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THE DECAY SCHEME OF 1.3 h ^{174}Ta

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Résumé. — La désintégration de ^{174}Ta ($T_{1/2} = 1,3$ h) a été étudiée au moyen de détecteurs Ge(Li) et Si(Li). Nous avons mesuré les spectres γ simple, en coïncidence et de raies sommes ainsi que les raies de conversion et des coïncidences e- γ . Les résultats sont en bon accord avec les études précédentes en ce qui concerne les bandes du fondamental et de vibration bêta. Au-dessus de ces bandes nous avons établi 14 niveaux ayant pour énergie (en keV), spin et parité les valeurs suivantes : 1 276,8 (3, 4) ; 1 318,9 (2^+) ; 1 394,4 (3, 4) ; 1 448,9 (3^-) ; 1 503,3 (4^+) ; 1 659,2 (4^+) ; 2 030,1 (3, 4) ; 2 124,5 (3, 4) ; 2 145,5 (4^+) ; 2 198,2 (4^-) ; 2 237,3 (5) ; 2 490,5 (3, 4) ; 2 590,7 (3, 4) et 3 023,7 (2). Le schéma de niveaux contient 49 des 60 transitions attribuées avec certitude à la désintégration du ^{174}Ta . Nous avons déterminé la différence de masse de la désintégration $^{174}\text{Ta} \rightarrow ^{174}\text{Hf}$: $Q = 3\,845 \pm 80$ keV. La période $T_{1/2}$ du premier état 2^+ a été remesurée et trouvée égale à $1,68 \pm 0,08$ ns. La structure du ^{174}Ta et des niveaux de ^{174}Hf est discutée dans le cadre des modèles nucléaires courants.

Abstract. — The decay of ^{174}Ta ($T_{1/2} = 1.3$ h) has been studied with Ge(Li) and Si(Li) detectors. Single, coincidence and sum γ -ray spectra, conversion lines and e- γ coincidence relations have been measured. The results are in good agreement with those of earlier investigations for the ground state and the beta-vibrational band. Above these bands 14 levels have been established having the following energies (in keV) spin values and parities : 1 276.8 (3, 4) ; 1 318.9 (2^+) ; 1 394.4 (3, 4) ; 1 448.9 (3^-) ; 1 503.3 (4^+) ; 1 659.2 (4^+) ; 2 030.1 (3, 4) ; 2 124.5 (3, 4) ; 2 145.5 (4^+) ; 2 198.2 (4^-) ; 2 237.3 (5) ; 2 490.5 (3, 4) ; 2 590.7 (3, 4) and 3 023.7 (2). The level scheme accounts for 49 of the 60 transitions firmly assigned to the decay of ^{174}Ta . The Q -value of the decay $^{174}\text{Ta} \rightarrow ^{174}\text{Hf}$ was determined to be $3\,845 \pm 80$ keV. The half life of the first 2^+ level was remeasured and found to be 1.68 ± 0.08 ns. The structure of ^{174}Ta and of the levels of ^{174}Hf are discussed in terms of current nuclear models.

1. **Introduction.** — The levels of ^{174}Hf have been previously investigated through the decay of ^{174}Ta [1]-[6] and through nuclear reactions [7]-[12]. These studies have well established the ground state rotational band and the beta vibrational band but no evidence have been obtained for the population of the gamma vibrational band and little has been known about the higher-lying levels. It was the aim of the present work to re-investigate the decay of ^{174}Ta with the aid of Ge(Li) and Si(Li) detectors. Ge(Li) coincidence and summing lines data have led to a consistent decay scheme. Multipole assignments spin and parities have been deduced from conversion coefficients measurements. The Q -value of the ($\beta^+ + \epsilon$) decay of ^{174}Ta was determined from the β -spectrum coincident with the 206.5 keV γ -ray.

2. **Experimental process and results.** — 2.1 SOURCE PREPARATION. — The ^{174}Ta activity was produced by bombardment of lutetium metallic foils with 54 MeV α -particles from the Synchrocyclotron of the University of Lyon. The sources contained about 10 % of 11 h ^{175}Ta and 8 h ^{176}Ta activities due to ($\alpha, 4n$) and ($\alpha, 3n$) reactions. The ^{174}Ta activity was recognized by means of its half-life. Spectra obtained from several targets were summed to improve statistics. For conversion line measurements thin metallic foils of about 1 mg/cm² were performed by rolling before irradiation.

2.2 THE SINGLE γ -SPECTRUM. — Low energy transitions were measured with a Ge(Li) detector having an active volume of 4 cm³ and a resolution (FWHM) of 2.5 keV for the 1 332 keV γ -ray from ^{60}Co . The

TABLE I

Relative intensities, conversion coefficients and multiplicities of observed transitions

a) *line not placed in the decay scheme.*

b) *The value $I_{\gamma, 1205.9} = 100$ is taken as the reference intensity.*

c) *Composite line.*

d) *Conversion line intensities are given in units of column 2. The value $I_{K_{206.55}}$ is taken as the reference intensity.*

