that of Myers and Swiatecki means that if the difference between curves (3) and (4) is added to the fission barrier of Ref. 5, the change in lifetime is small. The prediction of $2\times10^{19}$ yr there will become $2\times10^{21}$ yr. Since most of this change comes from the strongly deformed part of the fission barrier, the improvements mentioned above can be expected to shorten this lifetime. For ${}_{114}X^{298}$ with its short $\alpha$-particle decay lifetime, this may not be important, but for ${}_{110}X^{294}$ where the fission and $\alpha$-particle decay lifetimes are close, the fission lifetime may determine the total lifetime.

Shell-effect corrections can be calculated self-consistently for our statistical energy surface, following Strutinsky's approach.[13] Shell-model potentials can be obtained directly from the deformed densities[14] derived here. This way we shall avoid the usual uncertainties in extrapolating phenomenological shell-model potentials and can make more reliable predictions of the variation of potential with deformation. A study of this program is presently being made.

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# Decays of $Tm^{170}$ and $Tm^{171}$: $L_2$ and $L_3$ Subshell-Fluorescence Yields, Coster-Kronig Transition Probabilities, and $K$-Shell Conversion Coefficients in Yb†

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High-resolution Ge(Li) and Si(Li) x-ray detectors [404- and 290-eV full width at half-maximum (FWHM) at 6.4 keV, respectively] were employed to study the singles and coincidence spectra of x rays and $\gamma$ rays from the decays of $Tm^{170}$ and $Tm^{171}$. Measurements of the rates of $L_\alpha$, $L_\beta$, and $L_\gamma$ x-ray emission in coincidence with $K_{\alpha1}$ and $K_{\alpha2}$ x rays yielded the following values for $L_2$ and $L_3$ subshell-fluorescence yields ($\omega_2$, $\omega_3$), $L_2$-$L_3X$ Coster-Kronig transition probability ($f_{23}$), and relative $L$ x-ray intensity ratios ($s_2$, $s_3$): $\omega_2=0.182\pm0.011$, $\omega_3=0.183\pm0.011$, $f_{23}=0.170\pm0.009$, $s_2=0.192\pm0.010$, and $s_3=0.165\pm0.009$. The $K$-conversion coefficient of the 84.3-keV $E2$ transition in $Yb^{170}$ is found to be $1.39\pm0.04$ by the measurement of the intensity ratio for the $K$-x-ray and $\gamma$ transitions (XPG method). The $K$-conversion coefficient of the 66.7-keV transition in $Yb^{171}$ is found to be $7.45\pm0.36$, which leads to a value of 0.34 for the mixing ratio of $E2/M1$. The orbital-electron-capture branchings of $Tm^{170}$ to the first excited state (78.6 keV) and to the ground state in $Er^{170}$ are determined to be 0.04 and 0.10%, respectively.

## I. INTRODUCTION

THE present investigation was carried out particularly to exploit the new high-resolution techniques developed during recent years in low-energy photon spectrometry. Detectors of Si(Li) and Ge(Li) with sufficient resolution to separate clearly the full-energy peaks above $Z\approx65$ of the $K_{\alpha1}$, $K_{\alpha2}$, $K_{\beta1}'$, and $K_{\beta2}'$ components of $K$ x rays and the $L_l$, $L_\alpha$, $L_\beta$, and $L_\gamma$ components of the $L$ x rays of interest are available. Coincidence methods[1] are employed to measure the $L_2$ and $L_3$ subshell-fluorescence yields and the $L_2$-$L_3X$ Coster-Kronig transition probability in Yb from decay of $Tm^{170}$ and $Tm^{171}$. No prior measurements on Yb exist in which a radioactive source of $L$ subshell vacancies is used. Jopson *et al.*[2] measured $L_2$ and $L_3$ subshell-fluorescence yields by coincidence methods with NaI(Tl) detection and Yb foil targets in which $K$ and $L$ ionization was produced by an incident beam of $\gamma$ rays from a $Co^{57}$ source.

