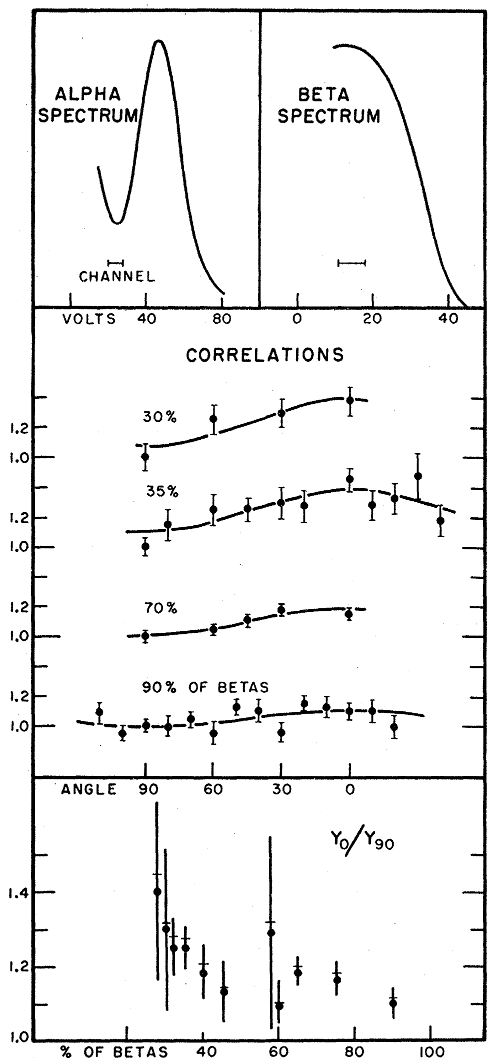

FIG. 1. Top: Differential pulse-height spectra. The prominent alpha-group is the 1.5-Mev group. Middle: Beta-alpha angular correlations for various portions of the upper part of the beta continuum. The 30 percent and 70 percent runs were made with a collimator on the beta-detector. The 35 percent run was with a fairly thick source. The alpha-detector was located at 180°. Bottom: Ratio of yields at 0° and 90° for various portions of the upper part of the beta-spectrum.

integral outputs of the discriminators were used. For the alpha-particles the bias was selected to include the 1.5-Mev group, which predominates (~90 percent).[2] Any higher energy groups were discriminated against in the detection of coincidences, either partially or wholly by the bias setting of the beta-discriminator, which ranged from an electron energy of 2 to 8 Mev. In Fig. 1 these settings are indicated by giving the approximate fraction of the beta-spectrum observed.

The data in Fig. 1 are the number of coincidences per recorded beta-particle. The curves, obtained by least-square analysis, are of the form $1+A_2\cos^2\theta$ and provide a reasonable description of the observations. Additional observations were made of the yields at 0° and at 90°. The ratio $Y_0/Y_{90}=1+A_2$ is plotted as a function of the bias setting of the beta-discriminator, at the bottom of Fig. 1. There is an apparent increase in the value of A_2 with increasing beta-energy, in accordance with the theoretical expectation. Approximate solid angle and scattering corrections have been made, and the corrected ratios are shown by the horizontal lines in the figure.

For the case $0^+-2^+-0^+$ for $Li^8-Be^8-He^4$, discussed by Gardner,[1] a pronounced maximum around 45° ($\sim\cos^2\theta-\cos^4\theta$) is expected. The results, therefore, favor the alternative scheme, $3^--2^+-0^+$, which gives $1+A_2\cos^2\theta$. Other assignments, including the possibility that the Be^8 state is double, have not yet been investigated. Any departure from isotropy rules out the possibility of spin 0 for the Be^8 state and confirms the forbidden character of the beta-process.

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Spontaneous Fission Rate of Cf^{246}†

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IN order to obtain further data which may be useful in a study of the spontaneous fission process as, for example, in confirmation of the exponential dependence of the spontaneous fission rate upon Z^2/A of even-even nuclides,[1,2] the spontaneous fission half-life of Cf^{246} has been measured. An extrapolation of previously available data[1,3] indicated that Cf^{246}, for which Z^2/A equals 39.04, should have a spontaneous fission "half-life" of approximately 2000 years. Our measured value is 2100±300 years, which is in excellent agreement with that predicted.

