the first excited state in Ni^{61}, both of which have been tentatively assigned a spin $7/2^-$ on the questionable basis of the angular distribution of proton group 4. The (n,γ) measurements show a strong transition to one of these states and the positron decay from Cu^{61} to the other is believed[10] to be allowed. Both of these observations are in disagreement with the 7/2 spin assignments. Whether these discrepancies can be attributed to the presence of one or more states which have not as yet been observed, to the presence of cascade gamma rays in the (n,γ) measurements, or to some other defect in our analysis, is not known at this time.

V. CROSS SECTIONS

From the known values of integrated deuteron beam current, target thickness, and solid angle subtended by the detecting plates, it is possible to obtain the cross section for the reaction leading to each observed transition. These results are presented in Table III. The absolute values of these cross sections are believed to be accurate to within about a factor of two. The errors in relative value are considerably less than this.

TABLE III. Cross sections for (d,p) reactions in Ni^{58} and Ni^{60} at a mean deuteron energy of 3.03 Mev.

Proton group	Target	$\sigma\times10^{28}$ (cm²)
1	Ni^{58}	6.6
2	Ni^{58}	8.8
3	Ni^{58}	2
4	Ni^{58}	6.0
	Ni^{60}	9.6
5	Ni^{58}	9.6

The writer wishes to express his appreciation to Professor James A. Jacobs and Mr. Philip R. Malmberg for valuable assistance with this work.

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Beta Spectra of Pr^{142}, Tm^{170}, and Rb^{86}†

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The beta spectra and gamma rays of the isotopes Tm^{170}, Pr^{142}, and Rb^{86} have been examined with various types of spectrometers. An intermediate-image beta-ray spectrometer with a 10 percent transmission and a 5.5 percent resolution was used to examine the total and coincidence beta spectra. Total beta spectra were also studied with a thin-lens spectrometer set to about two percent resolution. Gamma rays were also studied with a scintillation spectrometer.

The results of the investigation indicate that the 125-day activity of Tm^{170} has two beta groups with maximum energies of 970±2 kev and 886±9 kev. Their respective intensities are about 78 percent and 22 percent, and their respective log ft values are approximately 9.0 and 9.1. Both beta groups are assigned as first forbidden transitions with $\Delta I=\pm1$, "yes." The single observed gamma ray of Tm^{170} is assigned as an $E2$ transition with an energy of 84.1±0.4 kev.

The 19.2-hr activity of Pr^{142} has two beta groups with maximum energies of 2166±6 kev and 586±15 kev. The 2166-kev beta group has a log ft value of about 7.8 and the 586-kev beta group has a log ft value of about 7.1. The log$[(W_0^2-1)ft]$ value of the 2166-kev beta group is 10.2. The intensities for the 2166-kev and 586-kev beta groups were found to be, respectively, 90–95 percent and 5–10 percent.

The 2166-kev beta group is assigned as first forbidden with $\Delta I=2$, "yes" and the 586-kev beta group as first forbidden with $\Delta I=0$ or ±1, "yes." The single observed gamma ray, having an energy of 1572±8 kev, is tentatively assigned as an $E2$ or $M1$ transition. The $E2$ and $\Delta I=0$, "yes" choices are probably correct.

The 19.5-day activity of Rb^{86} has two beta groups with maximum energies of 1770±4 kev and 680±6 kev. Their intensities are about 88 percent and 12 percent, respectively. The log ft value for the 1770-kev beta group is about 8.5 and for the 680-kev beta group 7.8. The log $[(W_0^2-1)ft]$ value for the 1770-kev beta group is 9.7. This beta group is assigned as a first forbidden transition with $\Delta I=2$, "yes," and the 680-kev beta group is tentatively assigned as first forbidden with $\Delta I=0$, "yes." The single gamma ray has an energy of 1080±6 kev and is tentatively assigned as an $E2$ transition.

The Kurie plots of the 680-kev beta group of Rb^{86} and the 886-kev beta group of Tm^{170} were examined for deviations from a straight line. Within experimental error no deviation from a straight line was observed.

INTRODUCTION

In this work an attempt was made to examine primarily the beta decays of Pr^{142}, Tm^{170}, and Rb^{86} using a coincidence technique. An intermediate-image spectrometer[1] which has a transmission of 10 percent at 5.5 percent resolution was used for the coincidence work. For conventional spectra, a thin-lens spectrometer set to two percent resolution and a scintillation spectrometer were also used.