The $K$-shell conversion coefficient of the 84.3-keV $E2$ transition in $Yb^{170}$ following the $\beta$ decay of $Tm^{170}$ has been of considerable interest and has been the subject of many investigations since 1952. This transition was one of the first leading to a suspicion at one time that anomalies existed in experimental $E2$ conversion coefficients in the deformed region. Essentially three different techniques were employed to measure $\alpha_K$: (1) Measurement of the intensity ratio of the $K$-x-ray

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TABLE I. $K$-shell conversion coefficient for the 84.3-keV $E2$ transition in $Yb^{170}$ as measured by the XPG method.

| Author | Ref. | Year | $I_{Kx}/I_\gamma$ | $\omega_K$ assumed | $\alpha_K$ | Correction for EC applied | $I_{Kx}/I_\gamma$ (recalc)[a] | $\alpha_K$ (recalc)[a] |
|---|---|---|---|---|---|---|---|---|
| Graham *et al.* | 3 | 1952 | 1.47 | 0.92 | 1.60±0.02 | no | 1.433 | 1.53 |
| McGowan | 4 | 1952 | | | 1.5±0.2 | | | |
| Liden and Starfelt | 5 | 1954 | | | 1.56±0.15 | | | |
| McGowan and Stelson | 6 | 1957 | 1.535 | 0.930 | 1.65±0.12 | no | 1.497 | 1.60 |
| Houtermanns | 7 | 1957 | 1.246 | 0.930 | 1.34±0.07 | no | 1.215 | 1.30 |
| Bisi *et al.* | 8 | 1956 | 1.571 | 0.93 | 1.69±0.02 | no | 1.532 | 1.64 |
| | | | 1.497 | 0.93– | 1.61 | not necessary | 1.499 | 1.60 |
| Hooten | 9 | 1964 | 1.357 | 0.93 | 1.46±0.05 | no | 1.321 | 1.41 |
| Thosar | 10 | 1964 | 1.212 | 0.93 | 1.31 | not necessary | 1.213 | 1.29 |
| Croft *et al.* | 11 | 1965 | 1.555 | 0.937 | 1.66±0.11 | yes, 6% | 1.614 | 1.72 |
| | | | 1.424 | 0.937 | 1.52±0.007 | yes, 6% | 1.478 | 1.58 |
| Dingus *et al.* | 12 | 1966 | 1.377 | 0.937 | 1.47±0.05 | yes, 3.3% | 1.389 | 1.48 |
| Jansen *et al.* | 13 | 1966 | 1.237 | 0.937 | 1.32±0.005 | yes, 3.4% | 1.247 | 1.33 |
| Nelson and Hatch | 14 | 1969 | 1.340 | 0.937 | 1.43±0.04 | not necessary | 1.340 | 1.43 |
| Present work | | 1969 | | 0.937 | | not necessary | 1.304±0.039 | 1.39±0.04 |

[a] The values are corrected by using the correction for Er $K$ x rays from the present work and a value of 0.937 for $\omega_K$.

transition to the $\gamma$ transition (XPG),[3–14] (2) internal-conversion–external-conversion method (IEC),[15–17] and (3) Coulomb-excitation and lifetime measurements.[18,19] Almost all measurements of method 1 employed NaI(Tl) spectrometers, even the best of which have not clearly resolved the 84.3-keV $\gamma$ from the Yb $K$ x rays. In addition, the Er $K$ x rays from the EC decay of $Tm^{170}$ and the unresolved iodine $K$-x-ray escape peaks complicated the analysis. Tables I and II present a survey of the existing measurements of the $\alpha_K$ of the 84.3-keV transition in $Yb^{170}$. The theoretical estimates[20–23] of $\alpha_K$ show a spread of 10%, thus making it difficult to discuss meaningfully the deviations from theory of existing experimental values.

In the case of the 66.7-keV transition in $Yb^{171}$ fed from $Tm^{171}$, very little effort has been made to obtain accurate information on $\alpha_K$. The transition is of mixed $E2$-$M1$ type ($\frac{3}{2}^- \rightarrow \frac{1}{2}^-$) and an accurate measurement of $\alpha_K$ is of value in estimating the $E2/M1$ mixing ratio. Hansen[24] measured a value of 7.4±1.0 for $\alpha_K$ from the relative intensities of Yb $K$ x rays and 66.7-keV $\gamma$. Dingus *et al.*[12] measured a value of 6.9±1.0.

