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DECAY OF $^{110}, ^{110m}\text{Ag}$ TO ^{110}Cd

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Abstract: The decay of ^{110m}Ag to ^{110}Cd was investigated. Internal conversion electrons and beta rays were measured with a double-focussing spectrometer, gamma rays with a Ge(Li) detector and electron-gamma and beta-gamma coincidences with an orange-type, beta-ray spectrometer. Transitions (gamma intensities given in brackets) of the following energies in keV were obtained with an accuracy of about $1 : 10^4$: 446.76 (3.5), 620.22 (2.9), 657.72 (100), 677.47 (12.1), 686.88 (7.5), 706.61 (16.8), 744.13 (4.7), 763.86 (23.5), 817.93 (7.5), 884.59 (79.1), 937.32 (35.7), 1384.08 (27.6), 1475.65 (4.4), 1504.81 (14.5) and 1562.06 (1.34). End points and intensities of the following beta-ray branches were determined: 2891 keV (1.4 %), 2220 keV (0.1 %), 1630 keV (0.08 %) and 531 keV (33 %).

Energies in keV and intensities of the gamma scintillation spectrum of the decay of ^{110}Ag (24 sec) were measured as follows: 658 (100), 770 (0.6), 818 (1.3), 950 (0.7), 1130 (1.0) and 1476 (0.7).

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RADIOACTIVITY ^{110m}Ag [from ^{109}Ag (n, γ)]; measured $E_{\beta, \gamma}$, $I_{\beta, \gamma, ce}$, γce -, $\beta\gamma$ -coin; deduced Q_{β} levels, ^{110}Ag [from ^{109}Ag (n, γ)]; measured E_{γ} , I_{γ} . ^{110}Cd deduced levels. J , π , cc, log *ft*. Enriched and natural targets, Ge(Li) detector.

1. Introduction

The decay of ^{110m}Ag (249 d) has been extensively studied ^{1,2}, and the levels proposed by Funk and Wiedenbeck ³) may be considered as definitive. There are still large uncertainties or disagreements in the gamma-ray intensities and in some beta feedings, and there are inconsistencies in the isomeric decay of ^{110m}Ag .

The existence of semiconductor gamma detectors provides at present a method for good gamma-intensity determinations, which together with electron conversion measurements may lead to accurate internal conversion coefficients, multipolarity and spin determinations.

With these facts in mind, a remeasurement of gamma, electron conversion and beta rays was performed.

2. Sources

The activity was produced in Amersham, England by neutron capture on natural silver. The specific activity was of the order of 1 Ci/g. The detected lines of ^{108m}Ag (> 5 y) showed that the contribution of this isotope was negligible. The sources for internal conversion measurements were either electroplated on 0.4 mg/cm² nickel backings or molecular plated ⁴) on 2 mg/cm² aluminium foils.

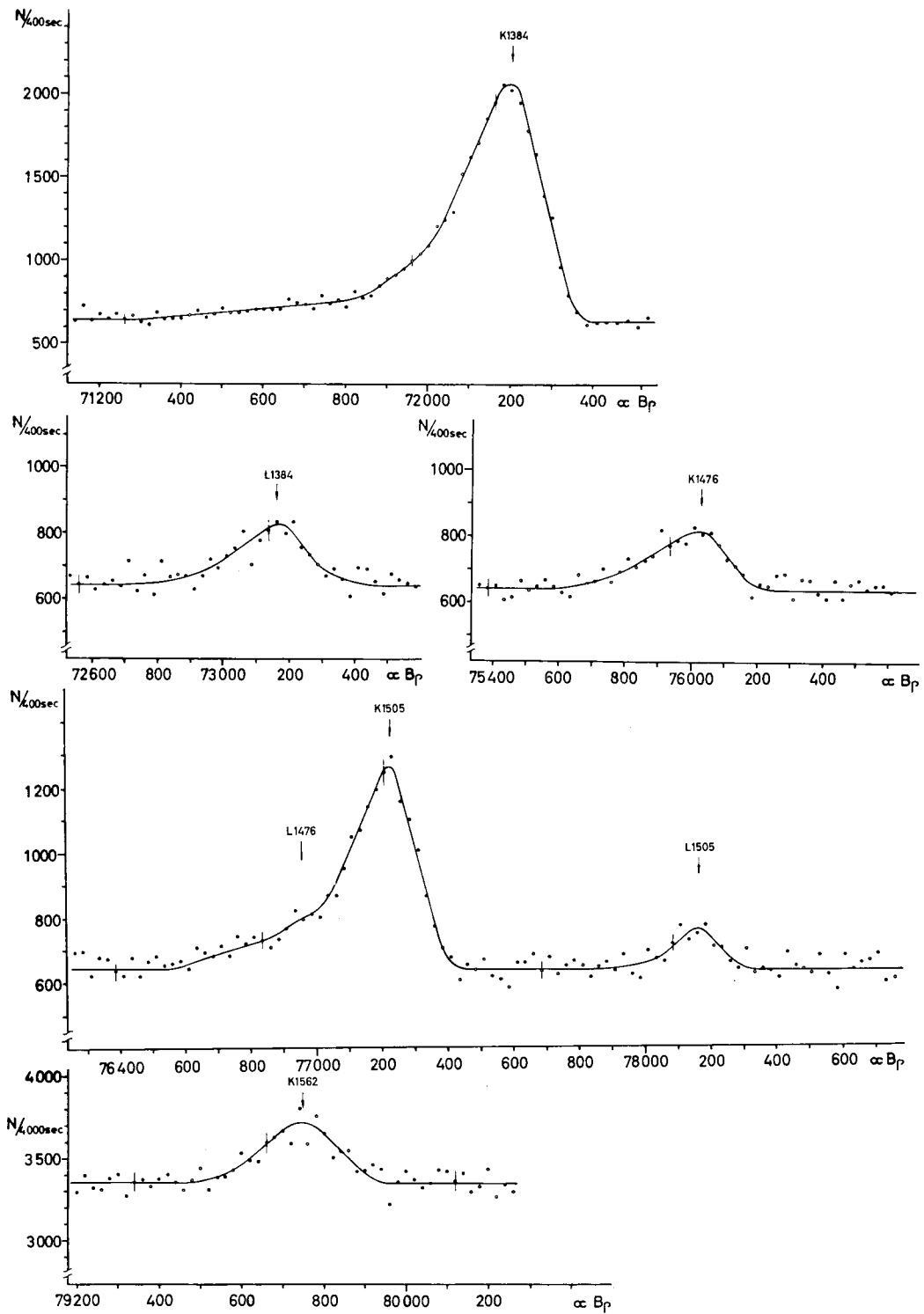


Fig. 1. High-energy internal conversion lines. The K 1562 keV line was measured with a stronger source.