In the intermediate-image spectrometer, the gamma rays were detected by a 5819 photomultiplier and a Lucite-covered NaI(Tl) crystal placed far enough behind the source to prevent distortion of the beta spectra by scattering (6292 phototubes are being used at present for the beta and gamma detectors). The focused beta particles were detected by an anthracene crystal and a

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* Now at the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota.

[1] Nichols, Pohm, Talboy, and Jensen, U. S. Atomic Energy Commission Report No. ISC-345, 1953 (to be published).

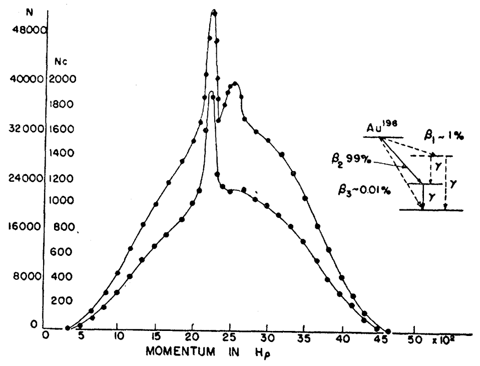

FIG. 1. Total and coincidence spectra of Au^{198}.

cooled (−40°C) 5819 photomultiplier. The scintillation pulses in the crystals were transmitted to the photomultiplier tubes by means of Lucite light pipes about 1.2 inches in diameter and 15 inches long.

To check the operation of the instrument, the activity of Au^{198} was examined; the coincidence and total beta spectra agreed well (Fig. 1). The Kurie plots of the total and coincidence spectra are indicated in Fig. 2. The end-point energy of 967±5 kev agrees with the value of 963 kev given by Hollander, Perlman, and Seaborg.[2] The Kurie plots deviate from a straight line below the conversion electron energy because of the presence of Au^{199} and the lower-energy beta group of Au^{198}. A detailed study of the contamination of Au^{198} by Au^{199} and its effect on the Au^{198} Kurie plot was made by Fan.[3] A very satisfactory coincidence counting rate of over 1000 counts per minute was obtained at the peak of the beta spectrum with about a five-microcurie source.

The coincidence circuit had a resolving time of about 0.5 microsecond. For most points the accidental coincidence counting rates were less than 40 percent of the true coincidence counting rates.

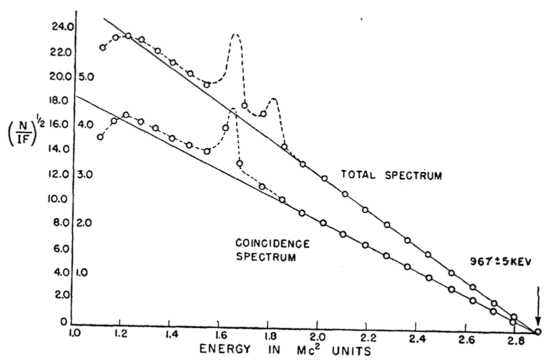

FIG. 2. Kurie plots of Au^{198} total and coincidence spectra.

[2] Hollander, Perlman, and Seaborg, Revs. Modern Phys. **25**, 469 (1953).
[3] Chan-Yun Fan, Phys. Rev. **87**, 252 (1952).

Reported work[4–10] on the 19.2-hour decay of Pr^{142} reveal that it has a complex decay. The investigations indicate that the decay of Pr^{142} has two beta groups with average energies of about 2.18 Mev and 0.65 Mev, and one gamma ray of about 1.58 Mev. The 0.65-Mev beta group was assigned an intensity ranging from 4 to 20 percent. The values of the maximum energy for the lower-energy beta group were determined by the subtraction method. Jensen *et al.*[9] ascribed a spin of two and odd parity to the ground state of Pr^{142} and a spin of one or two with even parity for the excited state of Nd^{142}. The 2+ assignment is probably correct because of the preponderance of 2+ first excited states for even-even nuclei.[11] Cork, Shreffler, and Fowler[5] also found additional gamma rays of 133.7, 328.9, 489.6, and 623.6 kev using a magnetic spectrograph.

Most investigators[2,12–27] of the 125-day activity of Tm^{170} found two beta groups with maximum energies of about 885 kev and 970 kev and one gamma ray at about 84.1 kev. Graham *et al.*[15] have made a thorough investigation of the radiations from Tm^{170}. They found the beta-ray spectrum to consist of two components with maximum energies of 968±4 kev and 884±4 kev and having relative intensities of 76 percent and 24 percent, respectively. The low-energy beta group was followed by a gamma ray having an energy of 84.1±0.1 kev. From the internal conversion coefficients the gamma ray was assigned as an $E2$ transition.