A detailed investigation of the EC branching of $Tm^{170}$ has not been made. Graham *et al.*[3] set an upper limit of 0.3% for $K$ capture and 0.01% for $\beta^+$ emission. Day[25] used a bent-crystal spectrometer to measure the relative intensities of Er $K$ x rays and 84.3-keV $\gamma$ rays and obtained an estimate of $K$-capture branching of 0.15%. Recently, Nelson and Hatch[14] estimated the $K$-capture branching to be 0.19±0.04%. These estimates were based on the assumption that all the EC leads to the ground state of $Er^{170}$. The level structure of the even-even nucleus $Er^{170}$ is partially known from Coulomb excitation,[26] and the first excited state is at about 79 keV. Since $Q_{EC} \approx 500$ keV [27] feeding of both

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TABLE II. $K$-conversion coefficient of the 84.3-keV transition in $Yb^{170}$ from methods other than XPG and from theory.

| Authors | Ref. | Year | Method | $\alpha_K$ |
|---|---|---|---|---|
| Bernstein | 18 | 1962 | Coulomb excitation | $1.52 \pm 0.11$ |
| Fossan and Herskind | 19 | 1962 | Coulomb excitation | $1.41 \pm 0.11$ |
| Jansen *et al.* | 15 | 1966 | IEC | $1.36 \pm 0.10$ |
| Erman and Hultberg | 16 | 1966 | IEC | $1.37 \pm 0.07$ |
| Hatch | 17 | 1966 | Magnetic and bent-crystal spectrometers | $1.47 \pm 0.10$ |
| Hager and Seltzer | 20 | | Theory (pure $E2$) | 1.42 |
| Bhalla | 21 | | Theory (pure $E2$) | 1.36 |
| Sliv and Band | 22 | | Theory (pure $E2$) | 1.36 |
| Rose | 23 | | Theory (pure $E2$) | 1.33 |

the ground and first excited states by EC is possible. Hansen and Hellström[28] used a Si(Li) detector with a resolution of only 1.5-keV FWHM at 84 keV to study the singles photon spectrum from the decay of $Tm^{170}$. By unfolding the unresolved photopeaks of $K_\alpha$ and $K_\beta$ x rays, they measured the intensity of Er $K$ x rays and estimated the total EC branching to be 0.25%. They observed the $\gamma$ transition in $Er^{170}$ at 78.7 keV.

## II. EXPERIMENTAL

### A. Source Preparation

Thin, uniform sources of radioactive $Tm^{170}$ and $Tm^{171}$ were obtained by evaporating from dilute HCl solution the activity on a Plexiglas holder. The $Tm^{170}$ source was of high specific activity and of approximately 10 $\mu g/cm^2$ thickness; the $Tm^{171}$ source was carrier free.

### B. Singles-Spectrum Studies

A Si(Li) x-ray detector having a resolution of 290-eV FWHM at 6.4 keV was employed to study the singles $K$-x-ray and $\gamma$ spectra of $Tm^{170}$. A typical spectrum is shown in Fig. 1. A detailed description of the detector and the determination of its photopeak efficiency are given elsewhere.[29] $K$ x rays of Er from the EC decay of $Tm^{170}$ are clearly separated from Yb $K$ x rays. $\gamma$ spectra from $Tm^{170}$ taken with a 16-$cm^3$ coaxial Ge(Li) detector indicated the presence of $\gamma$ rays with energies of 66.7 and 443 keV. These are attributed to the presence of $Tm^{171}$ and $Tm^{168}$ in trace amounts in the $Tm^{170}$ source. The latter contributes Er $K$ x rays from its EC decay, and the former contributes Yb $K$ x rays from conversion of the 66.7-keV transition in $Yb^{171}$. These contributions were calculated from the known values of the ratio of the intensities of Er $K$ x rays to 443-keV $\gamma$ rays in $Tm^{168}$ decays,[30–32] and from the ratio of intensities of Yb $K$ x rays to the 66.7-keV $\gamma$ in $Tm^{171}$ decay measured in the present work. A trace of $Bi^{207}$ also was identified but had no complicating influence on the present studies. No Tm $K$ x rays were observed (Fig. 1), indicating that source thickness was sufficiently small that self-excitation of $K$ x rays was negligible. The Ge(Li)–Ge(Li) coincidence system described below was used in a $\beta$-$\gamma$ coincidence arrangement at close geometry to search for $\beta$-excited $K$ x rays, which were negligible.