TABLE I
Energies relative intensities and conversion coefficients

transition energy measured adopted	Conversion electron measurement		Relative gamma-ray intensity			K-conversion coefficients $\times 10^3$		Multi-polarity according to the decay scheme	
	conversion shell	relative electron intensity	present work measured (adjusted)	Anton'eva <i>et al.</i> ¹³⁾	Voinova <i>et al.</i> ¹⁴⁾	experiment ^{d)}	theory ¹²⁾		
						M1	E2		
116.34 \pm 0.02 ^{a)}	K	309 \pm 21							
446.79 \pm 0.08	K	8.9 \pm 0.8	3.5 \pm 0.4	7 \pm 1 _{b)}	6 \pm 1 _{b)}	7.0 \pm 1.1	7.84	8.21	M1 + E2
446.76 \pm 0.05									
620.19 \pm 0.09	K	3.2 \pm 0.3	2.9 \pm 0.5	4 \pm 1 _{b)}	5 \pm 1 _{b)}	3.1 \pm 0.6	3.48	3.20	M1 + E2
620.22 \pm 0.07			(2.9)						
657.72 \pm 0.05	K	100 \pm 4	100 \pm 4	100	100	2.75	3.03	2.75	E2
657.72 \pm 0.05	L	12.3 \pm 0.9	(100)						
	M+N	2.8 \pm 0.9							
677.48 \pm 0.09	K	10.9 \pm 0.8	12.1 \pm 1.8	10 \pm 1		2.5 \pm 0.4	2.83	2.54	M1 + E2
677.47 \pm 0.07	L	1.2 \pm 0.3 ^{e)}	(11.2)						
686.92 \pm 0.11	K	6.0 \pm 0.5	7.5 \pm 1.5	7 \pm 1		2.2 \pm 0.5	2.74	2.45	M1 + E2
686.88 \pm 0.07	L	0.7 \pm 0.2 ^{e)}	(7.1)						
	M+N	0.11 \pm 0.05 ^{e)}							
706.62 \pm 0.08	K	16.0 \pm 0.9	16.8 \pm 1.1	21 \pm 2	18 \pm 2	2.62 \pm 0.23	2.57	2.29	(M1 + E2)
706.61 \pm 0.07	L	1.80 \pm 0.15	(17.0)						
	M+N	0.33 \pm 0.07							

744.11 ± 0.11	K	3.6 ± 0.3	4.7 ± 0.8	5 ± 2	2.1 ± 0.4	2.27	2.00	(E2)
744.13 ± 0.07	L	0.3 ± 0.1 ^{e)}	(4.5)					
	M+N	0.11 ± 0.05 ^{e)}						
763.89 ± 0.09	K	15.7 ± 1.0	23.5 ± 1.5	23 ± 2	1.84 ± 0.17	2.14	1.88	E2
763.86 ± 0.07	L	1.93 ± 0.15	(24.1)					
	M+N	0.43 ± 0.08						
817.96 ± 0.12	K	4.7 ± 0.3	7.5 ± 0.7	6 ± 1	1.72 ± 0.19	1.83	1.59	M1+E2
817.93 ± 0.08	L	0.4 ± 0.1	(7.3)					
884.56 ± 0.09	K	37.6 ± 1.0	79.1 ± 3.0	74 ± 4	1.31 ± 0.09	1.53	1.32	E2
884.59 ± 0.08	L	4.1 ± 0.4	(77.2)					
937.36 ± 0.11	K	15.5 ± 1.0	35.7 ± 2.0	33 ± 2	1.19 ± 0.10	1.34	1.15	E2
937.32 ± 0.09	L+M+N	2.2 ± 0.2	(35.5)					
1384.00 ± 0.17	K	5.6 ± 0.4	27.6 ± 1.1	24 ± 1	0.55 ± 0.04	0.58	0.50	M1+E2
1384.08 ± 0.12	L+M+N	0.72 ± 0.06 ^{e)}	(27.5)					
1475.7 ± 0.5	K	0.68 ± 0.08	4.41 ± 0.20	4 ± 1	0.43 ± 0.06	0.50	0.44	E2
1475.65 ± 0.13			(4.30)					
1504.72 ± 0.30	K	2.4 ± 0.2	14.5 ± 0.7	13 ± 1	0.46 ± 0.04	0.48	0.43	M1+E2
1504.81 ± 0.13	L+M+N	0.31 ± 0.08 ^{e)}	(14.1)					
1562.1 ± 0.6	K	0.22 ± 0.03 ^{e)}	1.34 ± 0.10	1.2 ± 0.3	0.46 ± 0.07	0.45	0.39	(E2)
1562.06 ± 0.14			(1.30)					

a) Transition in ¹¹⁰Ag. Geiger²³⁾ has obtained an energy value of 116.410 ± 0.015 keV.

b) May be influenced by ^{108m}Ag gamma rays.

c) No values have been previously reported.

d) Values are normalized to the E2 theoretical conversion coefficient of the 658 keV transition. Measured gamma-ray intensities have been used.

3. Internal-conversion and continuous beta-ray measurements

A double-focussing iron-yoke spectrometer of 50 cm radius similar to that described by Hedgran *et al.*⁵⁾ was used at a resolution setting of 0.15%. The weak lines above 937 keV were measured with a more intense source at a resolution of 0.26% (fig. 1). All the known lines were observed with energies and intensities in very good agreement with previous works^{1-3, 6-8)} but higher resolving power and better