Published work[10,28–35] on the 19.5-day activity of Rb^{86} indicates that it has two beta groups with maxi-

[4] DeWire, Pool, and Kurbatov, Phys. Rev. **61**, 564 (1942).
[5] Cork, Shreffler, and Fowler, Phys. Rev. **74**, 1657 (1948).
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[11] G. Scharff-Goldhaber, Phys. Rev. **90**, 587 (1953).
[12] P. J. Grant, Nature **165**, 1018 (1950).
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[15] Graham, Wolfson, and Bell, Can. J. Phys. **30**, 459 (1952).
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[21] M. Goldhaber and R. D. Hill, Revs. Modern Phys. **24**, 179 (1952).
[22] J. W. Mihelich and E. L. Church, Phys. Rev. **85**, 690 (1952).
[23] R. Bell and R. Graham, Phys. Rev. **78**, 490 (1950).
[24] H. Rose, Phil. Mag. **43**, 1146 (1952).
[25] D. Saxon and J. Richards, Phys. Rev. **76**, 186 (1949).
[26] R. L. Graham and D. H. Tomlin, Nature **164**, 278 (1949).
[27] Nakamura, Umezawa, and Takebe, Phys. Rev. **84**, 865 (1951).
[28] Macklin, Lidofsky, and Wu, Phys. Rev. **82**, 334 (1951).
[29] Zaffarano, Kern, and Mitchell, Phys. Rev. **74**, 682 (1948).
[30] H. R. Muether and S. L. Ridgway, Phys. Rev. **80**, 750 (1950).
[31] C. E. Mandeville and E. Shapiro, Phys. Rev. **77**, 439 (1950).
[32] E. T. Jurney, Phys. Rev. **74**, 1049 (1948).
[33] J. P. Palmer and L. J. Laslett, U. S. Atomic Energy Commission Report ISC-174, 1950 (unpublished).
[34] E. Haggstrom, Phys. Rev. **62**, 144 (1942).
[35] Hamilton, Lemonick, and Pipkin, Phys. Rev. **92**, 1191 (1953).

mum energies of about 1770 kev and 700 kev and one gamma ray of 1080 kev.

The 1770-kev beta group is found to have a shape characteristic of a $\Delta I=\pm 2$, "yes" transition.[28,30] The 700-kev beta group is generally reported as having an allowed shape.[30] Angular correlation measurements indicate an $E2$ transition for the gamma ray.[35,36]

Pr^{142}

The Pr^{142} activity was obtained by neutron bombardment of spectrographically pure Pr_6O_{11} at the Oak Ridge pile. (The Pr_6O_{11} and the Tm_2O_3 used in this work were made available through the courtesy of Dr. F. H. Spedding and Dr. J. E. Powell of this laboratory.) The source material had an estimated surface density of about 2 or 3 mg/cm² and was supported by a 40-μg/cm² Formvar-polystyrene film.

The investigation of the beta spectra of Pr^{142} revealed it has two beta groups. The higher-energy group

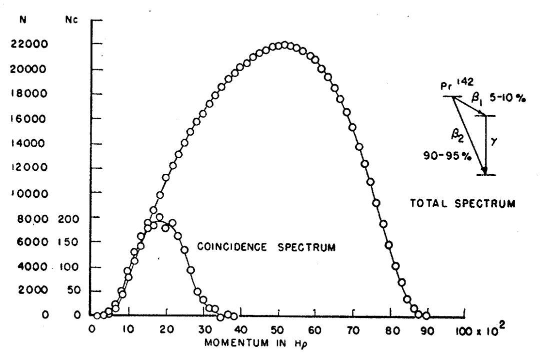

FIG. 3. Total and coincidence spectra of Pr^{142}.

has a maximum beta energy of 2166±6 kev. This beta group was examined with an intermediate image spectrometer set to 5.5 percent resolution and a thin-lens spectrometer set to 2 percent resolution. The values for the maximum beta energy of this group determined by the two instruments agreed within experimental error. In order to obtain a linear Kurie plot, it was necessary to apply the a correction factor. The correction factor is given by $a=(W_0-W)^2+\Lambda(W^2-1)$, where W is the total electron energy, W_0 is the total maximum electron energy, and the coefficient Λ is a function of electron energy and atomic number.[37] The total and coincidence spectra are shown in Fig. 3. The Kurie plots of the total spectrum are illustrated in Fig. 4, the lower-energy beta group being obtained by subtraction. The data shown in Fig. 4 were obtained with the thin-lens spectrometer. The Kurie plot of the coincidence beta spectrum is illustrated in Fig. 5.