In Fig. 2 is shown the spectrum of Yb $K$ x rays and the 66.7-keV $\gamma$ from $Tm^{171}$ decay. No disturbing im-

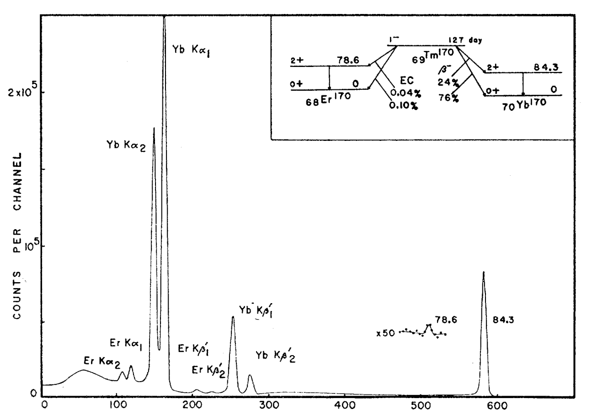


FIG. 1. The photon spectrum from $Tm^{170}$ decay taken with the Si(Li) detector in the region 50–85 keV (resolution 290-eV FWHM at 6.4 keV). A Plexiglas absorber of 3.2-mm thickness was used to stop $\beta$ rays. The inset shows the revised decay scheme of $Tm^{170}$, based on the present work. Energies are in keV.

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purities were found, and contamination from $Tm^{170}$ contributed less than 0.3% to the total intensity of Yb $K$ x rays.

### C. Coincidence Measurements

Two Ge(Li) x-ray spectrometers (8 mm diam × 5 mm depth with 0.005-in.-thick Be window) were used at 180° to observe $L_\alpha$, $L_\beta$, and $L_\gamma$ x rays in coincidence with $K_{\alpha 1}$ or $K_{\alpha 2}$ x rays. The energy resolution was of the order of 404-eV FWHM at 6.4 keV. A complete description of the coincidence arrangement has been given previously.[33] The determination of the efficiency of these detectors was discussed by Freund, Hansen, Karttunen, and Fink.[34] Yb $L$ x rays in coincidence with $K_{\alpha 1}$ or $K_{\alpha 2}$ x rays were observed with $Tm^{170}$ and with $Tm^{171}$ sources. Typical singles and coincidence $L$ x-ray spectra are presented in Fig, 3. The $L$ x-ray coincidence rates, corrected for the efficiency and solid angle of the detector and the attenuation due to materials between source and detector, are related to $\omega_3$, the $L_3$ subshell-fluorescence yield; $\omega_2$, the $L_2$ subshell-fluorescence yield; $f_{23}$, the $L_2$-$L_3X$ Coster-Kronig transition probability; $s_2$, the ratio of $L_\gamma$ to $L_{\beta+\eta}$ x rays from the $L_2$ subshell; and $s_3$, the ratio of $L_\beta$ to $L_{\alpha+l}$ x rays from the $L_3$ subshell. The derivation of the necessary relationships and a detailed account of the basis of the coincidence method was given in Ref. 1.

Two complete sets of coincidence runs were made

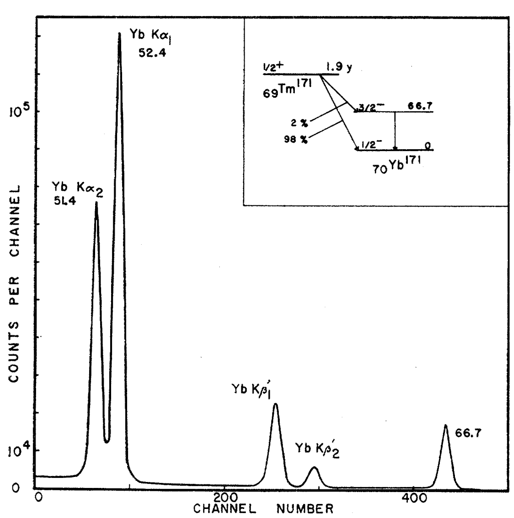


FIG. 2. The photon spectrum from $Tm^{171}$ decay taken with the Si(Li) detector in the region of 50–70 keV. The inset shows the decay scheme of $Tm^{171}$ from the literature. Energies are in keV.