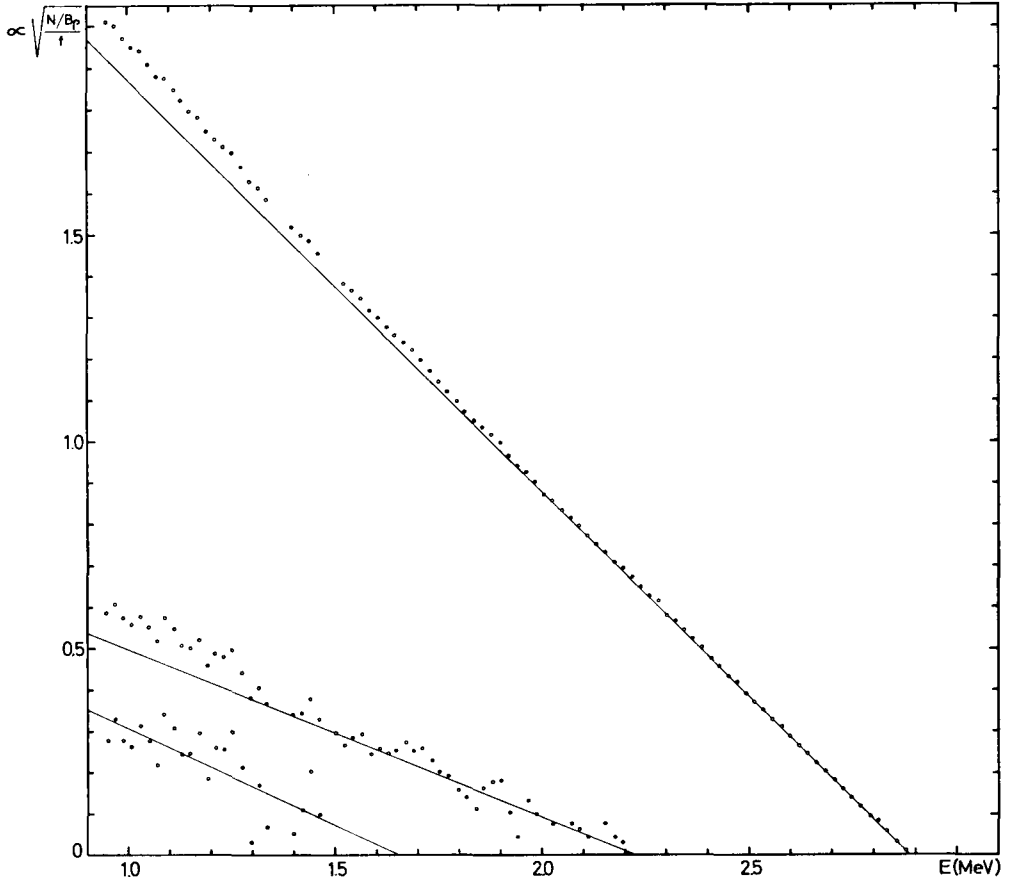


Fig. 2. Kurie plot of the high-energy, beta-ray branches. The values given in table 2 are the mean of three measurements with different sources.

statistics allowed for smaller errors. Table 1 shows the results. The K-line of the 1562 keV transition and several L-lines were observed for the first time. An upper limit of 1% of the intensity relative to the K 658 keV line can be given for possible conversion lines corresponding to the 260 keV and 317 keV transitions which might be placed between known levels of the decay scheme. In the region of 687 keV to 764 keV, an upper intensity limit of 0.1% may be given for any conversion line not reported.

TABLE 2
Beta rays in the decay of ^{110m}Ag and ^{110}Ag

Parent nucleus	Source ^{110m}Ag			Source ^{110}Ag	
	Katoh <i>et al.</i> ^{a), b)}	Daniel <i>et al.</i> ¹¹⁾	present work ^{a)}	Frevert <i>et al.</i> ^{15) c)}	present work ^{c)}
^{110m}Ag	<i>E</i> (MeV)	0.084	0.087 ± 0.002		
	<i>I</i>		61		
	log <i>ft</i>	4.5	5.4		
^{110m}Ag	<i>E</i> (MeV)	0.530 ± 0.005	0.529 ± 0.003	0.531 ± 0.002	
	<i>I</i>	33	36	33 ± 2	
	log <i>ft</i>	7.1	8.2	8.3	
^{110}Ag	<i>E</i> (MeV)	1.4 ± 0.1 ^{d)}	1.5 ± 0.1	1.63 ± 0.10	1.415
	<i>I</i>	0.10 ± 0.07	0.6	0.08 ± 0.04	0.0008 ± 0.0002 ^{e)}
	log <i>ft</i>	4.8	11.6		6.6
^{110}Ag	<i>E</i> (MeV)				0.002 ± 0.001 ^{e)}
	<i>I</i>				6.3
	log <i>ft</i>				
^{110}Ag	<i>E</i> (MeV)	2.18 ± 0.06	2.2 ± 0.2	2.220 ± 0.040	
	<i>I</i>	0.20 ± 0.07	0.3	0.10 ± 0.03	0.067 ± 0.004 ^{f)}
	log <i>ft</i>	5.2	4.9	5.3	5.5
^{110}Ag	<i>E</i> (MeV)	2.87 ± 0.01	2.86 ± 0.02	2.891 ± 0.004	
	<i>I</i>	1.4 ± 0.1	1.4	1.43 ± 0.15	1.43
	log <i>ft</i>	4.8	4.7	4.7	4.8

^{a)} The absolute values of the intensities have been obtained comparing the intensities of the beta branches and the K 658 keV conversion line and relating them to the intensity of the source via the theoretical E2 conversion coefficient of this transition.

^{b)} Intensities are normalized to 100 for the 0.53 MeV branch in tables of Katoh *et al.* The values we present have been derived in the way stated above using the data of Katoh *et al.*

^{c)} Intensities are normalized to our value for the 2.89 MeV branch.

^{d)} Katoh *et al.* assume that this beta branch decays from the ground state of ^{110}Ag .

^{e)} Energies and intensities are derived from the gamma energies and intensities. It has been assumed that the 1476 keV level has no other feeding than this beta branch. Frevert's value is based on the 1476 keV line, our value on the 818 keV line.

^{f)} Intensity from gamma-ray and 4 π beta-ray counting.

The intensity of the K 116 keV line in ^{110}Ag was measured against the K 658 keV line with a thinner source at a resolution of 0.18 %. The GM-counter window was 0.14 mg/cm^2 thick, therefore the absorption correction was negligible.

All the observed transitions have been fitted into the decay scheme of fig. 7, and it will be shown that there is enough evidence that these transitions are correctly placed. Using the measured values, we obtained the best values for the energy levels, and then we derived the "adopted" transition energies as a difference between the level energies. A good test of the accuracy of the energy measurements is the fact that the adopted and measured energies coincide within a fraction of the errors of the latter. The adopted values have lower errors which originate mainly in the error of the energy of the K 658 keV line which was used as a standard. This line was calibrated against the K 662 keV line of ^{138}Cs . An energy of $661\,627 \pm 20 \text{ eV}$ was assigned to it which was deduced from the $B\rho$ ratios between this line and the K and L conversion lines of the $411\,795 \pm 9 \text{ eV}$ transition⁹⁾ in ^{198}Hg obtained by the Chalk River group¹⁰⁾. The calibration was performed using a source made by two parallel, close-lying, 1 mm wide strips, one of silver and one of caesium, mounted on a ring. Both lines were measured first with the ring in one position and then with the ring rotated 180° , and the mean values of the two positions were obtained. Errors due to substitution of sources which may affect the reproducibility of the source position are eliminated in this way. Caesium sources were obtained by molecular plating caesium nitrate on aluminium foils.