The californium isotope was produced by helium ion bombardment of curium containing all the isotopes ranging from Cm^{242} to Cm^{245}, inclusive.[4] The target technique employed in this work has been previously described.[5] The curium used in this experiment had been produced by a neutron irradiation of long duration of Am^{241} at a position of high flux in the Chalk River pile.[6] After bombarding the curium with 35-Mev helium ions, the californium was separated from other elements, using previously described combinations of precipitation and ion exchange chemical methods.[7] By alpha-pulse analysis at the beginning of the experiment, the californium fraction was observed to contain essentially pure Cf^{246} radioactivity except for a small fraction of Pu^{238} alpha-radioactivity incompletely separated. The amount of Pu^{237}

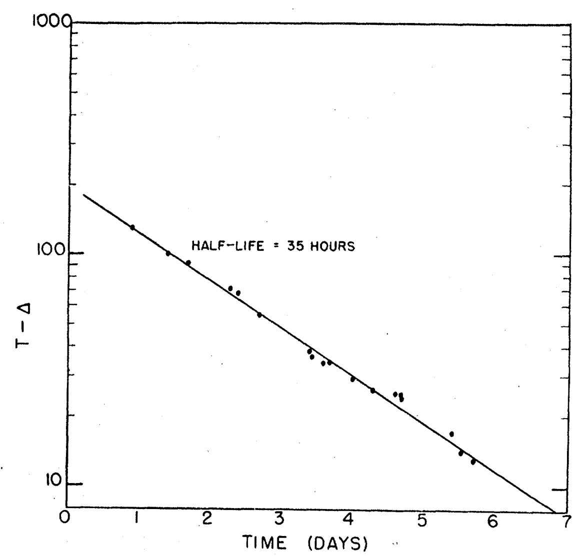

FIG. 1. Decay curve of observed fissions. T = total number of fissions observed and Δ = number of fissions observed to the time t.

present was insufficient to produce any spontaneous fission events in view of its long half-life for this process.[1]

The fission rate was determined by placing a known quantity of Cf^{246} in a thin deposit on one electrode of a parallel plate ionization chamber, filled with a mixture of argon and carbon dioxide. A stylus recorder maintained a record of each fission event and time of occurrence until essentially all of the Cf^{246} had decayed. The fission rate decreased with the same 35-hour half-life as that observed for the alpha-decay of Cf^{246},[4] thus proving that the fissions recorded originated from this isotope. The experimental data are best summarized in Fig. 1. The ratio of the alpha-disintegration rate to the spontaneous fission rate is 5.2×10^5, giving by a simple computation the spontaneous fission half-life of 2100 years. In view of its close agreement with the predicted value, this result might then be considered as evidence that a subshell of 148 neutrons does not exist since, on the basis of the considerations by Seaborg,[1] an abnormally small nuclear radius due to a closed subshell might be expected to result in an increased rate of spontaneous fission.

We are especially indebted to Professor Glenn T. Seaborg for his continued advice and encouragement during the course of this work. We also wish to express our appreciation to Professor J. G. Hamilton, G. B. Rossi, and the operating crew of the 60-inch cyclotron of the Crocker Laboratory for the intensive bombardment of curium, and to Nelson Garden and the Health Chemistry group for providing the excellent protective equipment used in handling the high level alpha-radioactivity. Likewise, the cooperative effort of the Canadian Chalk River Laboratory in handling some difficult problems connected with irradiating and shipping the sample is greatly appreciated.

