By elementary if tedious integration we find that for

Case I.—$(2k_m-k_0\leqslant k_a)$

$$\sigma_L(k_m, k_a, k_0)=A\int_{k_0-2k_m}^{k_a}k_e dk_e\int_{k_0-k_m}^{k_m+k_e}kQdk$$

$$=A\pi\left[\ln\left(\frac{k_m+k_a}{k_0-k_m}\right)\left[\frac{k_0^2+k_m^2}{4(k_0^2-k_a^2)}-\frac{1}{8}\right]\right.$$

$$\left.+\frac{1}{8}\frac{k_m}{k_m+k_a}-\frac{k_m}{4(k_0-k_a)}-\frac{1}{8}\frac{2k_m-k_0}{k_0-k_m}\right]. \quad \text{(A7)}$$

Case II.—$(2k_m-k_0\geqslant k_a)$

$$\sigma_L(k_m, k_a, k_0)=A\int_0^{k_a}k_e dk_e\int_{k_m-k_e}^{k_m+k_e}kQdk$$

$$=\frac{A\pi}{4}\ln\frac{k_m+k_a}{k_m-k_a}\left\{\frac{k_m^2+k_0^2}{k_0^2-k_a^2}-\frac{1}{2}\right\}$$

$$-\frac{\pi k_a k_m}{2}\left\{\frac{1}{k_0^2-k_a^2}+\frac{1}{2(k_m^2-k_a^2)}\right\}, \quad \text{(A8)}$$

where $A=6z^2/a_0^2k_a^3k_m$. This completes the derivation of Eq. (3).

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Radiations from Selenium[75]

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The radiations from 125-day Se^{75} have been examined by means of a thin lens spectrometer and absorption-coincidence techniques. Se^{75} was found to decay to As^{75} by orbital electron capture. The energies of ten transitions (0.066_6, 0.076_6, 0.098_3, 0.124_1, 0.138_4, 0.203_2, 0.268_8, 0.281_4, 0.307_8, and 0.405_0 Mev) were observed in the photoelectron and internal conversion spectra determined with the spectrometer. A decay scheme is proposed on the basis of the absorption-coincidence and spectrometer data. The multipole order of the 98.3-kev transition is discussed.

I. INTRODUCTION

A NUMBER of investigators[1–8] have examined the radiations from 125-day Se^{75}. From lead absorption measurements Burgus *et al.*[2] report two gamma-rays having energies of 0.18 and 0.335 Mev; Friedlander *et al.*[3] found a single gamma-ray having an energy of 0.4 Mev; Cowart *et al.*[5] report two gamma-rays with energies of 0.22 and 0.43 Mev; and Gest and Glendenin[6] found two gamma-rays having energies of 0.18 and 0.35 Mev. The three latter groups found x-rays corresponding to the K lines from arsenic, indicating that Se^{75} decays to As^{75} by orbital electron capture.

Ter-Pogossian *et al.*[7] examined the photoelectron spectra of Se^{75}, as obtained from lead and uranium radiators, in a 180° spectrometer. They report six, and possibly seven, gamma-rays with energies 0.076, 0.099(?), 0.123, 0.137, 0.267, 0.283, and 0.405 Mev. They did not obtain an internal conversion spectrum. Cork *et al.*[8] have examined the internal conversion spectrum of Se^{75} in spectrometers using photographic detection techniques. They report eleven gamma-rays with energies 0.0247, 0.0662, 0.0808, 0.0968, 0.1212, 0.1362, 0.1988, 0.2652, 0.2801, 0.3050, and 0.4019 Mev. They did not obtain a photoelectron spectrum.

DeBenedetti and McGowan[9] made a search for a metastable state in As^{75}, by means of delayed coincidences, and obtained a negative result in the range 10^{-6} to 10^{-3} sec.

Reports[10] have been made at various times on the decay and transition energies of Se^{75}, as determined

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[1] Kent, Cork, and Wadey, Phys. Rev. **61**, 389 (1952).

[2] Burgus, Edwards, Gest, Stanley, and Williams, Plutonium Project Report CN-2839, p. 9 (June, 1945); cited by Seaborg and Perlman, Revs. Modern Phys. **20**, 585 (1948).

[3] Friedlander, Seren, and Turkel, Phys. Rev. **72**, 23, 888 (1947).

[4] H. H. Hopkins, Jr., and B. B. Cunningham, Phys. Rev. **73**, 1406 (1948).

[5] Cowart, Pool, McCown, and Woodward, Phys. Rev. **73**, 1454 (1948).

[6] H. Gest and L. E. Glendenin, Radiochemical Studies: The Fission Products (McGraw-Hill Book Company, Inc., New York, 1951), paper 327, National Nuclear Energy Series, Plutonium Project Record, Vol. 9, Div. IV.

