm0.008)\times10^7$ disintegrations per minute in a low-geometry counter. The counting geometry was calculated from the dimensions of the counter and the sample, by using the equations described by Jaffey[9] for a spread source. The distance between the sample and the sensitive volume of the counter was large compared to the aperture radius, insuring that any error due to asymmetry in the distribution of the sample on the disk would be small.

Alpha pulse analysis (Table II) indicates that 12.60 ±0.09% of the alpha activity in the sample is contributed by Pu^{241} and Pu^{242}. The Pu^{241} contribution was calculated to be 0.043% of the total alpha activity.

The spontaneous fission activity on the disk was measured in a parallel-plate argon-methane counter similar to that described by Segrè.[10] The spontaneous fission disintegration rate of the Pu^{242} was 11.36±0.07 fissions per minute after subtraction of minor activities (less than 1%) due to Pu^{238}, Pu^{240}, and Pu^{244}. Multiple alpha coincidences were shown to be a negligible source of error by measuring these coincidences as a function of the bias setting of the fission counter. The efficiency of the counter for the sample (sample thickness less than 0.03 mg/cm²) was 100% within the limit of error quoted for the measurement. This was known by comparison to previous measurements, and by the fact that the slope of the entire bias plateau was less than 0.5%.

The ratio of the alpha activity of Pu^{242} to its spontaneous fission activity is $(1.819\pm0.018)\times10^5$ alphas/fission. The spontaneous fission half-life value, by comparison with the measured alpha half-life, was then calculated to be $(7.06\pm0.19)\times10^{10}$ years. This value is in agreement with the earlier values of $(6.7\pm0.7)\times10^{10}$ years[11] and $\sim8\times10^{10}$ years.[12]

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