^{229}Ac β^- decay 2002Gu15,2006Ru07

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 109, 2657 (2008)	1-Jun-2008

Parent: ^{229}Ac: E=0; $J^\pi=(3/2^+)$; $T_{1/2}$=62.7 min *5*; Q(β^-)=1170 *30*; %β^- decay=100.0

^{229}Ac-Q(β^-): from 2003Au03.

2002Gu15: Measured Eγ, Iγ, $\gamma\gamma$, ce, lifetimes by $\beta\gamma\gamma$(t). A mini-orange electron spectrometer was used for conversion electrons. Determined γ-ray multipolarities.

2006Ru07:Measured Eγ, Iγ, $\gamma\gamma$, lifetimes by $\beta\gamma\gamma$(t).

Evaluators have calculated (RADLST code) the following total K x ray relative intensities from the γ-ray data reported in 2002Gu15: I(Kα_2 x ray)=20 *1*, I(Kα_1 x ray)=32 *2*, I(Kβ x ray)=15 *2*. These values differ by a factor of≈3 from the following experimental values in 2002Gu15: I(Kα_2 x ray)(exp)=61 *2*, I(Kα_1 x ray)(exp)=93 *3*, and I(Kβ x ray)(exp)= 46 *1*. Either some γ-ray intensities or multipolarities are incorrect, or more likely, the additional intensity of K-x rays may have originated from x-ray fluorescence on the ^{232}Th target, which may have not been completely separated in the source used for the these measurements. The total average radiation energy calculated by evaluators (RADLST) is 1167 keV *17*. This value agrees well with Q(β^-)=1170 keV *30* from the mass adjustment in 2003Au03, which confirms the self consistency and completness of the decay scheme.

^{229}Th Levels

Additional information 1.

E(level)‡	J^π	$T_{1/2}$†	Comments
0#	$5/2^+$		
0.0076& *5*	$3/2^+$		Additional information 2. E(level): From Adopted Levels, Gammas.
29.1915& *5*	$5/2^+$		E(level): 29.1881 *32* (2002Gu15).
42.4393# *8*	$7/2^+$	172 ps *6*	Additional information 3. $T_{1/2}$: From 1970To12.
71.8213& *11*	$7/2^+$		Additional information 4.
97.1400# *8*	$9/2^+$	147 ps *12*	Additional information 5. $T_{1/2}$: From 1970To12.
125.4154& *21*	$9/2^+$		Additional information 6.
146.3498@ *5*	$5/2^-$	332 ps *8*	$T_{1/2}$: Weighted average of 336 ps *10* (2002Gu15) and 329 ps *8* (2006Ru07). Additional information 7.
148.1656@ *14*	$(7/2^-)$	689 ps *34*	Additional information 8.
162.92# *20*	$(11/2^+)$		
164.5312a *5*	$(3/2)^-$	55 ps *4*	$T_{1/2}$: Weighted average of 53 ps *4* (2002Gu15) and 61 ps *7* (2006Ru07).
217.1585a *6*	$(5/2)^-$	30 ps *7*	
236.35 *20*			
237.3711a *9*	$(7/2^-)$	≤34 ps	
261.966b *4*	$1/2^+$	15 ps *3*	$T_{1/2}$: Other value:<35 ps (2002Gu15).
288.597b *22*	$3/2^+$	16 ps *7*	Additional information 9.
303.06 *3*		110 ps *17*	Additional information 10.
317.1723 *9*	$(5/2)^+$	9.0 ps *16*	Additional information 11.
320.5485c *7*	$(5/2,7/2)^+$	10.3 ps *21*	Additional information 12.
365.8161c *11*	$(7/2^+)$	9 ps *4*	
424.01 *4*		190 ps *8*	
425.33c *3*	$^+$	290 ps *48*	
449.38 *3*	$^+$		
478.577 *16*	$(5/2,7/2)^-$	≤16 ps	Additional information 13.
526.78 *3*	$^-$		

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^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

^{229}Th Levels (continued)

E(level)‡	Jπ	Comments
534.97 *5*	1/2−	Configuration=1/2[501](77%)+1/2[770](1%)+ 1/2[651] and 1/2[640] coupled to octupole phonons (14%).
569.256 *15*	(3/2,5/2,7/2)+	Additional information 14.
576.39 *6*		
605.238 *14*	(3/2,5/2,7/2)+	Additional information 15.
638.48 *3*		
653.79 *4*		
661.780 *24*		
689.01 *5*		
779.29 *7*		

