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.

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

G. H. Higgins and W. W. T. Crane
Radiation Laboratory, University of California, Berkeley, California

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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.

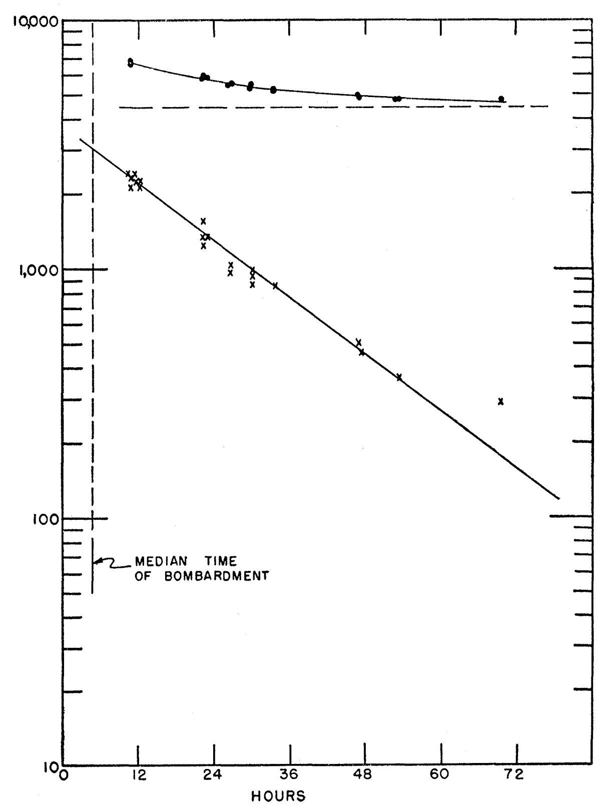

Fig. 1. Decay of slow-neutron-induced fission events in a sample containing Am^{242m}.

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]

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Electric Excitation of Tantalum†*

J. T. Eisinger, C. F. Cook, and C. M. Class
The Rice Institute, Houston, Texas

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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-

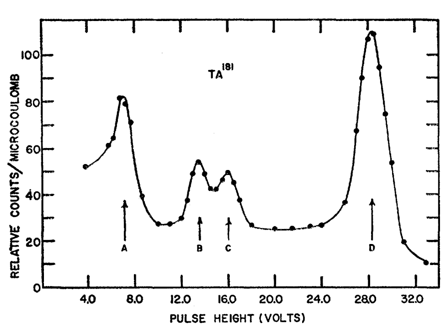

Fig. 1. The pulse-height distribution obtained for the radiation from a 5-mil tantalum target bombarded with 3-Mev protons using a 1-mm gold absorber. Peak A corresponds to the tantalum K x-ray. Peaks B, C, and D correspond to gamma rays of 139, 167, and 309 kev.

tion, and (3) the relative contribution of the photopeak to the total intensity.[5] The graphical resolution of the 137–166 kev doublet and the allowance for background were somewhat arbitrary, but the latter correction was guided by results obtained with absorbers which had a very small transmission for the 166-kev radiation while attenuating the 303-kev radiation only moderately. The ratio of the crossover to the cascade transitions was found to be 0.8. Using the result that 85 percent of the 166-kev radiation is due to $M1$ transitions,[4] the magnetic moment of the ground state of Ta was calculated[7] to be 3 nm. This is to be compared with the value of 2.8 nm obtained by Huus and Bjerregaard using a somewhat less direct method and a spectroscopic value of 2.1 nm.[6]

Further interest in the energy levels of tantalum arises from the agreement of the spacing of these levels with that predicted by the rotational model of the nucleus of Bohr and Mottelson.[7] For an even-odd nucleus with ground-state spin 7/2, (Ta^{181}) the model predicts excited states of spins 9/2 and 11/2 having energies above the ground state in the proportion of 9 to 20. This proportion agrees well with that found in experiments. Additional evidence supporting the spin assignments can be obtained from the angular distributions of the gamma radiation from these levels with respect to the beam. Figure 2 shows the experimental distribution obtained

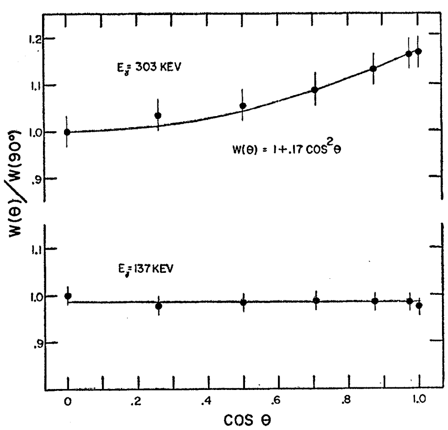

FIG. 2. The angular distributions of the 137-kev and 303-kev gamma rays from tantalum measured between 0° and 90° to the beam at $E_p = 3$ Mev. The theoretical distribution is shown for the 303-kev radiation.