[7] Ter-Pogossian, Robinson, and Cook, Phys. Rev. **75**, 995 (1949).

[8] Cork, Rutledge, Branyan, Stoddard, and Le Blanc, Phys. Rev. **79**, 889 (1950).

[9] S. DeBenedetti and F. K. McGowan, Phys. Rev. **74**, 728 (1948).

[10] Jensen, Laslett, and Pratt, U. S. Atomic Energy Commission Report AECD-1836, 1948; E. N. Jensen, Atomic Energy Commission Report AECD-2399, 1948; Progress Report in Physics, Iowa State College, ISC-46, 1949 (unpublished).

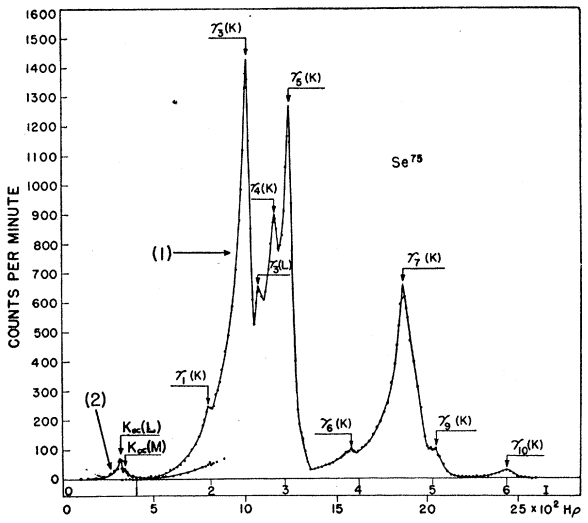

FIG. 1. Internal conversion spectrum of Se^{75}. Curves (1) and (2) were obtained with different counters. Curve (2) was determined from the same source as curve (1), but was obtained 2.3 half-lives later.

with a thin lens spectrometer. Nearly all of the transition energies so determined have been communicated privately to other workers and have subsequently been cited in several publications.[7,11,12] It is the purpose of this paper to present directly the evidence obtained here for the transition energies and decay scheme of Se^{75}.

The radioactive Se^{75} used in this investigation was produced by neutron bombardment of the metal in the Oak Ridge pile. The radiations were examined with a thin lens spectrometer[13] before it was modified to incorporate ring focusing.[14] The spectrometer was calibrated by means of the F conversion line of ThB and the annihilation radiation from Zn^{65}. All transition energies were calculated from the maximum counting rate of the respective lines, with corrections applied for the earth's magnetic field, the surface density of the source of electrons, and the resolution of the spectrometer.[13]

II. INTERNAL CONVERSION SPECTRUM

The source was mounted on 0.00025 inch aluminum which in turn was fastened to a Lucite holder. The surface density of the source was about 5 mg/cm². Such a thick source is of no great disadvantage in determining transition energies, since a correction can be made to take into account the surface density. There is a distinct advantage in that the counting rates are greatly increased, which enables the weaker transitions to be detected more readily.

The internal conversion spectrum of Se^{75} is shown in Fig. 1. Curve 1 was obtained with a Geiger counter having a Formvar window with a surface density of about 0.3 mg/cm². The pressure in the counter was 10 cm of mercury. Curve 2 was obtained from the same source as that used for curve 1, but was determined 286 days (2.3 half-lives) later than curve 1 and with a Geiger counter having a window of Formvar with a surface density of about 27 μg/cm². This window was supported between metal grids containing holes 0.040 inch in diameter and spaced 0.048 inch from center to center. The counter mixture was 33 percent alcohol and 67 percent argon, maintained at a pressure of 1.8 cm of mercury. For the curves shown in Fig. 1 the resolution of the spectrometer was 2.1 percent (half-width).

Curve 1 of Fig. 1 was redetermined 87 days later and, within experimental error, the intensities of all conversion electrons were found to have decreased by the same factor, indicating that the internal conversion lines shown in Fig. 1 are from the same activity.

It is apparent from Fig. 1 that no beta-rays are observed in the decay of Se^{75}. Furthermore the peaks labeled $K_\alpha(L)$ and $K_\alpha(M)$ are presumably attributable to Auger electrons. The corrected electron energy of $K_\alpha(L)$ is calculated to be 9.03 kev. The addition of the L binding energy of arsenic gives a value of 10.56±0.10 kev. This is in good agreement with the $K_{\alpha 1}$ and $K_{\alpha 2}$ values of 10.54 and 10.51 kev, respectively, for the As

TABLE I. Transition energies of Se^{75}.