E_{γ} (keV)	I_{γ} (rel)	I_K (^d)	α_K ($\times 10^2$)	mult.
—	—	—	—	—
90.94 \pm 0.05	390 \pm 60			
113.6 \pm 0.5	2.5 \pm 0.5			
115.7 \pm 0.7 (^a)	2.5 \pm 0.5			
124.2 \pm 1.0 (^a)	10 \pm 5			
175.4 \pm 1.0 (^a)	\approx 0.5			
206.55 \pm 0.10	1 380 \pm 120	215 (^d)	15.5	E 2
(220) (^a)				
(223) (^a)				
310.87 \pm 0.07	27 \pm 3	1.32 \pm 0.13	4.9 \pm 0.6	E 2
(334.8) (^a)				
418.8 \pm 1.0	6 \pm 1	0.13 \pm 0.04	2.1 \pm 0.7	E 2
(426.2) (^a)				
440.8 \pm 1.0	4 \pm 1			
453.5 \pm 0.6	6 \pm 1			
511.0	1 000 \pm 80			
597.4 \pm 0.8	7 \pm 2			
602.9 \pm 0.2	27 \pm 3	0.19 \pm 0.05	0.7 \pm 0.2	E 2
(660) (^a)				
764.65 \pm 0.10	26 \pm 4	1.14 \pm 0.10	4.4 \pm 0.7	E 0 + (M 1, E 2)
809.30 \pm 0.10	27 \pm 3	0.62 \pm 0.06	2.3 \pm 0.4	E 0 + (M 1, E 2)
827.0 \pm 1.0	—	\geq 0.05		(E 0)
(833) (^a)				
(852) (^a)				
(857) (^a)				
(865.1) (^a)				
899.0 \pm 0.3	6 \pm 2	} 0.053 \pm 0.018	0.31 \pm 0.15	(E 2)
900.5 \pm 0.3	11 \pm 3			
971.31 \pm 0.12	20 \pm 2	0.072 \pm 0.020	0.36 \pm 0.12	E 2
979.3 \pm 0.5 (^a)	3 \pm 1			
996.3 \pm 0.8 (^a)	5 \pm 2			
1 010.5 \pm 0.6 (^a)	5 \pm 1			
1 021.3 \pm 1.0	2.5 \pm 0.5			
1 038.5 \pm 1.0 (^a)	2.5 \pm 0.5			
1 083.3 \pm 0.2	9 \pm 1			
1 096.6 \pm 0.3	9 \pm 1	< 0.020	< 0.22	E 2 (E 1)
1 127.4 \pm 0.2	16 \pm 2			
1 135.9 \pm 0.2	19 \pm 2	< 0.019	< 0.10	E 1
1 151.3 \pm 0.2	21 \pm 2	< 0.023	< 0.11	E 1
1 181.9 \pm 0.6 (^a)	1.5 \pm 0.5			
1 185.9 \pm 0.4	9 \pm 2			
1 197.8 \pm 0.5	2 \pm 0.8			
1 205.86 \pm 0.08	100 (^b)	0.26 \pm 0.03	0.26 \pm 0.04	E 2(+ M 1)
1 212.4 \pm 0.3	13 \pm 2			
1 218.0 \pm 0.4	6 \pm 1			
1 227.8 \pm 0.5	25 \pm 8	0.30 \pm 0.03	1.2 \pm 0.4	E 0 + (M 1, E 2)
(1 234.1) (^a)				
1 245.2 \pm 0.3	13 \pm 1.5	0.021 \pm 0.006	0.16 \pm 0.07	E 2
1 259.5 \pm 0.5 (^a)	7 \pm 1			

E_γ (keV)	I_γ (rel)	I_K (^d)	$\alpha_K (\times 10^2)$	mult.
$1\ 264.9 \pm 0.8$ (^a)	2.0 ± 0.5			
$1\ 303.8 \pm 0.3$ (1 319)	6 ± 1			
$1\ 358.3 \pm 0.5$	41 ± 8	0.025 ± 0.012	0.06 ± 0.04	E 1
$1\ 361.7 \pm 1.0$ (1 581) (^a)	14 ± 4	0.039 ± 0.017	0.28 ± 0.15	E 2, M 1
$1\ 629.7 \pm 1.0$ (1 710)	9 ± 3			
$1\ 731.8 \pm 1.0$	4 ± 1			
$1\ 827.5 \pm 1.0$	6 ± 1			
$1\ 901.5 \pm 1.0$	4 ± 1			
$1\ 939.6 \pm 0.5$ (^c)	10 ± 2			
$2\ 033.6 \pm 0.8$	5 ± 2			
$2\ 123.8 \pm 0.5$	6 ± 1			
$2\ 144$ (^a) (^c)	5 ± 1			
$2\ 192.5 \pm 0.7$ (^a) (2 228)	10 ± 2			
$2\ 245.5 \pm 0.7$ (^a)	3 ± 1			
$2\ 293.3 \pm 0.7$ 2 348 (^c)	3 ± 1			
$2\ 400.1 \pm 0.8$	7 ± 2			
$2\ 436.0 \pm 0.7$ (^a)	5 ± 2			
$2\ 479.7 \pm 1.2$ (^a)	5 ± 2			
$2\ 499.7 \pm 1.0$ (2 582) (^a) (2 635) (^a) (2 762.5) (^a)	5 ± 2			
$2\ 796.1 \pm 0.7$ (^a) (2 818) (^a)	3 ± 1			
$2\ 932.5 \pm 1.0$	1.0 ± 0.5			