The energy of the K 116 keV line was measured against the K 658 keV and the F line of ThB with identical results.

The continuous beta-ray components were measured at a resolution setting of 0.45 %. Maximum energies and intensities are given in table 2 (see fig. 2). The intensity obtained for the 531 keV branch is in good agreement with earlier determinations^{6,11)} and with the gamma intensities which predict a feeding of 30.5 %. The total intensity we obtained for the beta branches decaying from the ground state is $1.53 \pm 0.17 \%$ compared to $1.31 \pm 0.10 \%$ transition intensity of the M4 116 keV transition deduced from its internal conversion intensity. Large disagreements may be found for the intensities of the 2.2 MeV and the 1.6 MeV branches as reported by different authors (see table 2). We have obtained for the 1.6 MeV branch a higher energy value than the previously reported ones, which does not fit for the beta branches proposed in the earlier decay schemes.

4. Single gamma-ray spectrum and conversion coefficients

The spectrum seen in fig. 3 was obtained with a $3 \text{ cm}^2 \times 2 \text{ mm}$ depletion RCA Ge(Li) detector and a RIDL 1600-channel analyser. The source was placed 5 cm from the detector. Other runs were taken with a $4 \text{ cm}^2 \times 3 \text{ mm}$ depletion Ortec detector. The gamma-ray intensities are given in table 1.

The efficiency calibration was made with standard reference sources. We have

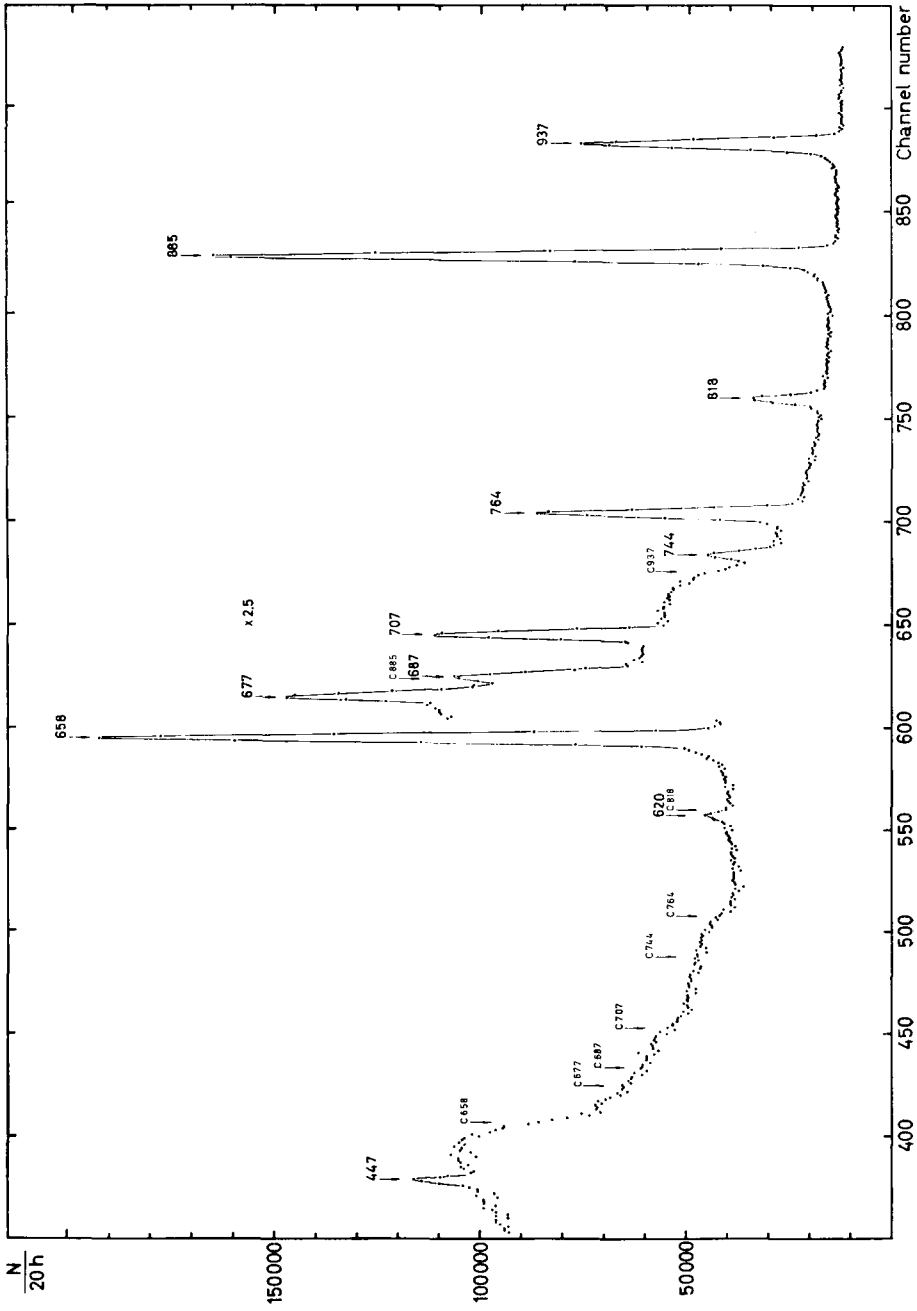


Fig. 3a.