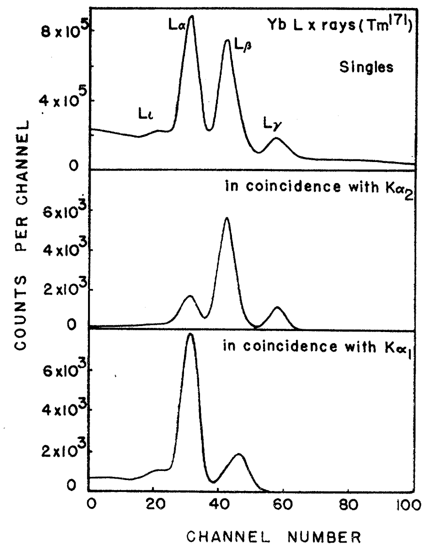


FIG. 3. $L$ x-ray spectra from $Tm^{171}$ decay taken with a Ge(Li) detector having resolution of 404-eV FWHM at 6.4 keV. Top: the singles spectrum, middle: $L$ x rays in coincidence with $K_{\alpha 2}$ x rays, bottom: $L$ x rays in coincidence with $K_{\alpha 1}$ x rays.

with each source and coincidence resolving times of 600 and 1200 nsec, respectively. The multichannel analyzer stored $K_{\alpha 1}$-$L$ and $K_{\alpha 2}$-$L$ coincidence spectra simultaneously, one in each half of the memory, the two coincidence units being run with equal resolving times. The coincidence efficiency was found to be unity, as verified by the independence of the results on the resolving time and further confirmed by a time-to-pulse-height-converter spectral analysis. The minimum resolving time for 100% coincidence efficiency was only 290 nsec. Chance coincidences were observed separately by introducing 5-μsec delay in the gating channel. Bremsstrahlung due to the $\beta$ continuum in the coincidence spectra is negligible, as seen in Fig. 3.

## III. RESULTS AND DISCUSSION

Results of the present work are summarized in Tables III and IV, and are discussed below. The errors quoted are standard errors and include contributions from all experimental origins. No attempt has been made to include errors in quantities obtained from theory.

### A. $L_2$ and $L_3$ Subshell-Fluorescence Yields and $L_2$-$L_3X$ Coster-Kronig Transition Probability in Yb

Table III presents the values of $\omega_2$, $\omega_3$, and $f_{23}$ obtained from $L_{\alpha,\beta,\gamma}$-$K_{\alpha 1,\alpha 2}$ coincidence measurements using both $Tm^{170}$ and $Tm^{171}$ decays as sources of $K$ and $L$ vacancies. The average number of $L$ x rays emitted per $L_2$ vacancy, $\nu_2$, is also included in Table III. The effects of angular correlation in the $L_i$ x-ray–$K_{\alpha 1}$ x-ray

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TABLE III. Results on the $L_2$ and $L_3$ subshells in Yb.

| Coincidence method | Quantity measured | Present work $Tm^{170}$ decay | Present work $Tm^{171}$ decay | Average | Jopsen *et al.*[a] | Scofield[b] (theory) |
|---|---|---|---|---|---|---|
| $L_{\alpha,\beta,\gamma}$–$K_{\alpha 1}$ | $\omega_3$ | 0.185±0.011 | 0.180±0.011 | 0.183±0.011 | 0.20±0.02 | |
| | $s_3$ | 0.170±0.009 | 0.161±0.009 | 0.165±0.009 | | 0.175 |
| $L_{\alpha,\beta,\gamma}$–$K_{\alpha 2}$ | $\nu_2$ | 0.218±0.013 | 0.210±0.013 | 0.214±0.013 | 0.34±0.05 | |
| | $\omega_2$ | 0.185±0.011 | 0.179±0.011 | 0.182±0.011 | | |
| | $f_{23}$ | 0.174±0.009 | 0.165±0.009 | 0.170±0.009 | | |
| | $s_2$ | 0.187±0.011 | 0.196±0.010 | 0.192±0.010 | | 0.181 |