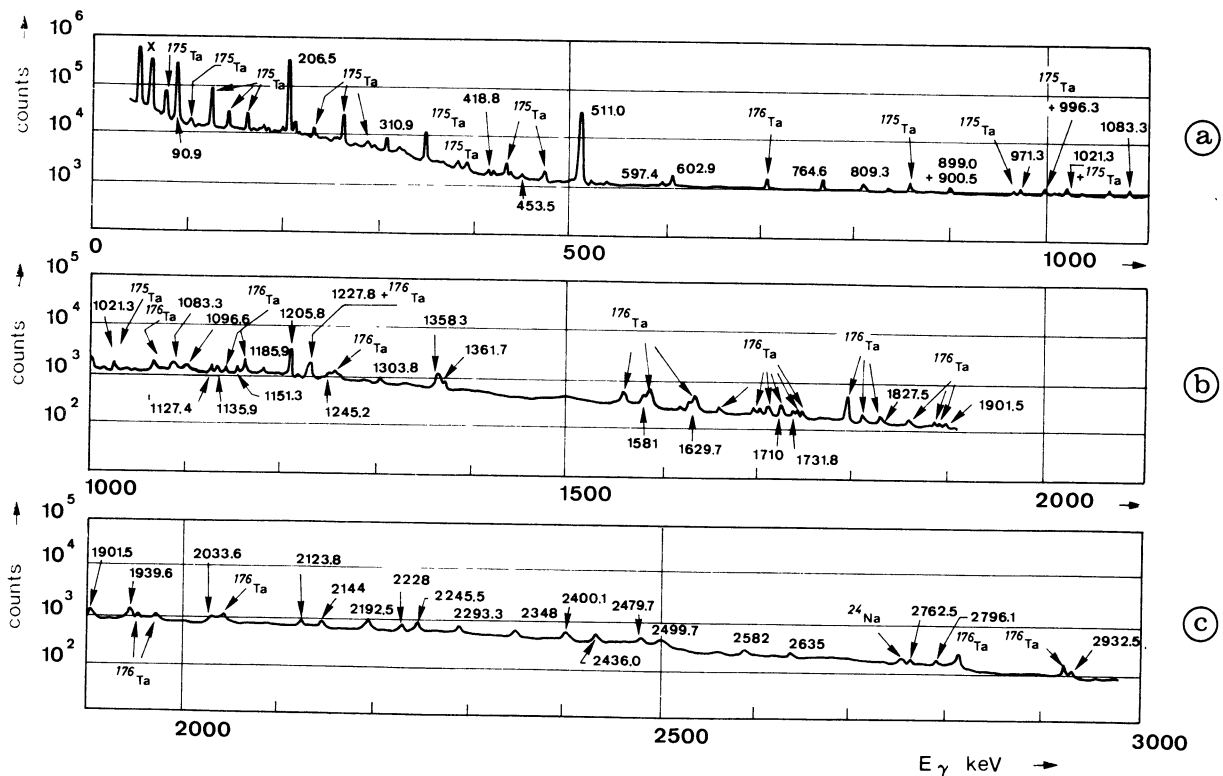


FIG. 1. — The spectrum of gamma radiation accompanying the decay of ^{174}Ta (a) and (b) spectrum obtained with the $4\text{ cm}^3\text{ Ge(Li)}$ detector. (c) spectrum obtained with the $66\text{ cm}^3\text{ Ge(Li)}$ detector. All energies are in keV.

system was calibrated for energy and intensity response with ^{56}Co , ^{57}Co , ^{60}Co , ^{88}Y , ^{152}Eu and ^{192}Ir . These sources were counted simultaneously with the ^{174}Ta activity. In favourable conditions, energies and intensities were respectively obtained with an error of about 0.10 keV and 8 %. Important uncertainties in some γ -rays are due to the presence of large amounts of ^{175}Ta and ^{176}Ta activities. High energy measurements have been performed with a 66 cm^3 Ge(Li) detector calibrated for energy with the γ -rays from ^{176}Ta [13].

The general aspect of the γ -spectrum is shown in figure 1. The results of the γ -ray energy and intensity measurements are listed in columns 1 and 2 of table I. A total of 77 lines was observed. 18 weak γ -rays, which have not been firmly assigned to the decay of ^{174}Ta , are indicated in parentheses.

2.3 COINCIDENCE AND SUM γ -SPECTRA. — γ - γ coincidence studies were performed using Ge(Li) detectors. The detectors were oriented at 135° . A standard cross-over timing coincidence system was employed yielding a resolving time (2τ) \approx 100 ns. A summary of the results of the coincidence measurements is presented in table II. The gating pulse for

TABLE II

γ -ray coincidences observed in the decay of ^{174}Ta

Gate energy (keV)	Coincident γ -rays (keV)
—	—
90.9	113.6 – 206.5 – 310.9 – 511.0 – 602.9 – 764.6 – 809.3 – 971.3 – (996.3) – 1 021.3 – 1 083.3 – 1 151.3 – (1 185.9) – 1 205.9 – (1 212.4) – 1 227.8 – 1 245.2 – 1 358.3 – 1 361.7 – 1 827.5 – 1 939.6
206.5	90.9 – 310.9 – 511.0 – 602.9 – 764.6 – (833) – 996.3 – 1 021.3 – (1 038.5) – (1 083.3) – 1 096.6 – (1 127.4) – 1 151.3 – 1 197.8 – 1 205.9 – 1 361.7 – 1 827.5 – (1 629.7)
1 205.9	90.9 – 206.5 – 511.0
1 358.3 +	90.9 – 206.5
1 361.7	

the multichannel analyzer was obtained from the 4 cm^3 Ge(Li) detector for the 90.9 keV and the 206.5 keV photopeak and from the 66 cm^3 detector for the 1 205.8 keV peak and the group (1 358.3 + 1 361.7 keV). The sum spectrum was measured using a well-type Ge(Li) detector. The use of a well-type detector for coincidence studies has

been investigated by Santhanam and Monaro [14]. The sum lines are identified through comparison of two spectra : the one obtained with the source placed inside the well and the second with a stronger source located at a distance of 8 cm from the detector. The most informative data were obtained in the high energy region of the sum spectrum. These summing lines are listed and interpreted in table III. Portions of the spectra are shown on figure 2.