The coincidence spectrum yields a maximum beta energy of 586±15 kev and has an allowed shape within

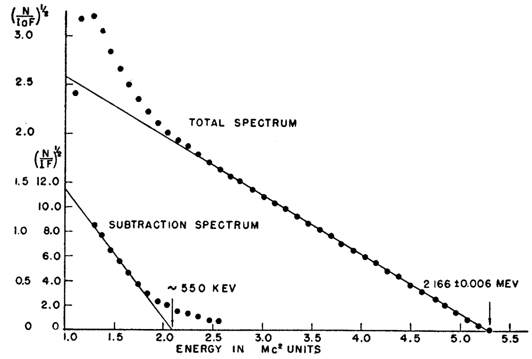

FIG. 4. Kurie plots of Pr^{142} total and subtraction spectra.

experimental error. The Kurie plot for the lower-energy beta group obtained by the conventional subtraction method, Fig. 4, shows considerable curvature near the maximum energy, apparently resulting from source thickness effects. Because of this, only a rough estimate could be made of the ratio of intensities of the two beta groups and of the maximum energy of the lower-energy beta group.

The scattering from the higher-energy beta group into the low-intensity, lower-energy beta group is probably responsible for most of the deviation of the subtracted Kurie plot near the maximum energy. This effect was not noticeable on the coincidence spectrum because scattered beta particles from the higher-energy group were not in coincidence with the gamma ray. From the subtraction data, the estimated intensities are 5–10 percent and 90–95 percent for the 586-kev and 2166-kev beta groups, respectively.

The log ft values were calculated using the average value of these estimated intensities, 7.5 percent and 92.5 percent. The 2166-kev beta group has a log ft value of 7.8 and a log $(W_0^2-1)ft$ value of 10.2. The 586-kev group has a log ft value of 7.1.

The gamma-ray spectrum of Pr^{142} was examined with an intermediate image spectrometer and a scintillation spectrometer. Using a lead radiator with a surface density of 23.2 mg/cm², a single gamma ray was

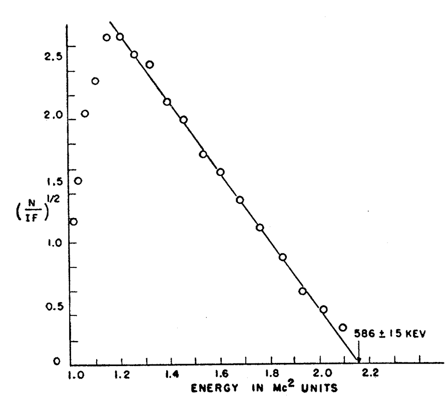

FIG. 5. Kurie plot of coincidence spectrum of Pr^{142}.

[36] D. T. Stevenson and M. Deutsch, Phys. Rev. **83**, 1202 (1951).
[37] Laslett, Jensen, and Paskin, Phys. Rev. **79**, 412 (1950).

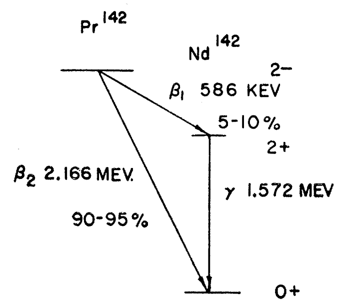

FIG. 6. Pr^{142} decay scheme.

observed. The K-shell photoelectron peak occurred at an energy of 1477 kev. When the K binding energy of 88 kev[38] and the correction for energy loss in the foil of 7 kev[39] were added to the electron energy, the gamma-ray energy was found to be 1572 ± 8 kev.

The scintillation spectrometer also indicated only one gamma ray with an energy of about 1600 kev. The additional gamma rays reported by Cork[5] were not observed. There appeared to be a slight peak at about 350 kev.

It is seen that the difference (1580 kev) between the maximum energy of the higher-energy beta group (2166 kev) and the maximum energy of the lower-energy beta group as obtained from the coincidence spectrum (586 kev) is in good agreement with the gamma-ray energy of 1572 kev.