[a] Reference 2.
[b] Reference 41.

coincidence measurement are taken into account[35–38] in obtaining the value of $\omega_3$. This correction amounts to 2%. There is agreement with the previous work of Jopson *et al.*[2] in the case of $\omega_3$, but the present value of $\nu_2$ seems to be considerably lower, as is generally found in comparisons of radioactive source methods with methods based on fluorescent excitation of foils. A recent study[39] of the $L$ Auger-electron spectrum in the EC decay of $Hf^{175}$ gave a value of $\omega_3=0.19\pm0.05$ for $Z=71$, in good agreement with the present result for $Z=70$. The present work also confirms the earlier results[1,37,40] that a considerable number of $L_2$ vacancies are filled by nonradiative Coster-Kronig transitions of the $L_2$-$L_3X$ type ($f_{23}\neq 0$).

The relative intensities of the resolved groups of $L$ x rays from the $L_2$ and $L_3$ subshells also are obtained from the present coincidence experiment and are compared with theoretical values derived from the recent work of Scofield.[41] The ratio of $L_\beta$ x rays to $L_{\alpha+l}$ x rays, $s_3$, is determined to be 0.165±0.009 (Table III) and compares well with Scofield's estimate[41] of 0.175. Similarly, the ratio of $L_\gamma$ to $L_{\beta+\eta}$ x rays from the $L_2$ subshell $s_2$ is determined to be 0.192±0.010 (Table III) and compares well with Scofield's estimate[41] of 0.181.

### B. *K*-Conversion Coefficient of 84.3-keV Transition in $Yb^{170}$

Table IV contains the relative intensities of the Yb $K$ x rays and the $\gamma$ rays observed from the decay of $Tm^{170}$, after correction for detector efficiency and attenuation of the 3.2-mm Plexiglas $\beta$ absorber. The ratio of intensities of Yb $K$ x rays and 84.3-keV $\gamma$ rays ($I_{Kx}/I_\gamma$) is calculated to be 1.304±0.039. The value is compared with the results of earlier work in Table I, which contains the intensity ratios and the values of $\omega_K$, the $K$-shell–fluorescence yield of Yb, used to obtain the reported values of $\alpha_K$. To facilitate comparison with the present value of $I_{Kx}/I_\gamma$, the intensity ratio from the various authors has been recalculated by using the correction for Er $K$ x rays arising from orbital electron capture as found in the present work (Sec. III D). The spread in the recalculated values apparently is due to the low resolution of the NaI(Tl) spectrometers used. The most recent measurement by Nelson and Hatch,[14] in which a bent-crystal spectrometer was employed to obtain the monoenergetic response function of an NaI(Tl) spectrometer, is in fair agreement with the present result.

The present value of $\alpha_K$ of the 84.3-keV transition was obtained from the relationship

$$\alpha_K=(1/\omega_K)(I_{Kx}/I_\gamma), \qquad (1)$$

where a value of 0.937 for $\omega_K$ is used.[42] For comparison we have listed the literature values of $\alpha_K$, determined by the XPG method, which are recalculated using $\omega_K=0.937$ and recalculated values of the intensity ratio. Taking into account only the recent XPG results (Ref. 13, 14, and the present work) and the other conversion-electron methods, the agreement with theoretical estimates (Table II) for pure $E2$ multipolarity is good. On the other hand, the accuracy of any of the experimental methods is insufficient to distinguish among the various theoretical estimates.

### C. *K*-Conversion Coefficient of the 66.7-keV Transition in $Yb^{171}$

The ratio of intensities of Yb $K$ x rays and 66.7-keV $\gamma$ rays following $\beta$ decay of $Tm^{171}$ was measured to be 6.98±0.34. With $\omega_K=0.937$, a value of $\alpha_K=7.45\pm0.36$ is obtained. The two previous measurements of this value are $\alpha_K=7.4\pm1.0$ [24] and 6.9±1.0 [12] and these are in agreement with the present work. The mixing ratio is calculated to be 0.34 using the theoretical estimates of Hager and Seltzer,[20] so that the transition is a mixture of 74% $M1$ and 26% $E2$ multipolarity.