TABLE III

Sum γ -rays observed in the decay of ^{174}Ta

Sum γ -rays (keV)	Single γ -rays (keV)	Corresponding level (keV)
—	—	—
1 228	1 021.3 \pm 206.5 809.3 + 418.8	1 318.9
1 277	1 185.9 + 90.9	1 276.8
1 319	1 227.8 + 90.9 900.5 + 418.8	1 318.9
1 412	1 205.9 + 206.5 602.9 + 809.3 440.8 + 971.3	1 503.3
(1 449)	1 358.3 + 90.9	1 448.9
1 536	1 083.3 + 453.5	2 145.5
1 567	1 361.7 + 206.5 971.3 + 597.4	1 659.2
(1848)	1 083.3 + 764.6	2 145.5
1939	1 629.7 + 310.9	2 237.3
2 033	1 827.5 + 206.5	2 124.5
(2 082)		
2 106	1 135.9 + 971.3 1 901.5 + 206.5	2 198.2
2 124	2 033.6 + 90.5	2 124.5
(2 146)	1 939.6 + 206.5 1 245.2 + 900.5	2 237.3 2 145.5
(2 328)		
(2 347.5)	(1 197.8 + 1 151.3)	2 646.0
2 400	2 192.5 + 206.5	2 490.5
(2 478)		
2 500	2 293.3 + 206.5	2 590.7
2 554	(2 348 + 206.5)	2 646.0
(2 816)		
2 932	2 123.8 + 809.3	3 023.7

2.4 CONVERSION ELECTRON MEASUREMENTS, TRANSITION MULTIPOLARITIES AND LEVEL SCHEME. — The conversion electron spectrum was investigated with the aid of a Si(Li) detector of 50 mm^2 and Li-drifted zone thickness of 3 mm. The detector was in a vacuum chamber and was cooled down to -30°C . The system resolution (FWHM) for the conversion lines of ^{207}Bi was \approx 4 keV. The system was calibrated for intensity with the 206.5 keV and 971.3 keV E2-transitions emitted in the decay of ^{174}Ta . Results of the conversion line intensity measurements are given

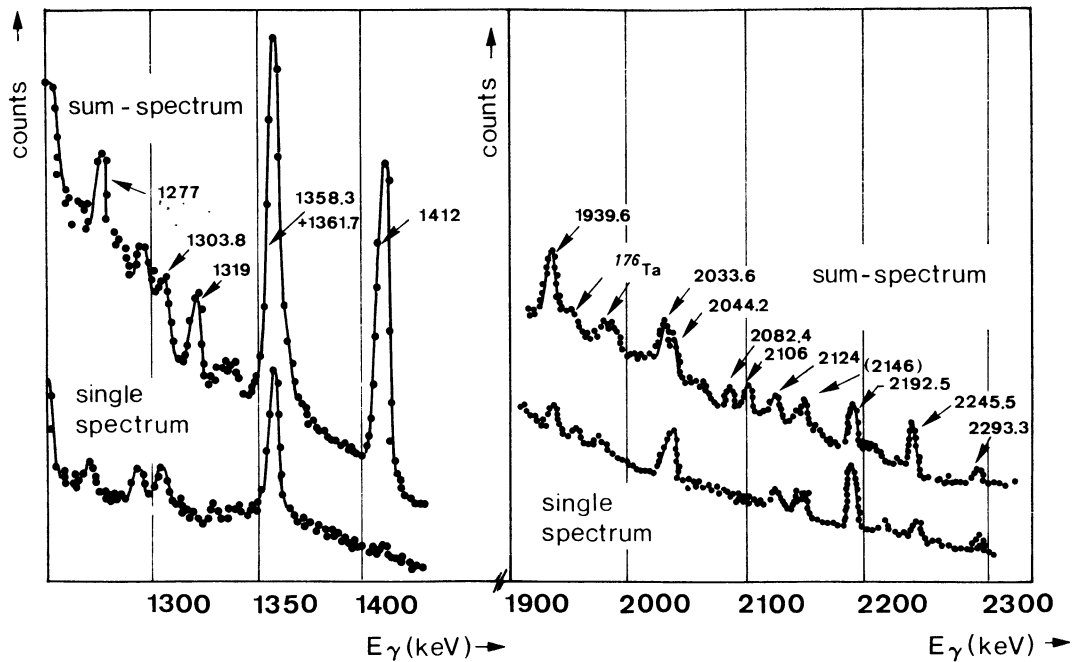


FIG. 2. — Portions of the sum spectrum obtained with the well-type Ge(Li) detector and the corresponding single spectrum.

