the assistance of the members of the Irradiation Physics Group of North American Aviation, Inc., particularly L. E. Glasgow and B. T. Harwick.

* This work was sponsored by the U. S. Atomic Energy Commission.
[1] Andrew, Jeppson, and Yockey, Phys. Rev. 86, 643 (1952).

Isomeric Branching and Threshold Behavior of the Reaction $Mo^{92}(n,2n)Mo^{91}$†

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IN a recent paper,[1] we reported an experimental study of the reaction $Mo^{92}(n,2n)Mo^{91}$ employing neutrons in the range from threshold to 27 Mev. A number of investigators have produced Mo^{91} by the (γ,n) process using betatrons. They find, in addition to the 15.5-min Mo^{91}, another Mo^{91} activity of 65.5–75 sec. Katz[2] and collaborators have measured the (γ,n) thresholds of the two activities (15.5 min: 13.1±0.1 Mev, and 65.5 sec: 13.3±0.1 Mev) and the energy dependence of the two photo cross sections. In reference 1, we reported the absence of the shorter half-life, but in view of the recent betatron data, we made another search for it.

Neutrons of various energies were produced by bombarding tritium with deuterons accelerated in a Van de Graaff machine. The geometrical arrangement of foils (normal molybdenum) and tritium target was similar to that employed in the cyclotron experiments.[1] A knowledge of the deuteron energy plus the angular position of the molybdenum foil with respect to the deuteron beam axis makes possible a calculation of the energy of the neutrons passing through the foils. Irradiations of various lengths of time were performed on the foils. They were counted within one minute of bombardment termination on a Geiger counter apparatus adapted for measuring half-lives of the order of one minute. Two- and 15.5-minute bombardments with 14.4-Mev neutrons produced no measureable trace of the short half-life although the 15.5-min activity was abundant. It was interesting to note[2] that 14.5-Mev gamma-rays gave a value of about 0.2 for the ratio of the 65.5-sec to the 15.5-min photo cross sections. Eighteen-Mev neutrons gave a weak 65.5-sec activity. In view of these results, branching will not affect the comparison of the statistical theory to experiment made in reference 1.

We also measured a number of relative cross-section values for the 15.5-min isomer. These values are presented in Fig. 1. The

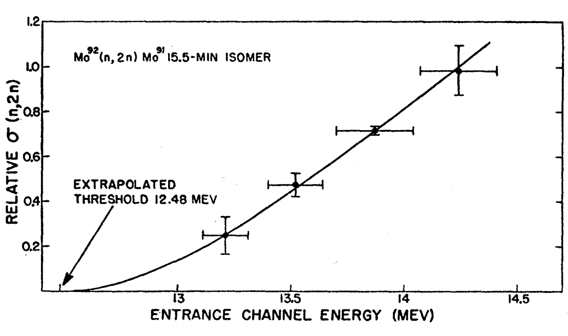

FIG. 1. Relative $\sigma(n,2n)$ as a function of channel energy: curve theoretical, points experimental.

vertical limits are 95 percent confidence intervals. The horizontal limits represent the maximum neutron energy spread intercepted by the foils. The curve drawn through the experimental points was calculated from the statistical theory using the values $a=3.16$ Mev^{-1} and $E_b=12.48$ Mev.

Keith Zeigler performed an iterated least squares calculation to fit the theoretical formula[3] to the data. The above values give the best fit. It is interesting to note that the new value of a is rather close to that obtained in reference 1. However, the threshold energy obtained from these data is in disagreement with betatron measurements. If E_b is varied by 0.1 Mev, the theoretical curve departs markedly from the data. Table I summarizes the results of the least squares calculation.

TABLE I. Comparison of calculated and observed relative cross sections.

Entrance channel energy (Mev)	Observed relative $\sigma(n,2n)$	Calculated relative $\sigma(n,2n)$	Difference
13.21	0.249	0.251	−0.002
13.52	0.474	0.454	0.020
13.87	0.715	0.713	0.002
14.24	0.986	1.005	−0.019

H. C. Martin operated the facilities employed in this experiment which were generously extended by Group P-3. L. K. Schlacks assisted with the computations.

† Work performed under the auspices of the U. S. Atomic Energy Commission.
[1] Brolley, Fowler, and Schlacks, Phys. Rev. 88, 618 (1952).
[2] L. Katz (private communication).
[3] U. S. Atomic Energy Commission Document NYO 636, p. 153 (unpublished).

Angular Correlation in the Decay of Li^8†

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OF the many processes which lead to the formation of the unstable Be^8 nucleus in its first excited state (~3 Mev), the $Li^8(\beta)Be^{8*}(\alpha)He^4$ reaction affords an interesting opportunity for performing a correlation experiment to provide information on this state. The beta-alpha correlation function may also depend on the nature of the Li^8 state and the degree of forbiddenness of the beta-process. Gardner[1] has given a discussion of the correlation functions expected for certain assignments of spin and parity to the participating states.