Transition	Conversion shell	Energy Mev	Relative weight	Average energy Mev
1	As(K)	0.0666	2	0.066_6
2	Pb(L)	0.0765	3	
	Pb(M)	0.0768	3	0.076_6
3	As(K)	0.0987	10	
	As(L)	0.0968	3	0.098_3
4	As(K)	0.1239	5	
	Pb(K)	0.1216	3	
	Pb(L)	0.1271	3	0.124_1
5	As(K)	0.1384	10	
	Pb(K)	0.1366	10	
	Pb(L)	0.1399	10	
	Pb(M)	0.1397	3	0.138_4
6	As(K)	0.2032	3	0.203_2
7	As(K)	0.2688	10	
	Pb(K)	0.2677	10	
	Pb(L)	0.2700	10	0.268_8
8	Pb(K)	0.2814	5	0.281_4
9	As(K)	0.3078	3	0.307_8
10	As(K)	0.4052	5	
	Pb(K)	0.4029	10	
	Pb(L)	0.4070	10	0.405_0

[11] G. T. Seaborg and I. Perlman, Revs. Modern Phys. **20**, 585 (1948).
[12] *Nuclear Data*, National Bureau of Standards Circular 499 (1950).
[13] Jensen, Laslett, and Pratt, Phys. Rev. **75**, 458 (1949).
[14] Pratt, Boley, and Nichols, Rev. Sci. Instr. **22**, 92 (1951); Keller, Koenigsberg, and Paskin, Rev. Sci. Instr. **21**, 713 (1950).

x-rays.[15] It thus appears that the spectral lines designated $K_\alpha(L)$ and $K_\alpha(M)$ may be attributed to Auger electrons ejected from arsenic, following orbital electron capture in Se^{75} and possible subsequent internal conversion.

Stokes[16] has measured the x-rays emitted from the decay of Se^{75} by means of a Cauchois bent crystal spectrograph and finds that the x-rays of As are present and that the x-rays of Se are not observed. Our data on the Auger electrons are thus in agreement with the findings of Stokes.

The lines shown in Fig. 1 can be ascribed to eight nuclear transitions. The energies of these transitions, as determined from the data given in Fig. 1, are included in Table I and designated as conversions in As. The probable error in the energies is estimated to be less than one percent.

III. PHOTOELECTRON SPECTRUM

The photoelectron spectrum of Se^{75}, as obtained from lead foils, is shown in Fig. 2. The radioactive source was placed in a Lucite holder and covered with an aluminum cap of sufficient thickness (0.031 inch) to absorb the internal conversion electrons. The lead foils were fastened to the aluminum caps. Curves 1 and 2 of Fig. 2 were obtained with a spectrometer resolution of 2.3 percent (half-width), while all the inserts were obtained with a resolution of 2.1 percent. Curves 1 and 2 were determined with Geiger counters having mica windows of surface densities 3.8 and 1.0 mg/cm^2 respectively.

The lines shown in Fig. 2 can be ascribed to six gamma-rays, of which four are also included in the internal conversion spectrum of Fig. 1. The energies of the gamma-rays, as determined from the data given in Fig. 2, are listed in Table I as conversions in lead.

IV. ENERGIES OF NUCLEAR TRANSITIONS

The average energies of the ten transitions listed in Table I are in good agreement with those given by Ter-Pogossian *et al.*[7] In only one case is the percentage difference greater than the estimated probable error of one percent. Transitions 1, 6 and 9 are in addition to those reported by Ter-Pogossian *et al.*[7] These transitions are very weak and were observed only in the internal conversion spectrum, which was not obtained by Ter-Pogossian *et al.*[7]

The average energies of the transitions listed in Table I are also in fairly good agreement with those given by Cork *et al.*,[8] although for six of the transitions the discrepancies are greater than the estimated probable error of one percent. In one case, transition 2, the difference is 5.4 percent. Cork *et al.*[8] report a transition

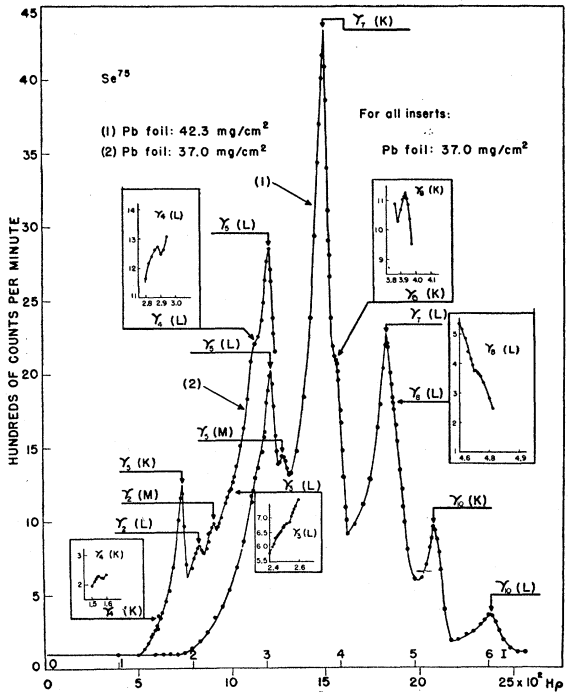

FIG. 2. Photoelectron spectrum of Se^{75}. Curves (1) and (2) were obtained with different counters. The inserts were obtained by more detailed examination of the regions indicated and with somewhat better resolution than used for curves (1) and (2).

