dent gamma rays were analyzed with a sodium iodide crystal (beryllium covered) and a multichannel pulse-height analyzer.

The alpha-gamma coincidence spectrum is shown in Fig. 1 and consists of peaks at 17, 48, and 75 kev. The 75-kev gamma ray is probably due to Am^{243} which was known to be present. The prominent peak at 48 kev is ascribed to a gamma ray of Am^{239} and that at 17 kev probably contains both L x-rays and the escape peak of the 48-kev photon. A subsequent alpha-gamma coincidence measurement in which the photons were detected with a xenon proportional counter established the energy of the 48-kev transitions as 48.3 ± 1.5 kev. The large limit of error here is due to the fact that the statistics were quite poor.

Upon integrating the peak at 48 kev and correcting for geometry, escape peak, and the contribution of Am^{243} to the alpha intensity, the intensity of this gamma ray was found to be 0.5 (±0.1) per alpha disintegration. For a gamma ray of this energy this intensity in itself identifies it as $E1$. The intensities of the 60- and 74-kev gamma rays of Am^{241} and Am^{243} are, respectively, 0.4 and 0.8 per disintegration.[2,5] Since it can be estimated that the conversion coefficient for this $E1$ transition is not far from unity, it follows that almost every alpha disintegration of Am^{239} goes through the 48-kev state, as is the case for the analogous transitions of Am^{241} and Am^{243}.

A comparison of the prominent features of the alpha-decay schemes of the three americium isotopes is shown in Fig. 2. To be sure, that for Am^{239} is too fragmentary to assess the exact similarity with the other isotopes, but the principal (favored) mode of decay almost surely leads to an analogous state. The regular decrease in energy of the excited state favored in alpha decay with decrease in neutron number is worthy of note.

The lifetime of this transition would be of interest in view of the measurable lifetime for the $E1$ transition in Am^{241} decay (6.3×10^{-8} second[2]) and the half-life

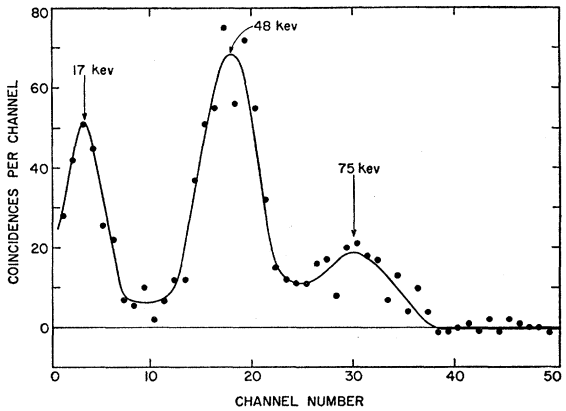

FIG. 1. Alpha-particle—gamma-ray coincidence spectrum of $Am^{239,243}$.

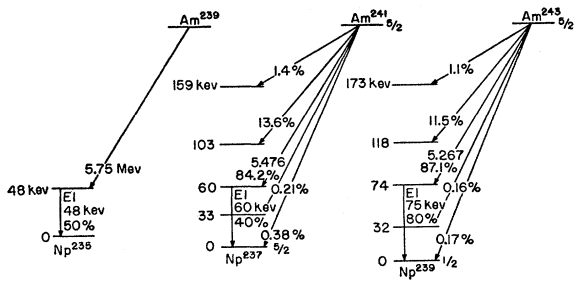

FIG. 2. Partial decay schemes of $Am^{239,241,243}$.

limit found for the corresponding $E1$ transition in Am^{243} decay ($<2\times10^{-9}$ second).[8] Rasmussen[9] has pointed out a possible reason why the 59.6-kev state of Np^{237} has a lifetime several orders of magnitude longer than the expected single-particle rate. His argument is that the odd-proton orbital of either this state or the ground state is $i_{13/2}$ and that the observed lower spin indicates a complex state. The transition therefore involves a considerable change in the proton orbital. This same behavior has also been noted for a number of other $E1$ transitions and has been discussed in terms of mixed states by Goldhaber and Sunyar.[10] Since a very small admixture of states permitting more rapid transitions will markedly change the lifetimes of such highly forbidden transitions, it is not too surprising that the lifetimes should vary erratically from one species to another.