Because it was necessary to plot the 2166-kev beta group of Pr^{142} with an a correction factor to obtain a linear Kurie plot, this transition is assigned as first forbidden with $\Delta I=2$, "yes." The log ft value is 7.8, which falls in the range of values for this type of transition.[40] The lower-energy beta group, within experimental error, appears to have an allowed shape as shown in Fig. 5. This information and its log ft value of 7.1 indicate that the transition is probably first forbidden with $\Delta I=0$ or ±1, "yes."

G. Scharff-Goldhaber[11] has surveyed the excited states of even-even nuclei and has found that in 66 out of 68 nuclei investigated an assignment of $I=2+$ for the first excited state is compatible with experimental results obtained on these isotopes. Taking the ground state of the even-even Nd^{142} nucleus to be $0+$, the ground state of Pr^{142} is a $2-$ state. This is compatible with the predictions of the nuclear shell model[41] in regard to parity and spin in accordance with the rule proposed by Nordheim[40] for the beta decay of odd-odd nuclei. If the first excited state of Nd^{142} is a $2+$ state, then the transition from the $2-$ ground state of Pr^{142} to the $2+$ excited state of Nd^{142} would correspond to a $\Delta I=0$, "yes" transition. The possibility exists that this lower-energy transition could also correspond to a $\Delta I=\pm1$, "yes" transition to a $1+$ state of Nd^{142}. However, because of the preponderance of $2+$ first excited states for even-even nuclei, the $2+$ choice is tentatively made for Nd^{142}. The resultant decay scheme is shown in Fig. 6. If the $2+$ choice is correct, the gamma radiation corresponds to an $E2$ transition.

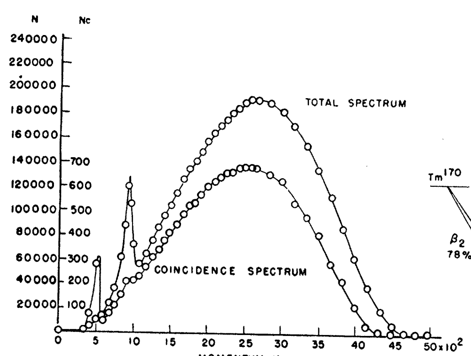

FIG. 7. Total and coincidence spectra of Tm^{170}.

Tm^{170}

The Tm^{170} activity was obtained by neutron bombardment of spectrographically pure Tm_2O_3 at the Oak Ridge pile. The sources were estimated to have an average thickness of about 1 mg/cm^2. The backing was a 40-$\mu g/cm^2$ Formvar-polystyrene film.

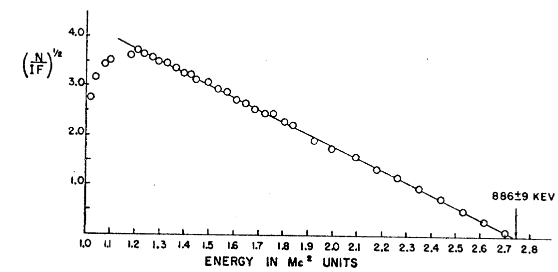

FIG. 8. Kurie plot of Tm^{170} coincidence spectrum.

It was found that Tm^{170} has two beta groups. The higher-energy group has a maximum beta energy of 970 ± 2 kev. This maximum energy was determined both with a thin lens and an intermediate-image spectrometer, and both values agreed within experimental error. The total and coincidence beta spectra are indicated in Fig. 7. The Kurie plot of the coincidence spectrum is illustrated in Fig. 8. Within experimental error, it has an allowed shape. The best coincidence values indicate a maximum energy of 886 ± 9 kev. This is an average of several determinations and is the value given in Fig. 8. The lower-energy beta group was also obtained by the conventional subtraction method on the total spectrum. The maximum energy obtained for the lower-energy group by this method was about 875 kev when the higher-energy group was assigned either as having an allowed or first forbidden shape with

[38] Hill, Church, and Mihelich, Rev. Sci. Instr. **23**, 523 (1952).
[39] Jensen, Laslett, and Pratt, Phys. Rev. **75**, 458 (1949).
[40] L. W. Nordheim, Revs. Modern Phys. **23**, 322 (1951).
[41] M. G. Mayer and S. A. Moszkowski, Revs. Modern Phys. **23**, 315 (1951).

$\Delta I=2$, "yes." In both cases, the subtraction group has an allowed shape. The Kurie plots are indicated in Figs. 9 and 10. Not all of the 25 points beyond the maximum energy of the lower-energy (886-kev) beta group used to perform the subtraction are indicated on the graphs. These data were obtained on a thin-lens spectrometer.