having an energy of 0.0247 Mev, which is in addition to those given in Table I. We did not observe this transition. The internal conversion electrons from the K shell for a 0.0247-Mev transition would appear at a current value of 0.93 amp on curve 2 of Fig. 1. This is at a slightly larger current value than the peak labeled $K_\alpha(M)$ which has a value of 0.85 amp. There is no indication of a peak at 0.93 amp. Since Cork *et al.*[8] observed only the L and M electrons of this transition it is possible that the lines labeled $K_\alpha(L)$ and $K_\alpha(M)$ in curve 2 of Fig. 1 are due to the radiation which they have ascribed to a transition of energy 0.0247 Mev. However, since Se^{75} decays by orbital electron capture, presumably the Auger electrons should be observed. The peaks which we ascribe to Auger electrons, in curve 2 of Fig. 1, are in excellent agreement with the characteristic x-ray energies of As.

An additional gamma-ray, having an energy of 0.0103 Mev, has been reported by Stokes.[16,17] This gamma-ray, however, was apparently from an impurity present in the original sample, since the gamma-ray was not observed in a second sample of Se^{75} from which the impurities had been removed.[18] Radioactive impurities of Sb and Te were detected in the sample of Se^{75} from which Stokes' original source was prepared.

[15] A. H. Compton and S. K. Allison, *X-Rays in Theory and Experiment* (D. Van Nostrand Company, Inc., New York, 1935), second edition, p. 784.

[16] R. H. Stokes, U. S. Atomic Energy Commission Report AECD-1843, 1948 (unpublished).

[17] Progress Report in Physics, Iowa State College Report ISC-46, 1949 (unpublished).

[18] R. H. Stokes (private communication).

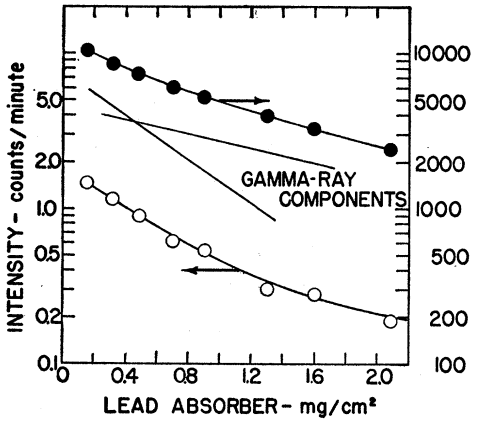

FIG. 3. Absorption curve for γ-γ coincidences with 225-mg Al/cm² in front of one counter and 225-mg Al/cm² plus varying lead absorbers in front of the other counter. 0=$\gamma-\gamma$ coincidence rate and ●=γ-ray count for second counter. The γ-ray components were obtained from the extended lead absorption curve by the usual subtraction method.

V. INTENSITIES OF GAMMA-RAYS AND INTERNAL CONVERSION ELECTRONS

An attempt has been made to calculate the approximate ratios of the intensities of the gamma-rays and the internal conversion electrons from the maximum counting rate of the respective lines. Corrections have been applied for the photoelectric absorption coefficient, the transmission of the counter window, the momentum spread of the electrons due to the surface density of the source of electrons, and the transmission of the spectrometer. The photoelectric absorption coefficients were calculated by means of Gray's[19] empirical formula and the average spread in momentum produced by the lead foils and Se sources by means of a formula given by Heitler.[20] Electron scattering in the source has been neglected. The intensities of the internal conversion lines have been evaluated relative to that of γ_7 in Fig. 1. These values are given in Table II as e_i/e_7. The intensities of the gamma-radiations have been expressed relative to that of γ_7, which gave rise to the K and L photoelectron peaks $\gamma_7(K)$ and $\gamma_7(L)$ of Fig. 2. These relative intensities are given in Table II as q_i/q_7. These intensity ratios are of some help in constructing a decay scheme. It is estimated that the ratio e_x/e_7 is about 130, where e_x represents the intensity of Auger electrons as given by $K_\alpha(L)$ and $K_\alpha(M)$ of Fig. 1. The relative intensities given in Table II are only approximate values and are not reliable to better than a factor of about two.