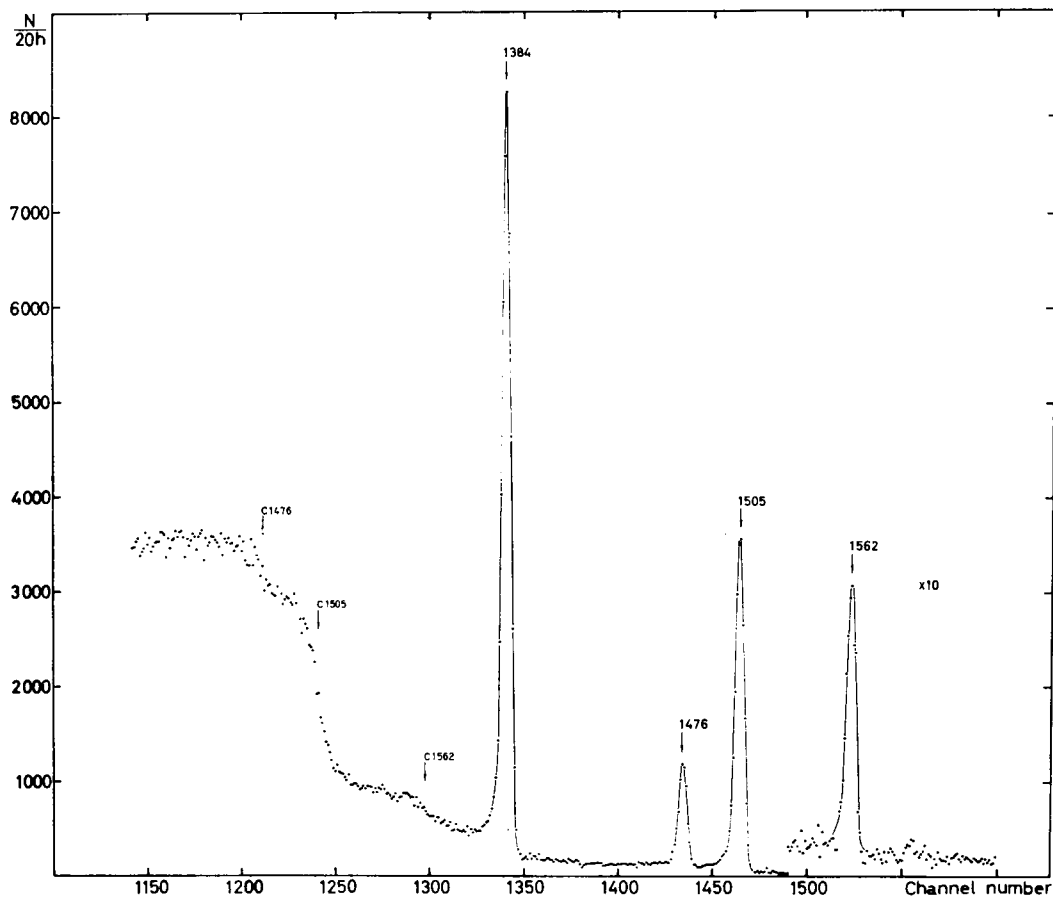


Fig. 3b.

Fig. 3 Gamma spectrum obtained with a $3 \text{ cm}^2 \times 2 \text{ mm}$ Ge(Li) detector. The weak line at channel 1555 corresponds to the background (double escape of the 2614 keV Th C'' line). The position of the Compton edges is shown.

included an error of 3% in all intensity errors (with the exception of the 658 keV line) because of uncertainties in this calibration.

The 677 keV and 687 keV lines lay on the Compton edge of the 885 keV gamma ray. Although the shape of the Compton background of the 885 keV and 937 keV rays was carefully estimated using the spectra of standard sources as ^{54}Mn , large errors had to be assigned to the intensities of the 677 keV and 687 keV lines. The 620 keV line was found to be somewhat distorted by the 615 keV transition of $^{108\text{m}}\text{Ag}$. Gamma-ray sources were then prepared with enriched silver and a lower relative intensity was obtained for the 620 keV gamma ray.

The intensity balance for the excited levels was checked, and the intensities not

accounted for are much smaller than the estimated errors. This may be seen by comparing the measured intensities with the adjusted values (table 1) which have been obtained assuming a perfect balance. In the decay scheme of fig. 7, we have quoted the measured intensities but normalized to 100 decays of $^{110\text{m}}\text{Ag}$.

Table 1 also contains the experimental K conversion coefficients (cc) normalized to the theoretical E2 cc of the 658 keV transition ¹²). All the transitions have an E2 or an M1 + E2 character, but the theoretical values corresponding to E2 or M1 are too close as to allow a decision to be made between these two possibilities.

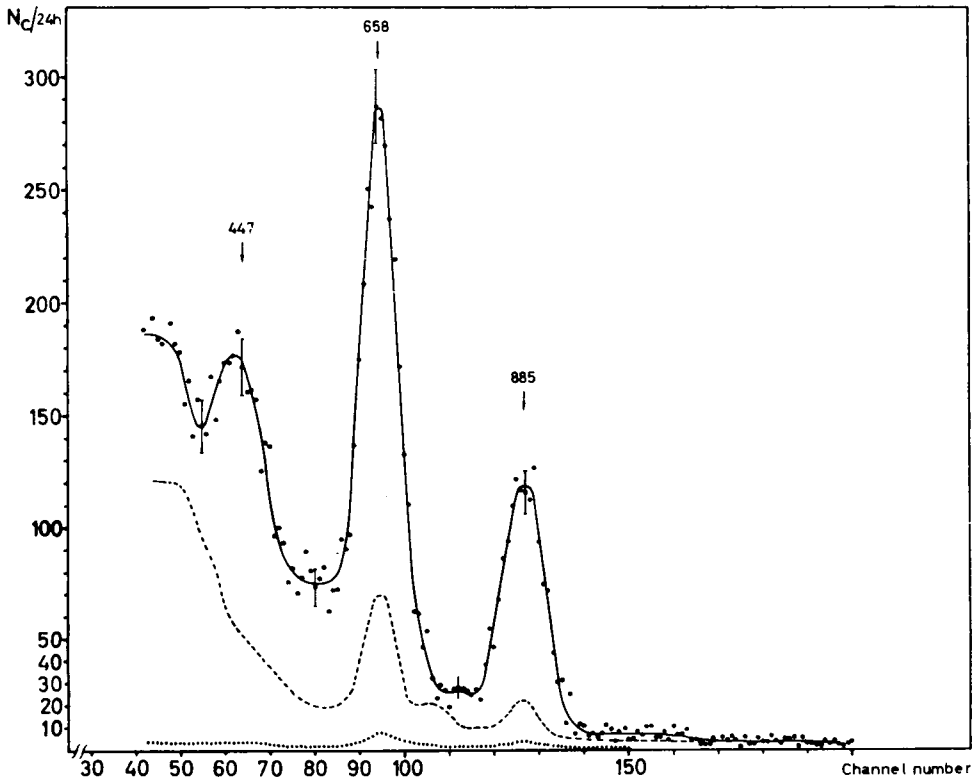


Fig. 4. Gamma spectrum coincident with the K 937 line. Contribution of the continuous spectrum is given in dashes. Random coincidences are negligible (dotted line).

There is good agreement with previous measurements of the cc of the 658, 885 and 937 keV transitions performed by Newbolt and Hamilton ²) by the internal-external conversion method. For the other transitions, these authors used the gamma-intensity measurements of Anton'eva *et al.* ¹³) and Voinova *et al.* ¹⁴) (external conversion) which have much larger errors than the present measurements.