In Figs. 9 and 10 what appears to be a third low-energy beta group when a second subtraction is performed has been reported by others.[15,16] The work of Graham *et al.*[15] indicated that this distribution results from scattering. It was not detected in the coincidence spectrum probably because a thinner source was used in making the coincidence measurements.

Considering the 970-kev beta group and the 886-kev beta group as having allowed shapes, their respective intensities are 78 percent and 22 percent and their respective log *ft* values are 9.0 and 9.1.

Using values for the intensities of the two beta groups obtained by averaging the results of this work and that of Graham *et al.*,[15] the coincidence beta spectrum was

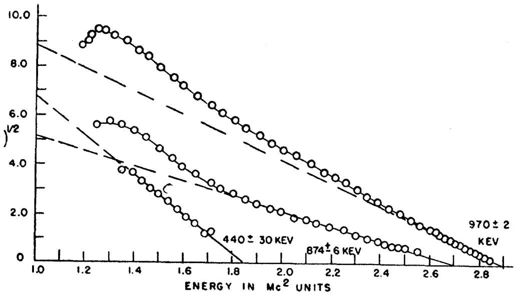

FIG. 9. Total and subtraction spectra of Tm^{170} (all groups plotted as allowed).

subtracted from the total spectrum. The Kurie plot of the resulting spectrum is illustrated in Fig. 11. These data were obtained with an intermediate image spectrometer and with a thinner source than that used in obtaining the data for Fig. 9. Within experimental error the Kurie plot is straight until the source thickness effect causes a deviation below 300 kev. The intensities used for the 886-kev and 970-kev beta groups were 23 percent and 77 percent, respectively.

The energy of the single gamma ray present in the decay of Tm^{170} was determined primarily from the composite L conversion line. The K conversion electron energy was near counter cutoff, and accordingly was unreliable. The energy correction for the composite L line was determined from relative intensities of the L_{I}, L_{II}, and L_{III} lines determined by Mihelich and Church.[22] The gamma-ray energy was measured to be 84.1 ± 0.4 kev.

It is seen that the difference between the maximum energy of the higher-energy beta group (970-kev) and the maximum energy of the lower-energy beta group as obtained from the coincidence spectrum (886 kev)

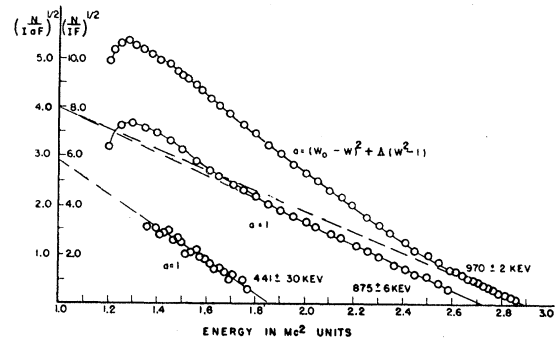

FIG. 10. Total and subtraction spectra of Tm^{170}.

is in good agreement with the 84.1-kev gamma-ray energy. These results on Tm^{170} are in good agreement with those of Graham *et al.*[15]

From the internal conversion data of Axel and Goodrich[42] and those of Hebb and Nelson,[43] it is found that the 84.1-kev gamma ray of Tm^{170}, which was determined to be an $E2$ transition,[17] should be highly converted. The Axel and Goodrich data were computed from the accurate relativistic calculations of Rose *et al.*[44]

The measurements of Fraser[16] and McGowan[17] also indicate that the gamma ray is converted more than 80 percent. The measurements of this work and those of Siegbahn[19] and Fraser[16] indicate that the number of conversion electrons is about 20 percent of the total number of beta particles.

If the 970-kev beta group of Tm^{170} is plotted with an a correction factor in the Kurie plot and a subtraction performed, Fig. 10, the intensities for the 970-kev and 886-kev beta groups are about 50 percent and 50 percent, respectively. This is in disagreement with the intensities expected from conversion electron measurements.

Because of the high conversion coefficient, the number of particles in the lower-energy 886-kev beta group should approximately equal the number of conversion electrons. If the 970-kev group is plotted as an allowed spectrum and a subtraction performed, Fig. 9, then the relative intensities are in agreement with the data on the number of conversion electrons, which indicates that the number of conversion electrons is equal to

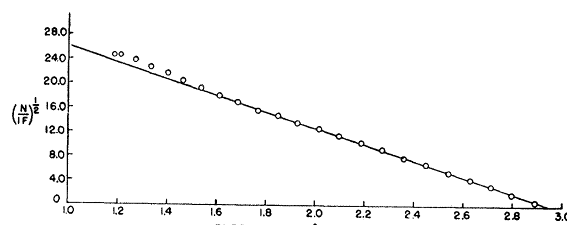

FIG. 11. Tm^{170} 970-kev beta group.