VI. COINCIDENCE COUNTING MEASUREMENTS

Coincidence counting experiments were performed on several samples of Se^{75} using the counter arrangements and circuits described previously.[21] The selenium was precipitated as the element in a small drop on a thin mica sheet, 2 mg/cm² thick. After evaporation of the solution the mica sheet was mounted with the sample spot directly in front of a 3-mm hole in either a brass or lead plate which could be inserted between the two end-window Geiger counters. Samples were counted without absorber, with a paraffin absorber (148 mg/cm²), and with an aluminum absorber (225 mg/cm²). Counts obtained through the aluminum absorber were due to gamma-rays, counts through paraffin minus counts through aluminum were taken as the As K x-ray component, and counts with no absorber minus counts through paraffin gave the conversion electron contribution.

In agreement with DeBenedetti and McGowan[9] no delayed coincidences were found in the region of 0.3–10 μsec. Coincidence counts were obtained with several permutations of absorbers before the two counters. The usual subtractions for accidental coincidence counts and backgrounds were applied to the data. These results taken in conjunction with the spectrometer data, permit some conclusions regarding the decay scheme. Experimental values of the ratio of coincidence counting rates to the rates of individual counters are given in Table III.

In the treatment of the data the following symbols have been employed. Subscript "c" indicates a coincidence counting rate. Subscript numerals refer to transitions as listed in Table II. Superscripts (′) and (″) refer to channel or counter 1 and 2, respectively. e=an electron component. q=a photon component (γ-ray or x-ray). α=a conversion coefficient, e/q. n_i=a transition rate in As^{75}. n_0=a disintegration rate from Se^{75} directly to the ground state of As^{75}. n_t=total disintegration rate. E=a counter efficiency for detecting a particular radiation.

In accordance with the procedure described previously, E has been separated into three factors,

$$E=\omega A\epsilon,$$

where ϵ is the intrinsic efficiency for counting a par-

TABLE II. Approximate relative intensities of gamma-rays and internal conversion electrons from Se^{75}.

Transition	Energy, Mev	e_i/e_7	q_i/q_7
1	0.066_6	0.7	
2	0.076_6		0.2
3	0.098_3	9	~0.01
4	0.124_1	1	~0.03
5	0.138_4	4	0.3
6	0.203_2	0.06	
7	0.268_8	1	1
8	0.281_4		~0.07
9	0.307_8	0.05	
10	0.405_0	0.03	0.2

[19] L. H. Gray, Proc. Cambridge Phil. Soc. **27**, 103 (1931).
[20] W. Heitler, *The Quantum Theory of Radiation* (Oxford University Press, New York, 1944), second edition, p. 219.
[21] Martin, Jensen, Hughes, and Nichols, Phys. Rev. **82**, 579 (1951).

ticular radiation which penetrates the counter, A is the absorption (and scattering) factor of absorber material placed between the sample and counter, and ω is the effective solid angle or geometry factor.

An examination of intensities from the spectrometer data, Table II, reveals that effective contributions to electron or photon counting rates in these experiments could be attributed only to transitions 2, 3, 4, 5, 7, and 10. In addition, the K x-rays will contribute to the photon component. Only these transitions have been considered in the subsequent treatment.

In one experiment with sufficient lead before each counter to remove effectively the gamma-rays with an energy less than 0.15 Mev, no coincidences in excess of background or accidental counts were observed. Individual counter intensities were sufficiently high that it can be concluded that gamma-rays 7 and 10 cannot occur in cascade. Gamma-ray 7, being the most intense, is presumably a transition to the ground state. Further evidence in support of this conclusion is the fact that Smith *et al.*[22] found a weak 265-kev gamma-ray in the radiations from Ge^{75}, which decays by beta-emission to As^{75}. It is seen from the ratios of Table III that gamma-gamma coincidences did occur. Figure 3 shows the coincidence rate as a function of lead absorber thickness before one counter and indicates that the gamma-gamma-cascade must contain a "hard" and a "soft" transition. It appears therefore that transition 7 is in cascade with either transition 2, 5, or both. These two gamma-rays cannot be resolved by lead absorption measurements since they lie on opposite sides of the lead absorption edge and have approximately equal absorption coefficients. Cascade of transitions 7 and 5 appears likely because their energies add within the accuracy of the measurement of the energy of transition 10.

The ratio, $(e'-q_x'')_c/q_x''$, is very much less than ω' and indicates that conversion electrons can accompany only a few percent of the disintegrations, which is in agreement with the large ratio of e_x/e_7 given in Sec. V. The very low $(e'-e'')_c/e'$ ratio requires that at least one of the transitions in cascade must have a very low conversion coefficient.

TABLE III. Coincidence counting ratios for thin samples of Se^{75}.