Li^8 nuclei were produced with the $Li^7(d,p)Li^8$ reaction by bombarding thin lithium targets with a deuteron beam of energy 0.65 Mev. In order to avoid detection of the many products of this bombardment, the beam was pulsed by means of a continuously rotating sector, and the decay products of the Li^8 nuclei were observed only during the period when the beam was interrupted by the sector.

Alpha-particles were detected with a thin, approximately 10-mil, sodium iodide crystal mounted in the vacuum of the target chamber and coupled to a photomultiplier tube through a quartz window. For convenience the alpha-detector was fixed at 90° to the deuteron beam. The target angle was 45°. Hence, the Li^8 nuclei, emitted into a forward 30° cone, were embedded in the target.

Beta-particles were detected with a sodium iodide crystal, 1 in.×1 in.×2 in., and a photomultiplier tube, free to rotate about the source. The cylindrical wall of the aluminum target chamber was about 20 mil thick, allowing beta-particles in the Mev range to pass through with an average loss of 250 kev. A lead collimator was provided between the chamber and the detector.

The pulses from each counter were amplified and passed through a discriminator, giving either a differential or an integral counting rate, and then to the coincidence detector. A switch between each amplifier and discriminator opened and closed the line in synchronization with the pulsing of the beam. The coincidence detector recorded the total number of coincidences, real and accidental, and also the accidental ones separately. The accidental rate was generally less than 10 percent of the real rate.

Differential pulse-height spectra of the alphas and betas are shown at the top of Fig. 1. In the detection of coincidences the

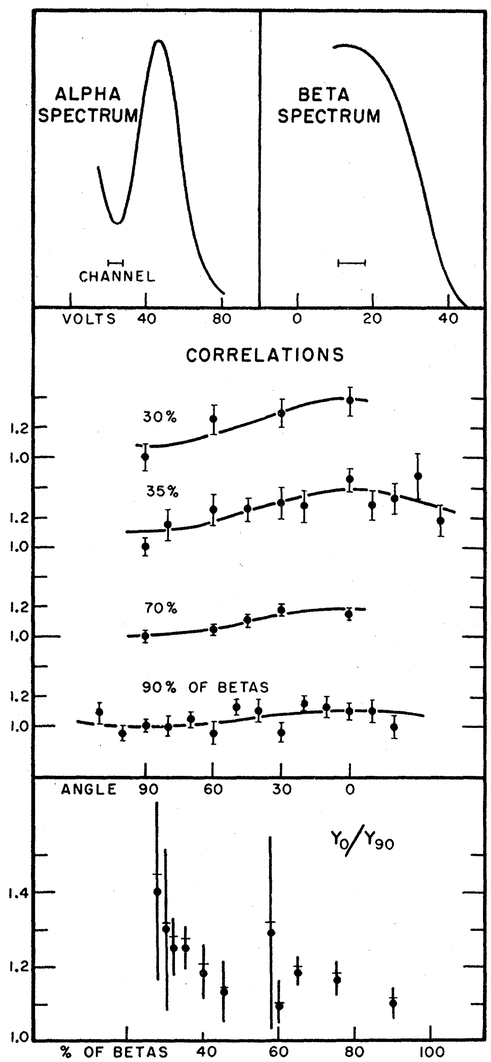

FIG. 1. Top: Differential pulse-height spectra. The prominent alpha-group is the 1.5-Mev group. Middle: Beta-alpha angular correlations for various portions of the upper part of the beta continuum. The 30 percent and 70 percent runs were made with a collimator on the beta-detector. The 35 percent run 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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[1] J. W. Gardner, Phys. Rev. **82**, 283 (1951).
[2] W. F. Hornyak and T. Lauritsen, Phys. Rev. **77**, 160 (1950).

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}

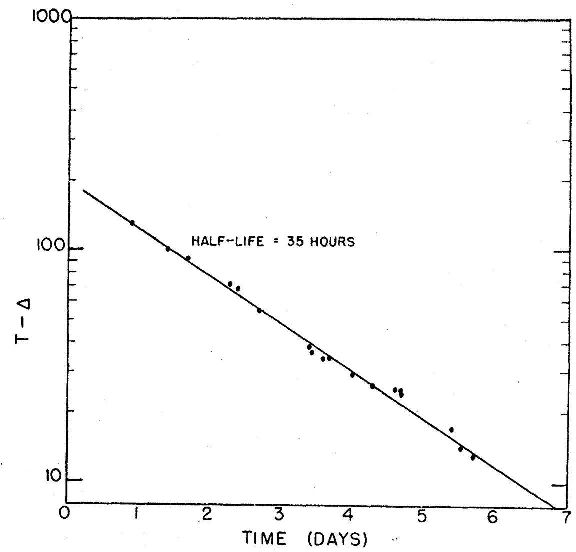

FIG. 1. Decay curve of observed fissions. T = total number of fissions observed and Δ = number of fissions observed to the time t.