It may be remarked that due to its relatively long half-life and conveniently spaced prominent lines $^{110\text{m}}\text{Ag}$ is a valuable energy calibration source. Furthermore, the

TABLE 3
Electron-gamma coincidence results

K-Internal conversion line (keV)	Gamma photopeak (keV)	$b(e; \gamma) \times 100$		K-Internal conversion line (keV)	Gamma photopeak (keV)	$b(e; \gamma) \times 100$		
		experimental	according to the decay scheme			experimental	according to the decay scheme	
620	658	93 ± 30	100	764	620 to 687	yes	yes	
	764	100 ± 40	100		818	818	yes	yes
	885	110 ± 40	100		885	885	yes	yes
658	447	5 ± 2	3.5	885	1476 to 1505	yes	yes	
	620	6 ± 3	2.9		658 to 707	658	yes	yes
	677 to 744	35 ± 10	34.3		744 to 764	744 to 764	yes	yes
	764	15 ± 7	21.4					
	818	7 ± 3	7.3		447	447	6 ± 2	4.5
	885	60 ± 8	77.2		620 to 707	620 to 707	107 ± 20	140
	937	24 ± 8	35.5		764	764	6 ± 2	4.5
	1384	25 ± 3	27.5		937	937	46 ± 5	47.4
	1505 to 1562	15 ± 2	15.8		1384	1384	32 ± 6	35.7
677	658 to 707	148 ± 70	200	937	447	12 ± 3	9.8	
	885	96 ± 30	100		658	658	95 ± 15	100
707	658 to 744	158 ± 60	192	1384	885	92 ± 10	100	
	818	14 ± 5	16.4		658	658	82 ± 16	100
	885	55 ± 10	66		885	885	99 ± 15	100
	1467	11 ± 3	10					
744	658	yes	yes	1476	687 to 707	89 ± 30	100	
	707	yes	yes		744 to 764	744 to 764	74 ± 25	100
	818	yes	yes		658	658	100 ± 20	100
	1476	yes	yes		764	764	100 ± 20	100

885, 937, 1384 and 1505 keV gamma lines are placed on low backgrounds and allow for easy and accurate relative intensity measurements which may be used in efficiency determinations.

5. Coincidence experiments

An eight-gap, iron-yoke, orange-type, beta-ray spectrometer was used in these experiments. The spectrometer was set at a resolution of 1.8 %. The energy discrimination of the electron scintillation detector was set at $\frac{2}{3}$ of the focussed energy. Gamma rays were detected with a 44 mm diam., 50 mm high NaI(Tl) crystal placed 4 cm from the source. The resolving time of the coincidence unit was set at 35 ns, and the coincidence efficiency above 400 keV was 100 %.

5.1. ELECTRON-GAMMA COINCIDENCES

The gamma spectra coincident with 12 conversion lines were obtained. The spectrum coincident with the K 937 line is shown in fig. 4. In table 3, we have given the experimental branching coefficients $b(e; \gamma)$ which have been derived from $N_c = N(e)\eta(\gamma)b(e; \gamma)$, where N_c is the number of collected coincidences at the photopeak after subtraction of random coincidences and coincidences due to the continuous beta-ray spectrum. The number $N(e)$ of conversion electrons entering the electron channel and belonging to a given line has been estimated for the weaker lines from the relative conversion line intensities. The coefficients $b(e; \gamma)$ represent the fraction of the transition accepted by the electron channel which is in coincidence with the transition corresponding to the photopeak. These coefficients were also calculated from the data given in the decay scheme using the adjusted intensities. The results are shown in the column four of table 3 and serve as a test of the agreement between coincidence experiments and the adopted decay scheme. When the coincidence spectrum presented a group of unresolved lines, we used for the experimental $b(e; \gamma)$ a mean gamma-detection efficiency (η_m) and correspondingly the "decay scheme" $b(e; \gamma)$ coefficient is given as $b(e; \gamma) = \sum_i b_i \eta_i / \eta_m$. Table 3 shows that the results support the presented decay scheme.

5.2. BETA-GAMMA COINCIDENCES

Beta-gamma coincidences were measured to determine the level fed by the 1.6 MeV beta branch. Regions of the continuum far from the conversion lines were selected in the electron channel and several 2-4 d long runs were performed. In fig. 5, we show a set of gamma spectra coincident with different beta energies. At a beta energy of 1700 keV, we observe only the 658 keV transition. Going to lower beta energies, the 885 keV gamma ray appears distinctly and confirms a feeding to the 1542 keV level, together with an unexpected gamma ray of 755 ± 15 keV. The spectra coincident with beta rays of about 1300 keV (not shown in fig. 5) give no definite evidence of the presence of the 755 and 885 keV gamma rays, but they are clearly seen at around 1090 keV. Hence, beta rays giving rise to the 755 keV coincidence line

must feed a level well below 1900 keV. The intensities of both the 885 and the 755 keV rays are very similar in all coincidence spectra, and they are of the same order