for a proton energy of 3 Mev with the counter subtending a solid angle of 0.13 steradian. The data were taken with a 3 mm Cu absorber which transmitted a strong 137-kev line relative to background but did not impair the resolution of the 303-kev line. The intensity of the 166-kev line was then only about 15 percent of that of the 137-kev line so that these two lines were not resolved. The data of Fig. 2 were corrected for the absorption of the radiation in the target (5 mils of tantalum) and for background. Errors shown in the curves are statistical. A systematic error due to uncertainties in the background subtraction could change the asymmetry by about 3 percent.

The theoretical form of the angular distributions has been predicted by Alder and Winther[8] assuming electric quadruple transitions from the ground state to the excited state in question ($E2$ in keeping with the B-M theory[7] according to which such transitions are especially favored) followed by $E2$ transitions back to the ground state. The distributions are obtained in a manner analogous to that giving the angular correlation between two gamma rays in cascade. However, the special nature of the excitation process modifies the distributions through energy dependent factors $a_k(\xi)$ which multiply the Legendre polynomials. The angular distribution function is then

$$W(\theta) = 1 + a_2(\xi)B_2P_2(\cos\theta) + a_4(\xi)B_4P_4(\cos\theta),$$

where the B_k are the gamma-gamma correlation coefficients tabulated by Biedenharn and Rose.[9] Expressing the theoretical distributions in a form easily compared with experiment gives $W(\theta) = 1 + 0.171\cos^2\theta + 0.006\cos^4\theta$ for the 303-kev gamma ray, which is the curve shown in Fig. 2, and $W(\theta) = 1 - 0.032\cos^2\theta + 0.037\cos^4\theta$ for the 137-kev gamma ray, which is isotropic within the accuracy of this experiment. The $a_k(\xi)$ were calculated for 3-Mev protons[10] and the B_k were determined by assuming the spins of the 137-kev and 303-kev states to be 9/2 and 11/2, respectively.

The good agreement between the experimental and theoretical distributions lends further support to the spin assignments and the excitation process which was postulated.

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$\pi^- - p$ Interactions at 1.5 Bev*

J. CRUSSARD, W. D. WALKER, AND M. KOSHIBA
Physics Department, University of Rochester, Rochester, New York
(Received February 23, 1954)

STACKS of 400μ G-5 stripped emulsion were exposed to the 1.5-Bev π^- beam at the Brookhaven cosmotron. The plates were aligned with respect to each other by means of x-ray dots so that it was possible to trace even minimum ionizing tracks through many emulsions.

The primary interest was in finding π^- – proton interactions. It was found that the only efficient way to detect these interactions is by "on-track" scanning. The work reported here is the result of scanning about 300 meters of track. The mean free path for a $\pi^- - p$ interaction was found to be about 4 meters of track. According to counter measurements of the total $\pi^- - p$ cross section at 1.5 Bev by Cool, Madansky, and Piccioni,[1] the mean free path

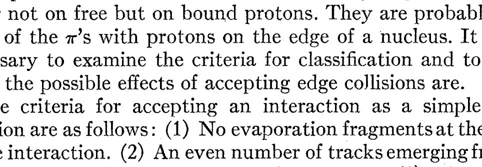

FIG. 1. A $\pi^- - p$ collision in which a π^0 is produced. The more heavily ionizing track is a proton of about 40-Mev energy.

in nuclear emulsion should be about 9–10 meters. This means that 50–60 percent of the interactions classed as hydrogen interactions occur not on free but on bound protons. They are probably collisions of the π's with protons on the edge of a nucleus. It is thus necessary to examine the criteria for classification and to decide what the possible effects of accepting edge collisions are.

The criteria for accepting an interaction as a simple $\pi^- - p$ collision are as follows: (1) No evaporation fragments at the vertex of the interaction. (2) An even number of tracks emerging from the interactions of which at most one is a proton. (3) The protons must of course be in the forward hemisphere, and if the proton emerges at an angle θ it cannot have an energy greater than an elastically scattered proton at this angle.

To date 4 cases have been rejected on this basis. The results of the search to date are as follows:

(a) $\pi^- + p \rightarrow \pi^- + p$ — 16 events,

(b) $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ — 31 events,