† From $\beta\gamma\gamma$(t) unless otherwise specified (2006Ru07).
‡ Deduced by evaluators from least-squares fit to γ-ray energies.
# Band(A): $K^\pi=5/2^+$ band. Configuration=5/2[633](84%) + 5/2[752] and 5/2[503] coupled to octupole phonons (16%).
@ Band(B): $K^\pi=5/2^-$ band. Configuration=5/2[752](83%)+5/2[503](1%)+ 5/2[633] coupled to octupole phonons (11%).
& Band(C): $K^\pi=3/2^+$ band. Configuration=3/2[631](43%)+3/2[642](31%)+ 3/2[761] and 3/2[512] coupled to octupole phonons (15%).
a Band(D): $K^\pi=3/2^-$ band. Configuration=3/2[761](80%)+3/2[642] and 3/2[631] coupled to octupole phonons (16%).
b Band(E): $K^\pi=1/2^+$ band. Configuration=1/2[631](57%)+1/2[640](11%)+ 1/2[770] and 1/2[510] coupled to octupole phonons (10%).
c Band(F): $K^\pi=5/2^+$ band. Configuration=5/2[622](85%)+5/2[633](1%)+ 5/2[752] coupled to octupole phonons (5%)+ 5/2[633] coupled to quadrupole phonons.

β^- radiations

E(decay)	E(level)	Iβ−‡	Log *ft*	Comments
(3.9×10^2 *3*)	779.29	0.0057 *6*	8.74 *13*	av Eβ=111 *10*
(4.8×10^2 *3*)	689.01	0.031 *4*	8.30 *11*	av Eβ=140 *10*
(5.1×10^2 *3*)	661.780	0.085 *6*	7.94 *10*	av Eβ=149 *10*
(5.2×10^2 *3*)	653.79	0.0054 *6*	9.16 *10*	av Eβ=152 *10*
(5.3×10^2 *3*)	638.48	0.019 *1*	8.65 *9*	av Eβ=157 *10*
(5.6×10^2 *3*)	605.238	2.2 *2*	6.68 *9*	av Eβ=168 *11*
(5.9×10^2 *3*)	576.39	0.11 *1*	8.05 *9*	av Eβ=178 *11*
(6.0×10^2 *3*)	569.256	4.2 *7*	6.49 *11*	av Eβ=180 *11*
(6.4×10^2 *3*)	534.97	0.022 *4*	8.85 *11*	av Eβ=192 *11*
(6.4×10^2 *3*)	526.78	0.22 *2*	7.87 *8*	av Eβ=195 *11*
(6.9×10^2 *3*)	478.577	0.97 *7*	7.33 *8*	av Eβ=212 *11*
(7.2×10^2# *3*)	449.38	0.52 *4*	7.66 *8*	av Eβ=222 *11*
(7.4×10^2 *3*)	425.33	0.09 *2*	8.47 *12*	av Eβ=230 *11*
(7.5×10^2 *3*)	424.01	0.097 *13*	8.44 *9*	av Eβ=231 *11*
(8.5×10^2 *3*)	320.5485	0.36 *9*	8.06 *13*	av Eβ=268 *11*
(8.5×10^2 *3*)	317.1723	0.16 *9*	8.4 *3*	av Eβ=269 *11*
(8.8×10^2 *3*)	288.597	0.5 *2*	7.98 *19*	av Eβ=279 *11*
(9.1×10^2 *3*)	261.966	1.6 *1*	7.52 *6*	av Eβ=289 *11*
(9.3×10^2 *3*)	237.3711	0.024 *8*	9.83[1u] *17*	av Eβ=293 *11*
(9.3×10^2# *3*)	236.35	0.016 *6*	9.56 *17*	av Eβ=298 *11*
(9.5×10^2 *3*)	217.1585	0.17 *2*	8.56 *7*	av Eβ=305 *11*
(1.01×10^3 *3*)	164.5312	3.8 *3*	7.30 *6*	av Eβ=325 *12*
(1.02×10^3# *3*)	148.1656	0.10 *1*	9.41[1u] *8*	av Eβ=323 *11*

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^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

β^- radiations (continued)

E(decay)	E(level)	Iβ^-[‡]	Log *ft*	Comments
(1.02×10^3 *3*)	146.3498	1.6 *1*	7.70 *6*	av Eβ=332 *12*
(1.14×10^3 *3*)	29.1915	3.3 *5*	7.55 *8*	av Eβ=376 *12* Iβ^-: Iβ=6.6% 9 in 2002Gu15 is inconsistent with γ-ray intensity balance.
(1.17×10^3 *3*)	0.0076			Iβ^-: combined feeding to g.s.+0.0076 is 79 *5*.
(1.17×10^3 *3*)	0	79[†] *1*	6.2	av Eβ=387 *12* Iβ^-: From (100 − Σ Iβ(excited states))= 100 − (21% 1) = 79% 1.

[†] Combined for g.s.+0.0076-keV level.
[‡] Absolute intensity per 100 decays.
[#] Existence of this branch is questionable.

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$

Iγ normalization: From cumulative ratios os Iγ(164)/Iγ(142)=0.17 *1* and Iγ(164)/Iγ(336)=0.125 *7* measured for t=120 min., and using absolute intensities of Iγ(142)=15.9% 5 and Iγ(336)=21.5% 6 for γ rays from ^{229}Fr β^- decay. Notice that there is no possible equilibrium in the ^{229}Fr β^- decay chain, and at t=120 min ^{229}Fr(T$_{1/2}$=0.8 min) and ^{229}Ra(T$_{1/2}$=4 min) have completely decayed. About 1% of the γ-ray intensity is unplaced. Iγ normalization=0.0261 *16* (2002Gu15).