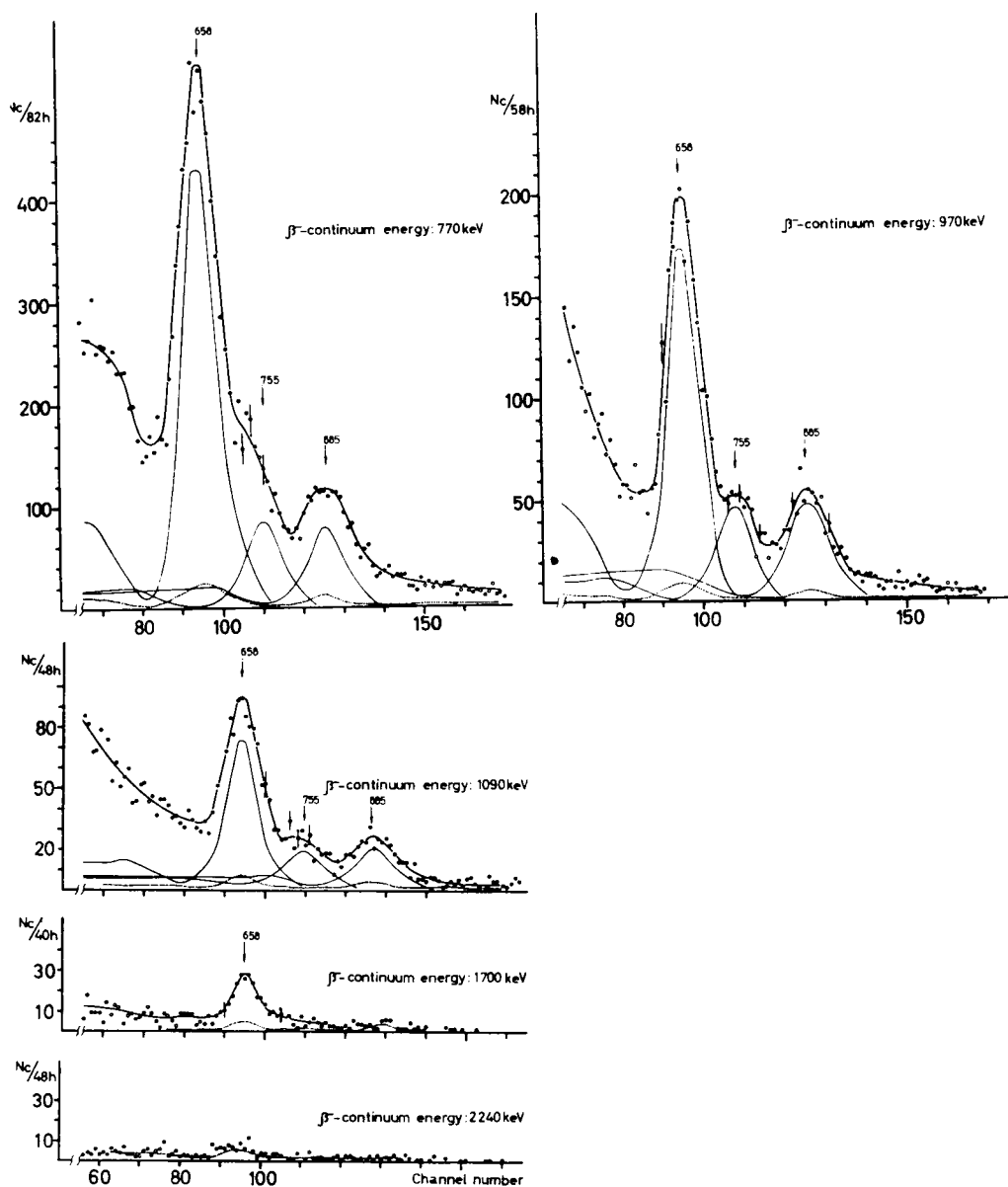


Fig. 5. Gamma spectra coincident with the beta continuum.

of magnitude as the 658 keV line. This fact excludes the possibility that the 885 keV and the 755 keV lines here observed have their origin in the ground state decay of

^{110}Ag , where a factor of more than 50 is observed between the intensity of the 658 keV transition and any other line (see below). We may now assume that the 755 keV gamma ray decays to the 658 keV level from a level at about 1413 keV, which would be fed by beta rays decaying from ^{110m}Ag with a maximum energy of about 1.697 MeV. This value is in agreement with the continuous beta-ray measurements. The beta rays feeding the 1542 keV level also decay from ^{110m}Ag with a maximum energy of 1.468 MeV. The intensities of the 1.697 and the 1.468 MeV branches given in the decay scheme have been evaluated using the beta continuum and the coincidence data.

6. Gamma spectrum of ^{110}Ag

The decay of ^{110}Ag has been studied by Frevert *et al.* ¹⁵). They used natural silver

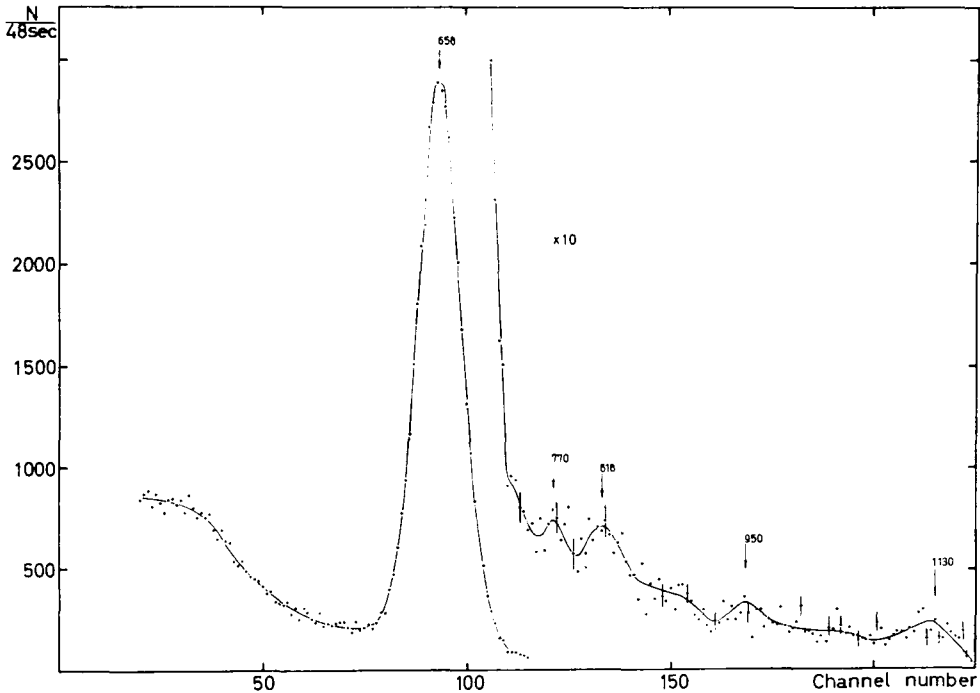


Fig. 6. Gamma spectrum of ^{110}Ag (24 sec) in the energy range 400-1200 keV.

as a target, and the gamma spectrum shows a very strong line at 658 keV followed by a steeply decreasing gamma background on which are seen two weak lines at 1020 keV (^{108}Ag) and at 1300 keV (pile up?) and a very weak line at 1480 keV which they interpreted as the de-excitation of the 1476 keV level in ^{110}Cd . The fact that the 818 keV transition was not observed was attributed to the high background. An earlier study by Boley ¹⁶) shows five lines; one of them is at 660 keV and all with

intensities of the same order. An investigation by Joshi *et al.*¹⁷⁾ reports only one line at 967 keV.

We have repeated these measurements using isotopically separated silver and a better geometry. A 7.6 cm diam. \times 7.6 cm long NaI(Tl) crystal with 7.5 % resolution was used instead of the well crystal employed by Frevert *et al.*¹⁵⁾. A few mg of ^{109}Ag was irradiated in a reactor during 10 sec in a flux of 10^{11} n/sec \cdot cm². Measurements started 25 sec after irradiation. Four to six spectra were measured at intervals of 24 sec. In fig. 6, we show the sum of two spectra. Several lines with an intensity of the order of 1 % or less of the 658 keV transition intensity may be seen, the most prominent one being the 818 keV gamma ray. Based on the intensity of this line, we obtained a feeding of the 1476 keV level relative to the 658 keV level 1.5 times larger than Frevert *et al.*¹⁵⁾.