Ratio	Experimental value	Calculated value from decay scheme, Fig. 4
$(e'-q_x'')_c/q_x''$	$1.34\pm0.04\times10^{-2}$	...
$(q_x'-q_\gamma'')_c/q_x''$	$3.7\ \pm0.5\ \times10^{-4}$	...
$(e'-q_x'')_c/e'$	$2.29\pm0.06\times10^{-3}$	$3.5\ \times10^{-3}$
$(q_\gamma'-q_x'')_c/q_\gamma'$	$1.2\ \pm0.2\ \times10^{-3}$	$1.7\ \times10^{-3}$
$(e'-q_\gamma'')_c/q_\gamma'$	$2.27\pm0.02\times10^{-3}$	1.64×10^{-3}
$(e'-q_\gamma'')_c/e'$	$1.26\pm0.01\times10^{-4}$	1.07×10^{-4}
$(e'-e'')_c/e'$	$1.0\ \pm0.3\ \times10^{-3}$	$6.8\ \times10^{-4}$
$(q_\gamma'-q_\gamma'')_c/q_\gamma''$	$1.8\ \pm0.1\ \times10^{-4}$	2.04×10^{-4}

[22] Smith, Caird, and Mitchell, Phys. Rev. **88**, 150 (1952).

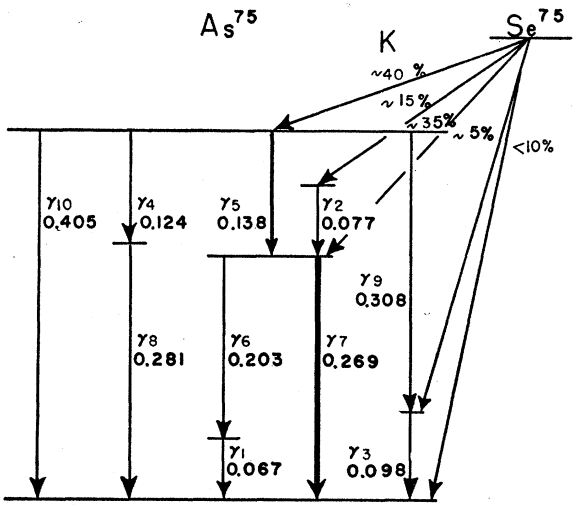

FIG. 4. Proposed decay scheme for Se^{75}. The energies are given in Mev.

VII. DECAY SCHEME

The decay scheme shown in Fig. 4 is consistent with the energies and relative intensities as given in Table I and II, respectively, and with the coincidence counting ratios of Table III. For this decay scheme the various counting rates could be calculated by the following equations:

$$q_\gamma'=\omega'\sum\frac{n_i\epsilon_{iq}}{1+\alpha_i}, \tag{1}$$

$$q_x''=\omega''\epsilon_{xq}''\left(\frac{1}{1+\alpha_x}\right)\left[\sum{}^{*}n_i+\sum\frac{n_i\alpha_i}{1+\alpha_i}+n_0\right]. \tag{2}$$

$\sum^{*}$ represents a summation of transitions in arsenic to the ground state. The disintegration rate $n_t=\sum^{*}n_i+n_0$.

$$e'=\omega'\sum\frac{n_i\alpha_iA_{ie}'}{1+\alpha_i}. \tag{3}$$

Coincidence rates are given by the following equations. Since $\alpha_i\ll1$ except for transition 3, a number of small terms can be omitted for simplicity:

$$(e'-q_x'')_c=\frac{\omega'\omega''\epsilon_{xq}''}{1+\alpha_x}\left[\frac{2n_5A_{5e}'\alpha_5}{1+\alpha_5}+\frac{2n_7A_{7e}'\alpha_7}{1+\alpha_7}+\frac{2n_3A_{3e}'\alpha_3}{1+\alpha_3}+\frac{2n_4A_{4e}'\alpha_4}{1+\alpha_4}\right]. \tag{4}$$

$$(q_x'-q_\gamma'')_c=\frac{\omega'\omega''\epsilon_{xq}'}{1+\alpha_x}\sum_i\frac{n_i\epsilon_{iq}''}{1+\alpha_i}. \tag{5}$$

$$(q_\gamma'-q_\gamma'')_c=\omega'\omega''\left[\frac{n_2(\epsilon_{7q}'\epsilon_{2q}''+\epsilon_{2q}'\epsilon_{7q}'')}{(1+\alpha_7)(1+\alpha_2)}+\frac{n_5(\epsilon_{7q}'\epsilon_{5q}''+\epsilon_{5q}'\epsilon_{7q}'')}{(1+\alpha_7)(1+\alpha_5)}\right]. \tag{6}$$

$$(e'-e'')_c=\omega'\omega''\left[\frac{n_2\alpha_2\alpha_7(A_{7e}'A_{2e}''+A_{2e}'A_{7e}'')}{(1+\alpha_2)(1+\alpha_7)}+\frac{n_5\alpha_5\alpha_7(A_{7e}'A_{5e}''+A_{5e}'A_{7e}'')}{(1+\alpha_5)(1+\alpha_7)}\right]. \quad (7)$$

$$(e'-q_\gamma'')_c=\omega'\omega''\left[\frac{n_5(\alpha_5A_{5e}'\epsilon_{7q}''+\alpha_7A_{7e}'\epsilon_{5q}'')}{(1+\alpha_5)(1+\alpha_7)}+\frac{n_2(\alpha_2A_{2e}'\epsilon_{7q}''+\alpha_7A_{7e}'\epsilon_{2q}'')}{(1+\alpha_2)(1+\alpha_7)}\right]. \quad (8)$$