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[9] J. O. Rasmussen, Jr., Arkiv Fysik **7**, 185 (1953).
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Energy Spectrum of Neutrons from Spontaneous Fission of Californium-252

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THE Cf^{252} source used in this work was prepared at the University of California Radiation Laboratory, Berkeley, California following the neutron

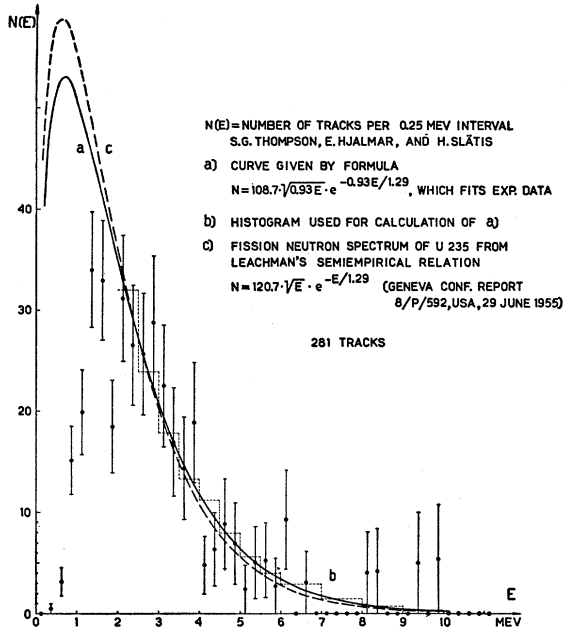

FIG. 1. Energy spectrum of neutrons from spontaneous fission of Cf^{252}.

irradiation of Pu^{239} in the Materials Testing Reactor at Arco, Idaho.[1] The source also contained some Cf^{250}, similarly produced in the irradiation. The spontaneous fission rate of the source was approximately 30 per minute and essentially all fissions were produced by Cf^{252} (the spontaneous fission half-lives are 66 years for Cf^{252} and 15 000 years for Cf^{250} [2,3]). The alpha-particle disintegration rate of the source was about 1000 per minute. The number of neutrons per fission in Cf^{252} is 3.87.[4]

The purpose of our investigation was to determine the energy spectrum of the neutrons. The essentially weightless source was prepared by the evaporation of a solution of the californium isotopes on a thin platinum foil which was covered with another foil in order to prevent alpha particles from escaping. The diameter of the active deposit was about 3 mm. The source was placed in the center of a wooden box of dimensions 35×35×50 cm on an Ilford photographic emulsion, Type C.2 of 100μ thickness (5×10 cm), and the plate was exposed to the neutrons for 14 days. After the emulsion was developed, it was examined for proton recoil tracks using an Ortholux research microscope (magnification 300). Since a small number of tracks was observed, it was necessary for the measurements to take into account all tracks, for which $|v| \leq 20°$ and $|\varphi| \leq 40°$. (v is the angle between the proton track and the emulsion plane, and φ is the projection on the emulsion plane of the angle ϑ between the direction of motion of the neutron and that of the proton, $\cos\vartheta = \cos v \cos\varphi$. The sample is mounted next to the emulsion so that the neutron paths lie in the emulsion plane.)

The energies of the protons were computed using the range-energy relation of Lattes, Fowler, and Cuer,[5] and the neutron energies were obtained from the relation $E_n = E_p/\cos^2\vartheta$. A total of 281 tracks fullfilled the conditions described above. The number of neutrons per energy interval was corrected for finite emulsion thickness and for the variation of neutron cross section with energy. The shape of the resulting neutron energy spectrum as shown in Fig. 1 is similar to that for neutrons from thermal fission of U^{235}.[6,7] However, the neutron energies from Cf^{252} seem to be slightly larger than from U^{235}, possibly by about 8%. This work is being continued with the objective of obtaining a more accurate energy spectrum.

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Radiations from 1− States in Even-Even Nuclei*

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IT has become well established that for even-even nuclei in the region well above the closed shell of 82 protons and 126 neutrons, there exist low-lying energy levels with spin and parity assignments 0+, 2+, 4+, etc.[1,2] Such a sequence of levels is described as a rotational band because the spins, parities, and energy spacing conform with the expectations of rotational states according to the Bohr-Mottelson unified

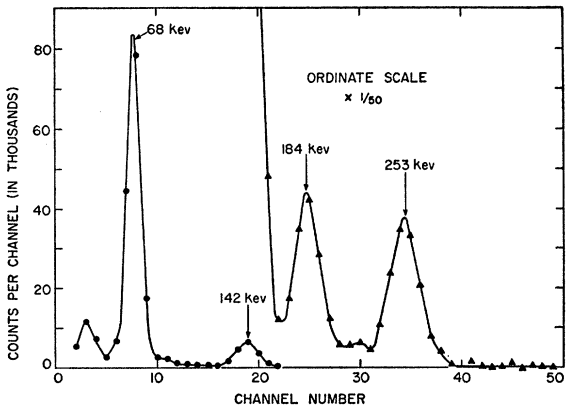

FIG. 1. Gamma-ray spectrum of Th^{230}.