The spectrum of ^{110}Ag seems to be sufficiently complex to justify a new study. We only add that half-lives of 25 ± 7 sec were obtained for the following rays (intensities ± 35 % given in brackets): 658 keV (100), 770 keV (0.6); 818 keV (1.3), 950 keV (0.7), 1130 keV (1.0) and 1476 keV (0.7).

7. Discussion

The level scheme presented in fig. 7 essentially coincides with the one proposed by Funk and Wiedenbeck³⁾ and confirmed by many other investigators. The presence of a level at about 1413 keV fed by a weak (0.04 %) beta branch depopulating ^{110m}Ag is discussed in connection with the beta-gamma coincidences. However, no line has been detected decaying from higher-excited states to this level, as one would expect. Its existence remains an open question.

All the other ^{110}Cd levels populated by the decay of ^{110m}Ag may be considered as well established and their energies measured with an accuracy of about $1 : 10^4$. The energies and intensities determined for the transitions between these levels have an excellent adjustment. In the following discussion we refer only to these states.

Spin and parity assignments are discussed in detail by Münnich *et al.* in connection with angular correlation measurements¹⁸⁾. We shall review briefly these assignments. All levels have positive parity because of the E2 or M1 + E2 multipolarity of all the transitions. Spins of the 658 keV (2^+), 1476 keV (2^+) and 1542 keV (4^+) levels have been determined from Coulomb excitation experiments^{19,20)} and confirmed by 658-885 keV angular correlation measurements and by the cc of the 658, 1476 and 885 keV transitions. The spins of the 2163 keV (3^+), the 2480 keV (6^+) and the 2926 keV (5^+) levels are determined by the 658-1505 keV, 885-937 keV and the 885-1384 keV angular correlations, respectively¹⁸⁾. In the case of the 2480 keV level, spin 4 is also possible if we admit that the 937 keV transition is M1 with only 7 % E2 admixture. The data of Hamilton *et al.* and our cc indicate a rather pure E2 transition. The spin assignment to the 2926 keV level requires to be unique, that the 1384 keV transition should not have a large octupole admixture, which in fact is excluded by

the cc. Finally the 2220 keV level is connected to 2⁺, 4⁺ and 5⁺ levels by E2 or M1 + E2 transitions, hence the spin has to be 3 or 4. Special care was taken in the determination of the cc of the 707 keV transition. The result indicates that a pure E2 multipolarity may probably be excluded and hence spin 4 is favoured.

The character of the ground state of ¹¹⁰Ag is considered to be 1⁺ from the log ft values of the beta branches decaying to the ground state and to the first and second 2⁺ states. The spin of the isomeric state ^{110m}Ag was measured ^{21,22}) to be 6 and even parity has been assigned ¹¹) to it based on the log ft values of the 84 keV branch and

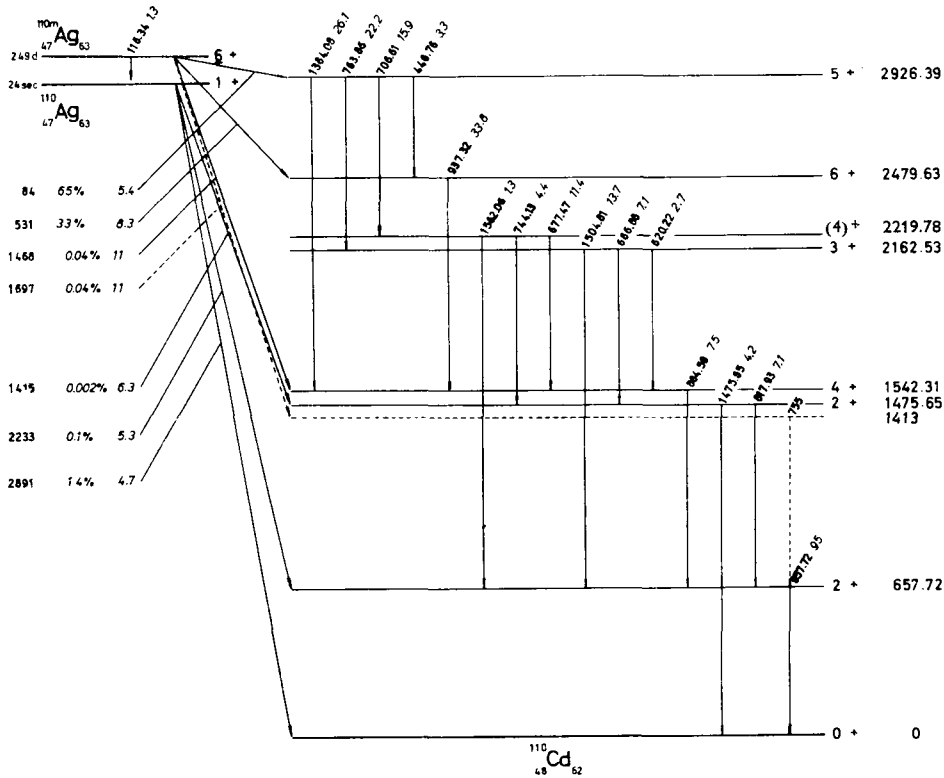


Fig. 7. Decay scheme of ^{110m}Ag.

the allowed shape of the 530 keV branch. The M4 multipolarity of the 116 keV transition is a consequence of several measurements of K/L ratios and of the careful determination of L-subshell ratios of Geiger ¹³).

The existence of an E1 transition following the 116 keV transition was postulated and received support from an energy difference (deduced from beta-ray energies) between the two isomers exceeding by 30 keV the 116 keV isomeric transition. Furthermore it has been mentioned that the number of Ag K-X-rays emitted per disintegration, as measured by Jaffee ²⁴), is much larger than the number expected from K-shell

internal conversion of the 116 keV transition. However, Hamilton *et al.* ⁸⁾ found no evidence for this transition down to 4 keV, and Pasternak and Nardi ²⁵⁾ failed to find any gamma transition down to 5 keV in coincidence with the K-X-rays of silver. An energy balance using the present beta-ray energy maxima and gamma transition energies gives a Q -value of 3010 ± 2 keV for ^{110m}Ag and an energy of 119 ± 5 keV for this isomeric level. This confirms the previous results ^{8,25)} and shows that any transition following the 116 keV isomeric ray must be of very low energy if it exists. Jaffee's measurements may perhaps be explained by the fact that ^{108m}Ag was present in his sources, this isomer being unknown at that time.

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