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Statistical Fluctuations in Ionization by 31.5-Mev Protons*

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USEFUL methods of identifying particles of different mass often involve a measurement of specific ionization and some other parameter such as momentum, energy, or range. These schemes require a counter of small stopping power and good proportionality to measure the ionization. It has often been thought that a gas proportional counter admirably satisfies these requirements, on the assumption that the statistical fluctuations in the energy loss of the particles traversing the counter are governed by the statistical fluctuations in the number of ion pairs, as calculated on the basis of about 25 ev per ion pair. Experiment and the theory of Landau and of Symon indicate, however, that the fluctuations are considerably larger.[1–3]

Protons of 31.5-Mev energy from the Berkeley linear accelerator were scattered elastically from a 0.00025-inch Pb target through a proportional counter and stopped in a NaI counter. The solid angle accepted was defined by a $\frac{1}{8}$-inch hole in a brass plate 10 inches from the target; this hole was centered on the 0.0005-inch thick, $\frac{1}{4}$-inch diameter windows of the proportional counter. The counter telescope and target were in an evacuated scattering chamber. The scattered protons passed through the cylindrical counter perpendicular to its axis and straddling the wire. The counter was $\frac{3}{4}$-inch i.d. and 5 inches long. The 0.003-inch stainless steel wire was accurately centered; the counter was thoroughly outgassed and filled with a mixture of 96 percent A and 4 percent CO_2 and operated at 1700 volts. The elastic protons were separated by means of a single channel pulse-height analyzer fed from the NaI counter, and the output of the analyzer was used to trigger the sweep of an oscilloscope; the proportional counter pulses after amplification and suitable delay were applied to the vertical plates. The oscilloscope screen was photographed on moving film and the film read on a microfilm viewer. The stability and linearity of the system have been shown to be reliably good in previous work.

An estimate of the inherent resolving power of the proportional counter was obtained by a pulse-height analysis of the pulses from collimated 5.5-Mev alpha-particles, which had an energy of 1.6 Mev and a range of about $\frac{3}{4}$ cm after penetrating the counter window. The observed distribution was approximately Gaussian with a full width at half-maximum of 17 percent. Lack of perfect collimation would introduce about 3 percent spread. The effect of fluctuations in energy loss in passing through the window are difficult to estimate; range straggling at this energy is about 2.5 percent and, as the counter sees only the end of the track, this fluctuation is madnified by a factor of four or more. Thus the inherent resolving power of the proportional counter is 12 percent or better and certainly adequate to investigate the observed distribution.

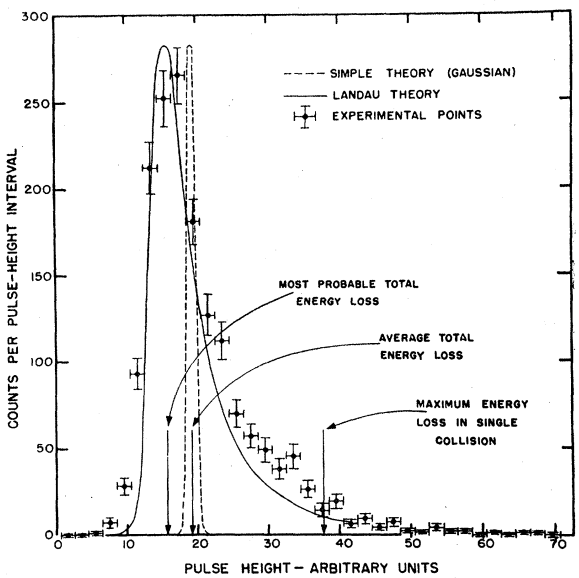

FIG. 1. Frequency distribution of energy losses of 31.5-Mev protons traversing $\frac{3}{4}$-inch proportional counter. Histogram of experimental points shows standard deviations and channel widths. The theoretical Landau distribution is computed from Symon (reference 2). The dashed curve is a Gaussian distribution based on ion pair statistics.

Figure 1 shows the histogram of 1636 pulses read. Amplifier noise limited the accuracy of reading the pulses to within the channel widths chosen. The pulse-height distribution has been observed to be independent of beam intensity, thus indicating that no significant part of it is due to pile-up. A theoretical curve was computed from the formulas and curves of Symon.[2] For comparison with experiment, both the theoretical curve and the experimental points were plotted on log-log graphs; the best fit by eye then gave scaling factors for both coordinates. The solid curve is the resulting theoretical distribution; no additional factors introducing spread have been folded in. The theoretical values of average total energy loss and of maximum energy loss by a 31.5-Mev proton in a single collision with an electron are shown. For comparison there is also shown a Gaussian distribution about the average of the width determined by statistics on the number of ion pairs formed at 25 ev per ion pair. The Gaussian