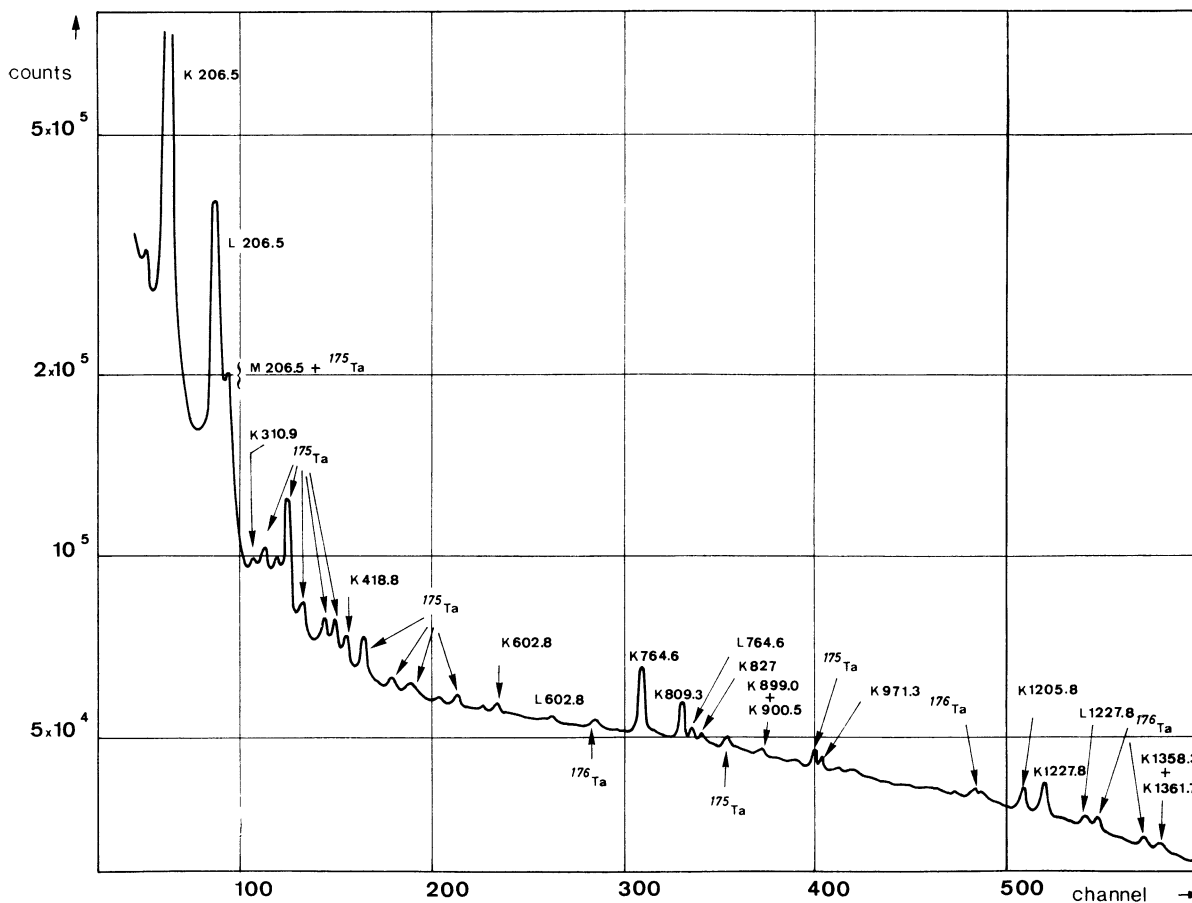


FIG. 3. — General aspect of the electron spectrum obtained with the Si(Li) spectrometer.

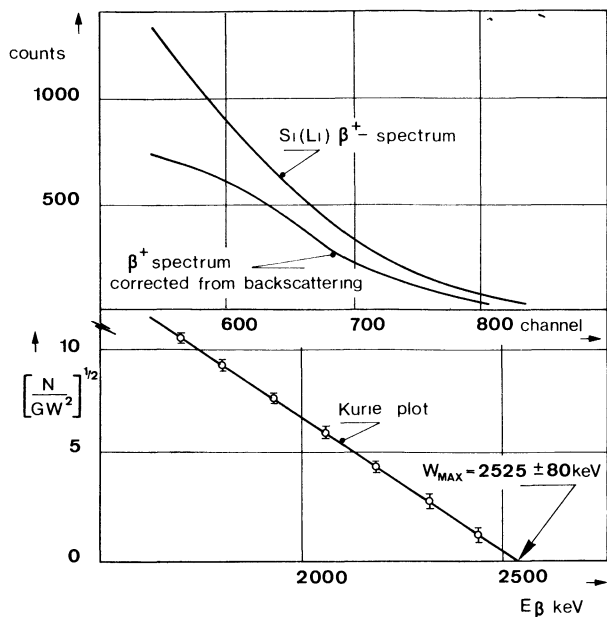


FIG. 4. — Si(Li) β -spectrum coincident with the 206.5 keV γ -ray and the corresponding Kurie plot.

The decay scheme $^{174}\text{Ta} \rightarrow ^{174}\text{Hf}$ based on available experimental evidence is presented on figure 5. It accounts for about 97 % of the decay. 14 levels situated above the beta vibrational band are established ; three others remain uncertain. It should be noted discrepancies between our results and those given recently by K. G. Bueno de Mesquita et al. [6]. They indicate levels at 1 326.8, 1 487.8, 1 939.1 and 1 529.5 keV that have not been identified in our study. Nevertheless, the other levels they have established are consistent with our experimental decay scheme.

