At least six measurements were made on all the elements except antimony, which was measured four times.

For 85-min Ba^{139}, the ratio of the 90° activity to the (0°+180°) activity was found to be the same (within 1 percent) as the corresponding ratio for unseparated fission product β activity. The 90°/(0°+180°) ratios for the other elements were all measured in terms of the ratio for barium, which was separated in all runs. The

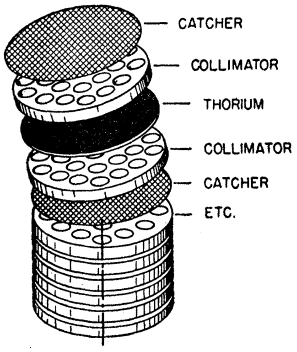

FIG. 1. An exploded view of one of the two stacks of foils and collimators. The axis of the stack is oriented either parallel or perpendicular to the x-ray beam. The half-angle of the collimator holes is 15°.

angular distribution of the unseparated fragments has been measured previously[1] using the same bremsstrahlung beam, and was found to be compatible with the form $a+b\sin^2\theta$ with respect to the x-ray beam. The experimental value of b/a was found to be 0.41 ± 0.05. The values of b/a for the other elements, taking barium

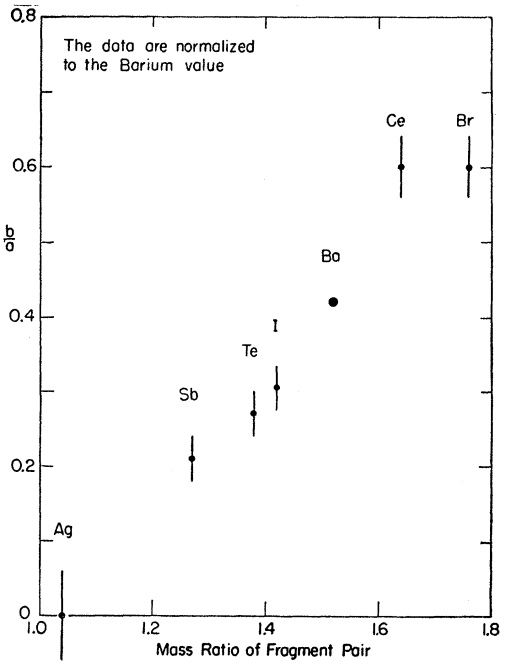

FIG. 2. Angular anisotropy of Th^{232} fission fragments as a function of the mass ratio of the fragment pair.

to be 0.41 exactly, are shown in Fig. 2, plotted as a function of the mass ratio of heavy-to-light fission fragment pair.

The errors shown on the points are probable errors based on the spread of the values obtained in the different runs. The experimental procedure was checked for systematic errors by making several runs with only one stack, dividing the catchers in two equal portions and separating several elements in each portion. The ratios of the fission yields of the several elements were the same within 5 percent in each of the two portions, indicating that the errors of chemical separation, determination of chemical yield, and counting are small.

The data of Fig. 2 imply that the mass-yield curve for the $\sin^2\theta$ component of the angular distribution is warped toward greater mass asymmetry than the curve for the isotropic component. But whatever the mechanism leading to the angular anisotropy, both curves display the same sort of double-humped shape characteristic of various types of fission, including photofission,[2-4] in this general energy region.

We hope, with increased beam currents, to repeat the experiment at lower energies where the angular anisotropy is larger.

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‡ The electron beam used had a maximum energy of 16 Mev and a broad energy spectrum peaked at about 13 Mev, with a width at half-maximum of 5 Mev.

[1] Winhold, Demos, and Halpern, Phys. Rev. **87**, 1139 (1952).
[2] R. A. Schmitt and N. Sugarman, Phys. Rev. **89**, 1155 (1953).
[3] H. G. Richter and C. D. Coryell, Phys. Rev. **90**, 389 (1953).
[4] D. M. Hiller and D. S. Martin, Jr., Phys. Rev. **90**, 581 (1953).

Decay Scheme of Xe^{135}

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THE 9.2-hr Xe^{135} has been shown to decay by emission of 910-kev β particles to an excited level of energy 250 kev in Cs^{135}.[1,2] Moreover, a very weak γ ray of energy 610 kev has been reported.[2] This γ ray has now been studied by means of coincidence measurements on electromagnetically separated Xe^{135} samples in an intermediate image β spectrometer.[3] Behind the β source a large NaI(Tl) crystal (diameter 1 in.×1 in.) was placed. This was optically connected with an EMI 6262 photomultiplier by means of a perspex light pipe of 15-cm length. The G-M pulses and the scintillation spectrometer pulses were fed to a coincidence circuit of resolving time 2.5×10^{-7} sec.