[42] P. Axel and R. F. Goodrich, Office of Naval Research Report, University of Illinois (unpublished).
[43] M. H. Hebb and E. Nelson, Phys. Rev. **58**, 486 (1940).
[44] Rose, Goertzel, and Perry, Phys. Rev. **83**, 79 (1951).

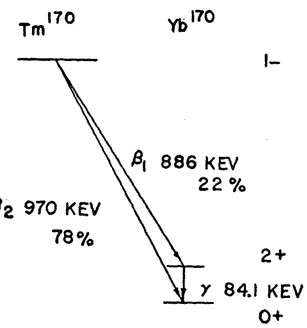

FIG. 12. Tm^{170} decay scheme.

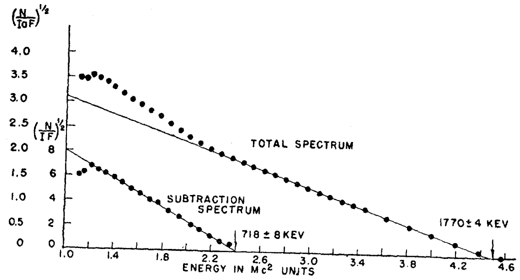

FIG. 14. Kurie plots of Rb^{86} total and subtraction spectra.

about 20 percent of the total number of beta particles. Therefore, the 970-kev group is assigned an allowed shape.

From the coincidence spectrum, the 886-kev beta group was observed to have an allowed shape.

Using the measured K and L ratios and half-life measurements, McGowan[17] and others[22,23] determined the gamma ray to be an $E2$ transition. Therefore the excited state of Yb^{170} is assigned a 2+ state because of the $E2$ transition and the 0+ ground state for the even-even nucleus of Yb^{170}. From experimental evidence, both beta groups are found to have allowed shapes and log ft values of about 9. This suggests $\Delta I=0$ or ±1, "yes" transitions. A consistent decay scheme can then be obtained by assigning the ground state of Tm^{170} as a 1− state. The resultant decay scheme consistent with experimental data is given in Fig. 12. Both beta groups are assigned as $\Delta I=\pm1$, "yes" transitions.

Rb^{86}

The Rb^{86} sample was obtained from the Oak Ridge Isotope Division. The average source thickness was less than 2 mg/cm². The backing was a 40-μg/cm² Formvar-polystyrene film.

Two beta groups were found in the activity of Rb^{86}. The higher-energy group has a maximum energy of 1770±4 kev and the lower-energy group has a maximum energy of 680±6 kev which was determined by coincidence measurements. The maximum energy of the lower-energy beta group was also obtained by the conventional subtraction method. This yielded a maximum energy of 718±8 kev. The maximum energy of the higher-energy beta group was determined both with a thin-lens spectrometer and an intermediate image spectrometer. The values for both spectrometers agreed within experimental error. To obtain a linear Kurie plot, it was necessary to use the a correction factor on the higher-energy beta group. Both the coincidence and subtraction spectra of the lower-energy beta group indicate that it has an allowed shape. The total and coincidence beta spectra are shown in Fig. 13. The Kurie plots of the total and subtraction beta spectra are illustrated in Fig. 14. These data were obtained with an intermediate image spectrometer. The Kurie plot of the coincidence beta spectrum is indicated in Fig. 15.

The intensities were found to be 88 percent and 12 percent for the 1770-kev and 680-kev groups, respectively. Using these relative intensities, the log ft values are 8.5 and 7.8, respectively. The log $[(Wo^2-1)ft]$ value for the 1770-kev group is 9.7.

The gamma radiation of Rb^{86} was examined by means of an intermediate image spectrometer and a lead radiator with a thickness of 16.7 mg/cm². When the correction for the K binding energy and the average energy loss in the foil was made,[39] the gamma-ray energy was found to be 1080±6 kev.