2.5 BETA SPECTRUM COINCIDENT WITH THE 206.5 keV γ -RAY. The $4^+ 0$ member of the ground state rotational band is strongly fed in the decay of ^{174}Ta . The β -spectrum coincident with the 206.5 keV γ -ray was recorded in order to determine the Q -value of the electron capture decay of ^{174}Ta . The coincidence experiment was performed with the Si(Li) detector and the 4 cm³ Ge(Li) one. The Si(Li) β -spectrum was corrected from backscattering according to Charoenkwan's method [15]. The β -spectrum and the

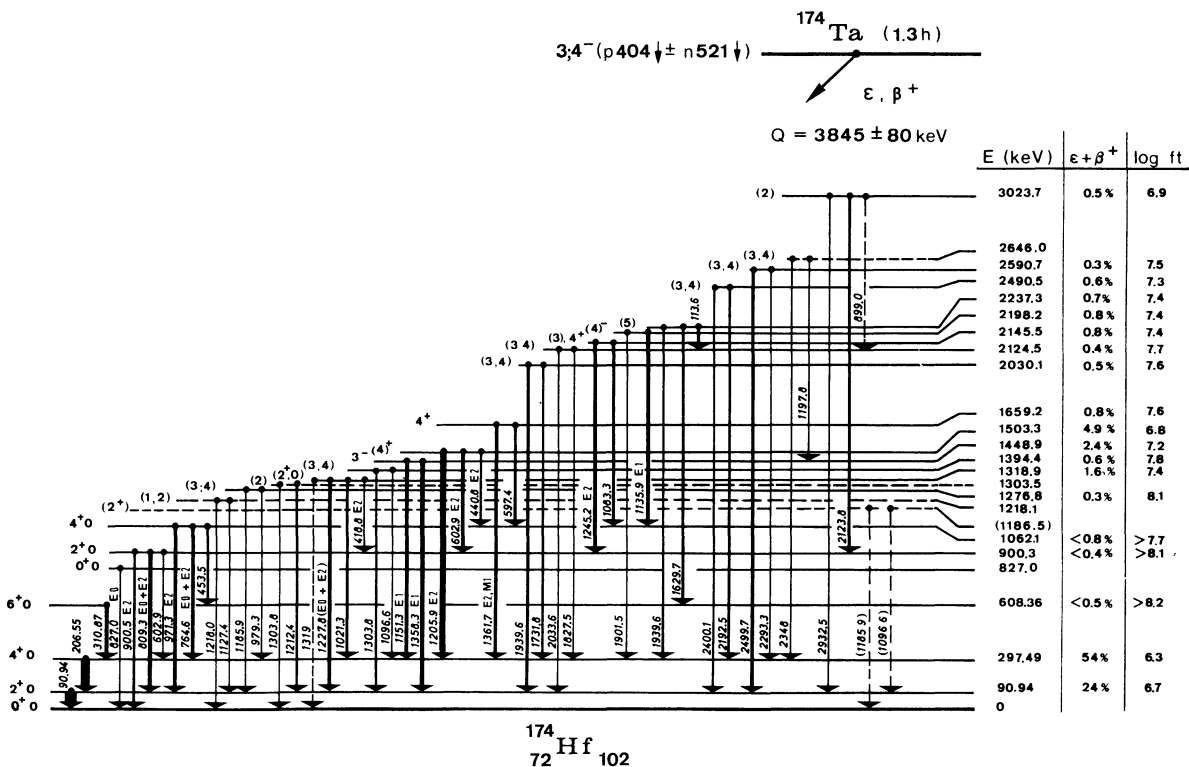


FIG. 5. — The decay scheme for ^{174}Ta deduced from the present study. All energies are in keV.

in column 3 of table I for 18 intense transitions. Experimental conversion coefficients α_K and conclusions about multiplicities are listed in columns 4 and 5 of table I. The general aspect of the spectrum is shown on figure 3. The large uncertainties are due to the positron distribution and to poor statistics in the high energy region.

corresponding Kurie plot are shown on figure 4. Corrections due to the first forbidden nature of the β -transition are assumed to be unimportant and have not been taken into account. The end point energy W_{max} was found to be $2\,525 \pm 80$ keV. Hence, the Q -value is $3\,845 \pm 80$ keV. This value was used as a basis for determining log ft values. It may be noted

that this result agrees with the semi-empirical Q -value estimate given by Zeldes et al. [16] for this nucleus (3 910 keV).

2.6 HALF LIFE OF THE 90.9 keV LEVEL. — The half-life of the first 2^+ level was determined from delayed γ - γ coincidence measurements on the 206.5 – 90.9 keV cascade. Plastic detectors (2.5×3.8 cm) were used. The resolving time of the coincidence circuit was $\tau = 0.7$ ns. The half life of the 90.9 keV level was found to be 1.68 ± 0.08 ns in good agreement with the result obtained by Abou Leila [3] (1.64 ± 0.10 ns).

3. Discussion. — **3.1 THE STRUCTURE OF ^{174}Ta .** — The experimental data on the $^{175,176}\text{Ta}$, ^{173}Hf and ^{175}W nuclei indicate that the ground state of ^{174}Ta should correspond to the configuration $3^-, 4^- \{p 404 \downarrow \pm n 521 \downarrow\}$. A particularity of the decay of ^{174}Ta is the strong feeding of the $2^+ 0$ and $4^+ 0$ levels of the ground state rotational band. Nevertheless the $\log ft$ values corresponding to those states may be consistent with first forbidden transitions.