Counter characteristics used in these equations have been tabulated in Table IV. These equations were used with the relative intensities given in Table II which give the ratios of electron intensities, $n_i\alpha_i/(1+\alpha_i)$, and photon intensities, $n_i/(1+\alpha_i)$, compared to the corresponding quantities for transition 7. When the expression for $(e'-q_x'')_c/q_x''$ from Eqs. (2) and (4), including the numerical values from Tables II and IV, is set equal to the experimental ratio of 1.34×10^{-2}, the values of each electron component, $n_i\alpha_i/n_t(1+\alpha_i)$, can be calculated. Likewise a similar treatment using the ratio for $(q_x'-q_\gamma'')_c/q_x'$ was used to give values for $n_i/n_t(1+\alpha_i)$. From these two sets of data the intensity and conversion coefficient for each of the transitions were calculated and included in Table V. Transitions 3, 7, and 10 to the ground state account for more than 95 percent of the disintegrations. It was concluded that only a few percent of the orbital electron captures, at most, can lead directly to the ground state. With these results the remaining six coincidence counting ratios were calculated and appear in Table III. Support of the decay scheme shown in Fig. 4, is demonstrated by the satisfactory agreement between the calculated and observed values in every case.

TABLE IV. Counter characteristics used in Eqs. (1)–(8).

Quantity	Value	How estimated
ω'	0.115	From β-γ coincidences of Au^{198} and Co^{60}.[a]
ω''	0.135	
A_{xq}''	0.68	Calculated from mass absorption coefficient.[b]
α_x	0.92	Reference c.
A_{2e}'	0.0	From air and window absorber thickness assuming a linear absorption curve.[d]
A_{3e}'	0.6	
A_{4e}'	0.7	
A_{5e}'	0.75	
A_{7e}'	0.9	
ϵ_{xq}	33×10^{-3}	From β-γ coincidences of Au^{198} and counting efficiency ratios given by experimental curve for copper wall counters.[e]
ϵ_{2q}	6.6×10^{-3}	
ϵ_{5q}	3.0×10^{-3}	
ϵ_{7q}	2.0×10^{-3}	
ϵ_{10q}	2.5×10^{-3}	

[a] See reference 21.
[b] See reference 15, p. 800.
[c] See reference 15, p. 488.
[d] L. E. Glendenin, Nucleonics **2**, No. 1, 12 (1948).
[e] H. Saurer, Helv. Phys Acta No. 4. 381 (1950).

Similar computations were carried out for the alternative decay scheme in which transition 2 terminated in the ground state and was not in cascade with other transitions. For this case the ratio $(q_\gamma'-q_\gamma'')_c/q_\gamma'$ was 8.3×10^{-5}, disagreeing seriously with the experimental value of 1.8×10^{-4}.

Assuming that none of the orbital electron captures lead directly to the ground state, as is indicated by the coincidence data, it is possible to determine the conversion electron and photon intensities, the transition intensities, and the conversion coefficients from the decay scheme shown in Fig. 4, the relative intensities given in Table II, the ratio of Auger electrons to conversion electrons in transition 7 (i.e., e_x/e_7) and the fluorescent yield for arsenic x-rays (which is about 0.52) (see p. 488 of reference 15). These calculations make use of two equations, of which one gives the x-ray transition rate and the second gives the disintegration rate. The transition intensities (e_i+q_i) obtained in this way are in good axreement with those given in Table V. The conversion coefficients, α_i, calculated by this method are, however, approximately one-half of those given in Table V. This discrepancy is primarily due to the difference in the electron intensities, e_i. The ratio e_x/e_7 was not used in calculating the values given in Table V.

The intensity of transition 3 is appreciably greater than that of transition 9 and therefore requires that there be decay by orbital electron capture to the energy level 0.0983 Mev above the ground state of As^{75}. Similarly, there must also be decay by orbital electron capture to the energy level 0.269 Mev above the ground state of As^{75}.

Cork *et al.* have proposed a decay scheme which in many ways is similar to the one shown in Fig. 4. Two possible objections to their decay scheme might be mentioned, however. They have transition 3 precede and decay through the parallel transitions 9 and the 24.7-kev disintegration. As can be seen from Table II and Figs. 1 and 2, transition 3 is many times more intense than 9. As mentioned previously we have not found any evidence for the existence of the 24.7-kev gamma-ray or its internal conversion electrons. We would infer that, if it exists, it must be very weak. Hence, it appears improbable that transition 3 precedes 9. Cork *et al.*[8] also propose that the parallel transitions 1 and 2 precede and decay through 6. Our data, shown in Table II, indicate the e_1 is considerably larger the e_6 and that q_2 is also considerably larger than q_6 and hence it seems improbable that transitions 1 and 2 in parallel can precede and decay through 6.