The 1770-kev beta group of Rb^{86} is considered as a $\Delta I=\pm2$, "yes" transition because the a correction factor is necessary to obtain a linear Kurie plot and because of the log $[(Wo^2-1)ft]$ value of 9.7. From this information and the 0+ assignment to the ground state of the even-even nucleus Sr^{86}, the ground state of Rb^{86} can be assigned as a 2− state. The lower-energy beta group (680 kev) was found to have an allowed shape

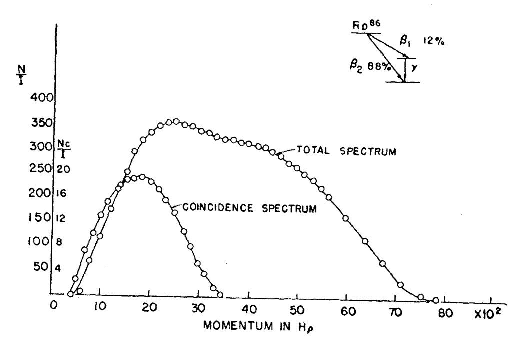

FIG. 13. Total and coincidence spectra of Rb^{86}.

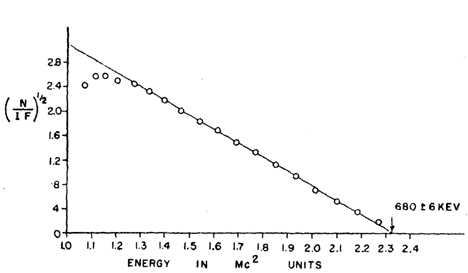

FIG. 15. Kurie plot of Rb^{86} coincidence spectrum.

and a log *ft* value of 7.8. This suggests a first forbidden transition with $\Delta I=0$ or ± 1, "yes" for the 680-kev group. The first excited state of Sr^{86} is tentatively assigned as a 2+ state because of the probable *E*2 assignment[36] to the 1.080-Mev gamma ray. This is consistent with the beta-gamma polarization correlations made by Hamilton, Lemonick, and Pipkin.[35] A consistent decay scheme is then obtained by assigning the lower-energy beta group as a $\Delta I=0$, "yes" transition. This decay scheme is indicated in Fig. 16.

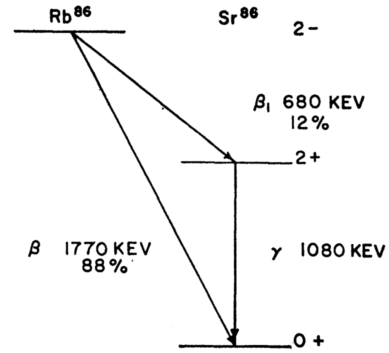

FIG. 16. Rb^{86} decay scheme.

DISCUSSION

The correction for the effect of the finite DeBroglie[45] wavelength was applied to the spectrum of Rb^{86}. This correction made no significant difference in the end points or shape of the subtraction or total spectra.

The Kurie plots of the 680-kev beta group of Rb^{86} and the 886-kev beta group of Tm^{170} were examined for deviation from a straight line. Limits on the value of the quantity ϕ defined by Mahmoud and Konopinski[46] for the Fierz interference effect were determined. For the 680-kev group of Rb^{86}, ϕ was -0.05 ± 0.10. For the 886-kev group of Tm^{170}, ϕ was 0.05 ± 0.08. The error given is the probable error determined by the statistics. The quantity 2ϕ is equal to r as defined by Davidson and Peaslee.[47] Within experimental error, there appears to be no deviation from a straight line.

It was found in general that the maximum energies obtained by coincidence methods are in better agreement with the energy differences between high-energy beta end points and gamma-ray energies than those obtained from subtraction spectra.

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$A^{40}(\gamma,n)$ Threshold and the Mass of A^{39}†

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The $A^{40}(\gamma,n)A^{39}$ reaction is found to have a threshold at 9.85 ± 0.15 Mev. Using the most recent mass spectrograph measurements for the mass of A^{40}, the mass of A^{39} is calculated to have a value of 38.97681 ±0.00020. The relationship of this measurement to other reaction energy data is discussed.

INTRODUCTION

THE recent modification of the neutron detection apparatus used in this laboratory for the study of photonuclear reactions to accommodate gaseous targets[1] has permitted a determination of the $A^{40}(\gamma,n)$ threshold. Using the accurate mass spectrographic data for the mass of A^{40}, the measurement yields a precise value for the mass of A^{39} and an important check on nuclear transmutation data in this region of mass number.

EXPERIMENT

The apparatus is identical to that previously reported[1] for the study of the properties of the giant (γ,n) dipole resonances in gaseous targets, and the entire operational procedure is identical except that neutron yields in the vicinity of threshold are taken with greater statistical precision and are more closely spaced in betatron energy.

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