The ground state of odd-odd nuclei often corresponds to a $\Sigma = 1$ coupling. Then the state of ^{174}Ta would be 4^- .

However the $\log ft$ values for the β -transition to the $2^+ 0$ and the $4^+ 0$ states are not very different and either a 3^- or a 4^- state may be expected for the ground state of ^{174}Ta .

3.2 GROUND STATE, BETA AND GAMMA ROTATIONAL BANDS. **3.2.1 Ground state band.** — We have determined the energies of the first three levels at

$$90.94 \pm 0.05 \text{ keV } (2^+ 0),$$

$$297.49 \pm 0.15 \text{ keV } (4^+ 0)$$

and

$$608.36 \pm 0.22 \text{ keV } (6^+ 0).$$

The $2^+ 0$ and $4^+ 0$ levels are the most strongly fed in the decay of ^{174}Ta . The half-life of the first excited level is 1.68 ± 0.08 ns. Hence the corresponding reduced transition probability $B(E 2 \downarrow)$ is

$$B(E 2 \downarrow) = 0.915 \pm 0.045 e^2 10^{-48} \text{ cm}^4.$$

3.2.2 Beta vibrational band. — A conversion line was observed at 762 keV in competition with the M-764.6 keV line. The experimental ratio I_e (total) $762 \text{ keV}/I_{L-764.6 \text{ keV}}$ was found to be ≈ 0.7 . Though the M/L theoretical ratio is uncertain (most of the 764.6 keV transition is from the $E 0$ multipolarity), a M/L value of ≈ 0.3 can be estimated. Hence, a $E 0$ contribution must be expected ($\approx 50\%$) and a lower limit can be given for the intensity of the corresponding K-827 keV $E 0$ line ($I_K(E 0) \approx 0.05$ unit of table I). This $E 0$ line has been previously reported by Graetzer et al. [10].

Obviously, this 827 keV 0^+ level is weakly populated in the decay of ^{174}Ta and no significant evidence was

obtained for the corresponding ($0_\beta^+ \rightarrow 2_g^+$) 736 keV transition in the γ -spectrum. In the limit of errors, the intensity of such a transition must be < 2 units of table I. Hence a lower limit can be estimated for the X -parameter value X

$$X = \frac{\rho^2 e^2 R_0^4}{B(E 2, 0_\beta^+ \rightarrow 2_g^+)} > 0.2.$$

The $2^+ 0$ and $4^+ 0$ levels of the β -vibrational band are established at 900.3 keV and 1 062.1 keV respectively. These values are in good agreement with those reported in previous studies [5], [10], [6]. The experimental α_K values for the 809.3 keV and the 764.6 keV transitions imply that at least 60 % of these $\Delta I = 0$ lines is from the $E 0$ multipolarity. The $\log ft$ values corresponding to the 900.3 keV and the 1062.1 keV level (respectively > 8.1 and > 7.7) indicate that this band is weakly populated in the decay of ^{174}Ta . The Z_0 mixing parameter of this band can be estimated by comparing the experimental ratios of reduced transition probabilities with the band mixing predictions [17]. The ratios $B(E 2, 2^+ \rightarrow 0^+)/B(E 2, 2^+ \rightarrow 4^+)$ and $B(E 2, 4^+ \rightarrow 6^+)/B(E 2, 4^+ \rightarrow 2^+)$ which account only for pure $E 2$ transitions must be used. However the ($2^+ \rightarrow 4^+$) 602.9 keV transition has been placed elsewhere in the decay scheme and the estimation of the first ratio cannot be obtained. The second ratio $B(E 2, 4^+ \rightarrow 6^+)/B(E 2, 4^+ \rightarrow 2^+)$ is found to be 13.5 ± 2.6 . Hence, the corresponding mixing parameter is $Z_0 = 0.030 \pm 0.006$. This result is not significantly different from the estimation ($Z_0 \approx 0.02$) given by Graetzer et al. [10].

3.2.3 The gamma vibrational band. — No evidence has been previously obtained for the population of the gamma vibrational band. Two levels at 1 447 keV (3) and 1 704 keV (5) had been reported by Graetzer et al. [10] and tentatively interpreted as being members of the gamma band. We effectively established a level at 1 448.9 keV but this state was assigned to be 3^- .

According to the results of neighbouring nuclei, the $2^+ 2$ vibrational state is to be situated at about 1 200 – 1 300 keV. Several levels have been observed in this region and we can suggest possibilities for the gamma band.

First, we can interpret the 1 303.5 keV and the 1 394.4 keV levels as being respectively the $2^+ 2$ and the $3^+ 2$ states. But this interpretation is most unlikely: a) no evidence can be obtained for the population of the corresponding $4^+ 2$ level which is expected at about 1 515 keV, b) the ratios of reduced transition probabilities for the 1 303.5 and the 1 394.4 keV levels are inconsistent with the predictions of the collective model.