No coincidences were found between K conversion electrons of the 250-kev γ ray and γ quanta of energy higher than 550 kev. However, coincidences were recorded between these K-conversion electrons and γ quanta of energy ~370 kev. A small bump on the high-energy tail of the very strong 250-kev γ line in the scintillation spectrum of Xe^{135} may partly be explained as due to a γ ray of energy ~370 kev.

It was also shown that the 600-kev γ ray is emitted in cascade with a β continuum. A Fermi plot of the coincidence distribution showed an upper limit of 548 kev.

The results of the coincidence measurements strongly support the decay scheme given in Fig. 1.

According to the extreme one-particle shell model,[4] the second excited level might be $s_{\frac{1}{2}}$ or $d_{\frac{1}{2}}$. The former alternative seems im-

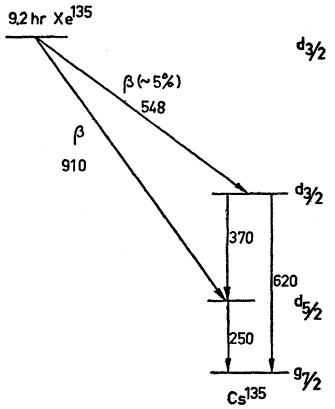

FIG. 1. Proposed decay scheme of Xe^{135}. Energy values in kev.

probable, since then the transition to the ground state would be of the $M3$ type. The half-life of the 620-kev level would then be $\sim 10^{-2}$ sec, according to the semiempirical formula of Goldhaber and Sunyar.[5] This would be in contradiction to our coincidence data. Therefore the $d_{\frac{3}{2}}$ alternative, shown in Fig. 1, seems to be the most probable.

[1] Thulin, Bergström, and Hedgran, Phys. Rev. **76**, 87 (1949).
[2] I. Bergström, Arkiv Fysik **5**, 191 (1952).
[3] H. Slätis and K. Siegbahn, Arkiv Fysik **1**, 339 (1949).
[4] M. G. Mayer, Phys. Rev. **75**, 1969 (1949); Haxel, Jensen, and Suess, Z. Physik **128**, 295 (1950).
[5] M. Goldhaber and A. W. Sunyar, Phys. Rev. **83**, 906 (1951).

Thermal Neutron Fission Cross Section of Am^{242m}

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SINCE Am^{242m} is the first member in the chain of nuclides produced by successive neutron captures on Am^{241}, its fission cross section is of considerable importance for calculating yields of masses heavier than 242.

The method for measurement consisted of irradiating a sample of Am^{241} in the high neutron flux of the MTR (Materials Testing Reactor, Arco, Idaho) to produce the Am^{242} and Am^{242m}, placing the americium on a platinum plate in one side of a double-fission counter and exposing it to a well-thermalized flux of neutrons. Since Cm^{242} has a very small fission cross section,[1] the observed counting rate decayed with the sixteen hour half-life of Am^{242m}, superimposed on a long-lived background due to the fissions of Am^{241}, Am^{242}, and small amounts of uranium. The experimental data are presented graphically in Fig. 1.