It would be highly desirable to make coincidence measurements between individual transitions in order to verify the proposed decay scheme shown in Fig. 4.

VIII. DISCUSSION

There appears to be a real discrepancy between the K/L ratio and the apparently large internal conversion

coefficient for transition 3. A multipole order of the radiation cannot be assigned which is consistent with the K/L ratio, internal conversion coefficient, lifetime of the excited state, and the nuclear shell model. Most of the available evidence indicates magnetic dipole radiation. The evidence for this conclusion is given in the following discussion.

From the data shown in Fig. 1, a value of 11 is found for the K/L ratio of transition 3, for which the energy is 98.3 kev. The experimental curves of Goldhaber and Sunyar[23] indicate a K/L ratio of about 8 for both magnetic dipole and quadrupole radiation for $Z=33$ and $E=98.3$ kev, and a K/L ratio of about 4.3 and 3.0 for electric quadrupole and octupole radiation respectively. Hence the K/L ratio, although appreciably larger than the values given by the experimental curves of Goldhaber and Sunyar,[23] indicates magnetic dipole or quadrupole radiation with lifetimes of the excited state of 3×10^{-11} sec and 1×10^{-4} sec, respectively. These lifetimes are estimated from the formula of Weisskopf,[24] taking into account the internal conversion coefficients as determined from the tables of Hebb and Nelson[25] and the curves given by Axel and Goodrich.[26] The latter lifetime is in the region of 10^{-6} to 10^{-3} sec, within which DeBenedetti and McGowan[9] did not observe any delayed coincidences. Also, Feenberg and Hammack[27] and Nordheim[28] have pointed out that "islands of isomerism" exist for odd nuclei with $39\leqslant(N$ or $Z)\leqslant49$ and for $63\leqslant(N$ or $Z)\leqslant81$, where N and Z are respectively the number of neutrons and protons in the nucleus. As^{75}, with 33 protons and even N, does not fit into either one of these "islands." This would seem to indicate that transition 3 is magnetic dipole radiation.

The assignment of magnetic dipole radiation to transition 3 is inconsistent with the large internal conversion coefficient of 4 to 8, which is obtained from the data presented in this paper. From the curves given by Axel and Goodrich,[26] the relativistic K shell internal conversion coefficient for transition 3 in 0.07 for magnetic dipole radiation. It should be stated that the internal conversion coefficient for transition 3 as calculated from our data is a very approximate value, since, as can be seen in Fig. 2, the photoelectrons due to gamma-ray 3 had a very low intensity. This low intensity indicates, however, that the internal conversion coefficient must be fairly large.

TABLE V. Intensities and conversion coefficients for the transitions following the decay of Se^{75} as determined from coincidence data.

Transition	Energy Mev	Electron intensity e_i	Photon intensity q_i	Transition intensity e_i+q_i	Conversion coefficient e_i/q_i
1	0.066_6	0.005		0.005	
2	0.076_6		0.14	0.14	
3	0.098_3	0.058	~0.007	0.065	~8
4	0.124_1	0.006	~0.02	~0.03	~0.3
5	0.138_4	0.026	0.21	0.24	0.12
6	0.203_2	0.0004		0.0004	
7	0.268_8	0.0064	0.70	0.71	0.090
8	0.281_4		~0.05	~0.05	
9	0.307_8	0.0003		0.0003	
10	0.405_0	0.0002	0.14	0.14	0.0015
To ground state of As^{75}				0.03	

If one alternatively assumed magnetic octupole radiation for transition 3, the relativistic K shell internal conversion coefficient[26] would be about 5.7 and the K/L ratio given by the experimental curves of Goldhaber and Sunyar[23] would be approximately 6.0. The K/L ratio is appreciably smaller than the experimental value of 11. The lifetime[24–26] of the excited state expected for this radiation is about 3.5 min. This lifetime is inconsistent with the nuclear shell model. We have looked for a relatively long-lived metastable state in As^{75} by making a rapid (5 min) chemical separation of As from Se^{75}. About one percent of the total Se^{75} activity was observed in the separated As fraction, but this small activity could not be distinguished from the radiations of Se^{75} on the basis of half-life and absorption curves.

It should also be noted that the L and M electron lines of transition 2 were observed in the photoelectron spectrum of Fig. 2, but no internal conversion lines were observed in Fig. 1. This perhaps indicates that the internal conversion coefficient of transition 2 is small.

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