Another possibility can be suggested by interpreting the 1 276.8 keV and the 1 394.4 keV levels as being respectively the $3^+ 2$ and the $4^+ 2$ members of the gamma band. Hence a $2^+ 2$ level must be expected at

about 1 186 keV. This interpretation agrees with the properties of the gamma bands :

a) A 1 186 keV level could be effectively placed with a weak part of intensity of the 1 185.9 keV and of the 1 096.6 keV transitions.

b) The coefficients of the relation

$$E = E_0 + AJ(J + 1) + BJ^2(J + 1)^2$$

are coherent ($A = 15.7$ and $B = -0.030$).

c) In the limit of errors, the ratios of reduced transition probabilities corresponding to the 1276.8 keV and the 1394.4 keV levels are consistent with the theoretical predictions of the collective model. These ratios and estimations for the Z_2 parameter are given in table IV. This band would be weakly populated. This fact seems to be a particularity of the ^{174}Hf nucleus. Experimental data on the energies of the 2^+ vibrational states of Yb, Hf and W isotopes as a

TABLE IV

Ratios of E2 reduced transition probabilities from the 1 276.8 keV and 1 394.4 keV levels to the $K = 0$ ground state rotational band.

Level	Transitions	Experimental ratio	Z_2 value
1 276.8	$3 \rightarrow 4/3 \rightarrow 2$	0.86 ± 0.33	$0.022 < Z_2 < 0.095$
1 394.4	$4 \rightarrow 2/4 \rightarrow 4$	0.27 ± 0.07	$0.000 < Z_2 < 0.035$

function of N are given in figure 6. It should be noted that the energies of the 2^+ states grow with increasing N in the neutron deficient region. This description agrees with a 2^+ state situated at 1 186 keV for the ^{174}Hf nucleus.

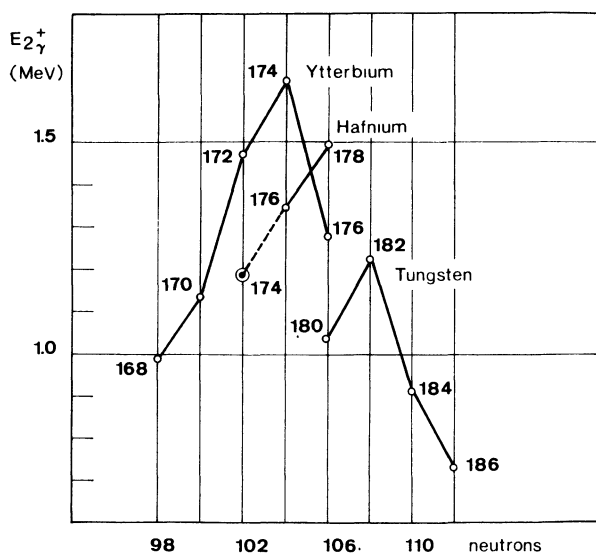


FIG. 6. — Experimental energies of 2^+ vibrational states for Yb, Hf and W.

3.3 OTHER LEVELS. — The large α_K value of the 1 227.8 keV transition likely corresponds to a mixing of $E2$ and $E0$ multipolarities. This indication supports the $2^+ 0$ assignment for the 1 318.9 keV level. Evidence for several $K^\pi = 0^+$ states has been previously obtained in even-even nuclei. It should be noted that this 1 318.9 keV level is connected to ground state only by a weak 1 319 keV transition.

A 3^- state has been established at 1 448.9 keV and can be interpreted as being an octupole vibrational state. The ratio of reduced transition probabilities

$$\frac{B(E1, 3^- K \rightarrow 4^+ 0)}{B(E1, 3^- K \rightarrow 2^+ 0)} = 1.20 \pm 0.40$$

is consistent with $K = 1$ (or possibly $K = 0$). The calculated values given by Soloviev [18] are respectively 1.89 and 1.27 MeV for the $K = 0^-$ and $K = 1^-$ octupole states. On the assumption that the state of the 1 448.9 keV level is $I^\pi K = 3^- 1$, the corresponding $1^- 1$ level must be situated at about 1 300 keV in good agreement with theoretical predictions of Soloviev.

The 2 145.5 keV level (4^+) is connected only with the beta vibrational band by transitions which are likely from the $E2$ multipolarity. The energy of this level is about twice as large as that of the 4^+ level of the beta vibrational band. We interpret it as being a two phonon vibrational state.

Three levels at 1 503.3 keV (4^+), 1 659.2 keV (4^+) and 2 198.2 keV (4^-) can be interpreted as being two-quasiparticles states.

The 1 503.3 keV levels is strongly populated in the decay of ^{174}Ta . It de-excites principally to the 4^+ level of the ground state band. It can be interpreted as the $nn(521\downarrow + 514\downarrow)$ two quasi neutron state. This structure corresponds effectively to the 1 st forbidden transition $p404\downarrow \rightarrow n514\downarrow$. The configuration $nn(521\downarrow + 514\downarrow)$ has been predicted respectively at 1.6, 1.6 and 1.9 MeV for the neighbouring ^{174}Yb , ^{176}Hf and ^{172}Yb nuclei [19].

The 1 659.2 keV level (4^+) corresponds likely to the two quasi proton structure $pp(404\downarrow + 411\downarrow)$. This configuration has been predicted at 1.9 MeV for the ^{176}Hf nuclei.

The 2 198.2 keV level (4^-) is an odd parity state. The only possibility is the two quasi neutron structure $nn(521\downarrow - 624\uparrow)$. This structure has been predicted at 2.1 MeV for ^{176}Hf . The corresponding transition $p404\downarrow \rightarrow n624\uparrow$ has been previously observed in the decay of ^{178}Ta to the levels of ^{178}Hf .

The parity of other high lying levels could not have been established. They have not been interpreted. Generally those levels are weakly populated in the decay of ^{174}Ta .

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