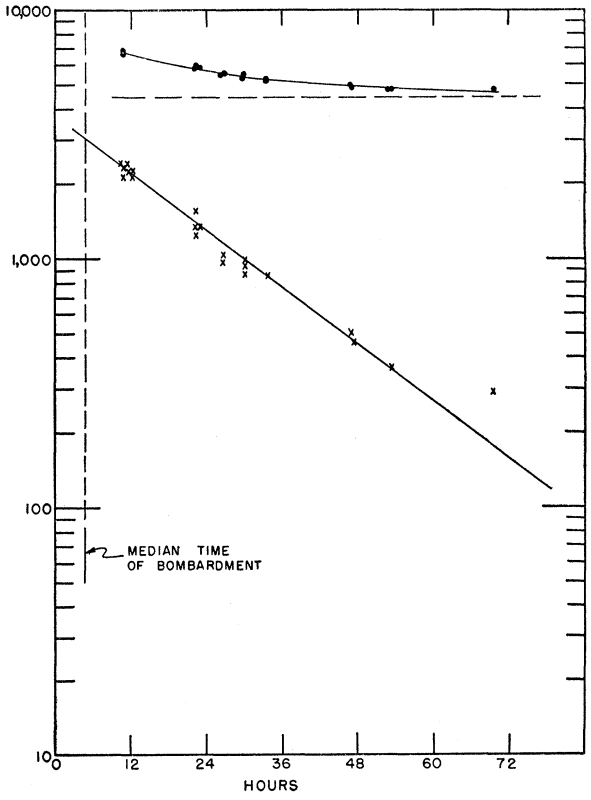

FIG. 1. Decay of slow-neutron-induced fission events in a sample containing Am^{242m}.

A weighed sample of U^{235} was irradiated in the other side of the same counter in the same flux, and the number of Am^{242m} atoms was determined by alpha pulse analyses of the Cm^{242}—Am^{241} mixture after the Am^{242m} had decayed. The fission cross section of Am^{242m} was then calculated from the number of atoms of U^{235} and Am^{242m}, the counting rate of the two samples in the same flux, and the known fission cross section of U^{235}:

$$\sigma_f(Am^{242m}) = \frac{\text{counting rate } Am^{242m} \times \text{No. atoms } U^{235} \times \sigma_f(U^{235})}{\text{counting rate } U^{235} \times \text{No. atoms } Am^{242m}}.$$

The results of this experiment lead to a value of 2950 barns for the fission cross section of Am^{242m}. This value may be in error if the transition between Am^{242m} and Am^{242} occurs in more than 5 percent of the decay events.[2-4]

[1] Hanna, Harvey, Moss, and Tunnicliffe, Phys. Rev. **81**, 893 (1951).
[2] O'Kelley, Barton, Crane, and Perlman, Phys. Rev. **80**, 293 (1950).
[3] R. Hoff, University of California Radiation Laboratory Report UCRL-2325, 1953 (unpublished).
[4] H. Jaffe (unpublished work, 1953).

Electric Excitation of Tantalum†*

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IT is now well known that low-lying levels of heavy and intermediate nuclei can be excited by the interaction between the electric field of an incident charged particle and the nuclear protons.[1-3] This process, called electric or Coulomb excitation, occurs at energies for which the penetration of the bombarding particle into the nucleus is negligible. A particularly interesting example of this type of interaction is furnished by Ta^{181} when bombarded with protons. Gamma rays corresponding to levels at 137 kev and 303 kev are observed, and conversion electrons have been detected[4] with energies corresponding to transitions from the 137-kev level to the ground state and between the two excited states. Measurements carried out in this laboratory have also established the presence of a 166-kev gamma ray. The spectrum, shown in Fig. 1, was taken at a proton energy of 3 Mev, and the radiation was detected with a conventional NaI scintillation spectrometer having a resolution of 10 percent. The background due to target x-rays was reduced to an acceptable level by using a 1-mm thick gold absorber. The energies assigned to the observed gamma rays were 139, 167, and 309 kev, to an accuracy of 5 kev, in agreement with the more accurate measurements of 137, 166, and 303 kev.[4] The possibility that the Compton edge of the 303-kev line, which comes at 164 kev, was contributing significantly to the observed intensity of the 166-kev line was excluded by measurements with appropriate Pb absorbers.

The relative probabilities of gamma-ray transitions from the 303-kev level directly to the ground state, and through the 137-kev level, were determined from the data of Fig. 1. Corrections to the measured intensities were made for (1) background, (2) absorp-

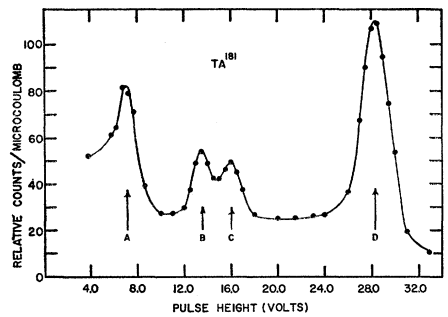

FIG. 1. The pulse-height distribution obtained for the radiation from a 5-mil tantalum target bombarded with 3-Mev protons using a 1-mm gold absorber. Peak A corresponds to the tantalum K x-ray. Peaks B, C, and D correspond to gamma rays of 139, 167, and 309 kev.