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### D. Electron-Capture Decay of $Tm^{170}$

In Table IV are presented the intensities of Er $K$ x rays and 78.6-keV $\gamma$ rays from the EC decay of $Tm^{170}$. The 78.6-keV $\gamma$ is attributed to the first excited state in $Er^{170}$. This energy state has not been previously established conclusively, although a value of 79.3 keV has been quoted.[25] Chupp *et al.*,[43] who investigated the first excited states by Coulomb excitation of natural Er targets, identified two $\gamma$ rays at 78.59 and 79.31 keV, and assigned them to $Er^{167}$ or $Er^{170}$. They were unable to determine which $\gamma$ is associated with each Er isotope. In the present work, the 79.3-keV $\gamma$ was not found, but $\gamma$ rays at 78.6±0.4 keV were observed, leading to the conclusion that EC in $Tm^{170}$ decay leads to both the ground and the first excited states in $Er^{170}$.

From data in Table IV, a value of $2.64\pm0.40\times10^{-2}$ is obtained for the ratio of intensities of Er $K$ x rays to Yb $K$ x rays in $Tm^{170}$ decay. The former arise from internal conversion of the 78.6-keV transition and from $K$ capture to the ground and first excited states in $Er^{170}$. Taking the theoretical conversion coefficient $\alpha_K=1.77$ from Hager and Seltzer[20] and a value of $\omega_K=0.933$ for $Z=68$,[42] the total number of $K$ x rays arising from the $K$ conversion of the 78.6-keV transition can be estimated. The fraction of total Er $K$ x rays due to $K$ conversion of this transition is 0.059. The EC branching can be calculated using theoretical EC ratios[44–46] to the ground and first excited states. Taking the value of $Q_{EC}=460$ keV,[27] the theoretical values of the probability of $K$ capture, $P_K$, to the ground and first excited states in $Er^{170}$ are 0.800 and 0.837, respectively. These values, together with the relative intensities presented in Table IV, yield 0.04% EC decay to the 78.6-keV level and 0.10% to the ground state in $Er^{170}$, if one assumes that 76% of the $Tm^{170}$ $\beta$ emission leads to the ground state of $Yb^{170}$.

TABLE IV. Relative intensities of $K$ x rays and $\gamma$ rays from the decay of $Tm^{170}$ and $Tm^{171}$ from the present work.

| Source | Photon emission | Relative intensity |
|---|---|---|
| $Tm^{170}$ | Er $K$ x rays | 3.44±0.14 |
| | Yb $K$ x rays | 130.4±3.9 |
| | 78.6-keV $\gamma$ | 0.122±0.024 |
| | 84.3-keV $\gamma$ | 100 |
| $Tm^{171}$ | Yb $K$ x rays | 698±34 |
| | 66.7-keV $\gamma$ | 100 |

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# Fissionability as a Function of Angular Momentum for the $Re^{181}$ Compound Nucleus at an Excitation Energy of 70 MeV*

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A method is described which allows the calculation of the spin dependence of the probability for fission of compound nuclei from experimental data. The method is applied to the study of the behavior of $Re^{181}$ compound nuclei formed in three different ways with an excitation energy of 70 MeV: $C^{12}+Tm^{169}$, $O^{16}+Ho^{165}$, and $Ne^{22}+Tb^{159}$. The experimental fission cross sections were taken from Sikkeland. The fission probability is found to increase with increasing angular momentum in accord with liquid-drop-model calculations.

## INTRODUCTION

LIQUID-DROP-MODEL calculations[1–4] have shown that the fission barriers of compound nuclei at a given excitation energy decrease with increasing spin. The relatively large fission cross sections observed in reactions[5] with heavy ions leading to compound nuclei with low values of $Z^2/A$ seem to confirm these predictions. The effect of angular momentum was further elucidated by experiments in which the same compound nuclei were formed by several different entrance channels which differed only in their spin distributions.[6,7] However, even these latter experiments did not produce a quantitative relationship between angular momentum and fissionability. The principal difficulty in a detailed interpretation arose from the broad distribution of

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