Intensity of x-ray transitions

Energy	Intensity	Th x rays
11.12(5)	13.8(6)	L_l x ray
12.97(5)	131(5)	$L\alpha_1$ x ray
15.60(5)	37(2)	$L\beta_2$ x ray + $L\beta_{15}$ x ray
16.20(5)	79(3)	$L\beta_1$ x ray
18.98(5)	18.6(8)	L_γ x ray
89.96(4)	61(2)	$K\alpha_2$ x ray
93.35(4)	93(3)	$K\alpha_1$ x ray
104.82(4)	11.7(3)	$K\beta_3$ x ray
105.60(4)	24.3(7)	$K\beta_1$ x ray
108.58(4)	9.7(3)	$K\beta_2$ x ray

E$_\gamma$ ‡	I$_\gamma$ ‡ [b]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.	α [c]	Comments
(0.0076 *5*)		0.0076	3/2$^+$	0	5/2$^+$			
1.81#	0.00038# *3*	148.1656	(7/2$^-$)	146.3498	5/2$^-$	[M1]		
16.36#	0.0012# *2*	164.5312	(3/2)$^-$	148.1656	(7/2$^-$)	[E2]		
18.17 *5*	0.084 *14*	164.5312	(3/2)$^-$	146.3498	5/2$^-$	[M1]		E$_\gamma$,I$_{(\gamma+ce)}$: from $\gamma\gamma$ coin data.
x19.56 *5*	7.4 *3*							
x24.08 *5*	0.58 *3*							
24.8† *1*		661.780		638.48				
25.14d *10*	0.65 *3*	97.1400	9/2$^+$	71.8213	7/2$^+$	[M1]	217 *4*	α(L)=164 *3*; α(M)=39.7 *8*; α(N+..)=13.6 *3* α(N)=10.59 *20*; α(O)=2.51 *5*; α(P)=0.487 *9*; α(Q)=0.0465 *9* Uncertain transition (2002Gu15).
x26.19 *10*	0.30 *1*							
x27.29 *10*	0.24 *1*							
(28.7#)	0.012# *2*	317.1723	(5/2)$^+$	288.597	3/2$^+$	[M1]	147.0	α(L)=111.0 *16*; α(M)=26.8 *4*; α(N+..)=9.21 *13* α(N)=7.15 *10*; α(O)=1.694 *24*; α(P)=0.329 *5*; α(Q)=0.0314 *5*
29.1846@ *30*	1.98 *8*	29.1915	5/2$^+$	0.0076	3/2$^+$	M1	139.9	α(L)=105.6 *15*; α(M)=25.5 *4*; α(N+..)=8.76 *13* α(N)=6.81 *10*; α(O)=1.612 *23*; α(P)=0.313 *5*; α(Q)=0.0299 *5*
(32.1#)	0.012# *2*	320.5485	(5/2,7/2)$^+$	288.597	3/2$^+$	[M1]	105.6	α(L)=79.8 *12*; α(M)=19.2 *3*; α(N+..)=6.61 *10* α(N)=5.14 *8*; α(O)=1.216 *17*; α(P)=0.236 *4*; α(Q)=0.0225 *4*
42.43 *5*	≈0.44	42.4393	7/2$^+$	0	5/2$^+$	M1	46.4	α(L)=35.1 *5*; α(M)=8.44 *13*; α(N+..)=2.90 *5*

$^{229}_{90}Th_{139}$-4

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡][b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α[c]	Comments
								α(N)=2.25 *4*; α(O)=0.534 *8*; α(P)=0.1036 *15*; α(Q)=0.00988 *15* E_γ: Weighted average of 42.45 *5* (2002Gu15) and 42.34 *10* (2006Ru07). E_γ: Eγ for doublet=42.584 *5*. I_γ: 0.94 *4* for 42.45+42.63.
42.66 *4*	≈0.5[&]	71.8213	7/2$^+$	29.1915	5/2$^+$	M1	45.7	α(L)=34.5 *5*; α(M)=8.31 *12*; α(N+..)=2.85 *4* α(N)=2.22 *4*; α(O)=0.525 *8*; α(P)=0.1019 *15*; α(Q)=0.00973 *14* E_γ: Weighted average of 42.63 *5* (2002Gu15) and 42.68 *4* (2006Ru07). E_γ: Eγ for doublet=42.584 *5* (2002Gu15). I_γ: 0.94 *4* for 42.45+42.63 (2002Gu15).
(45.3[#])	0.037[#] *7*	365.8161	(7/2$^+$)	320.5485	(5/2,7/2)$^+$	[M1]	38.3	α(L)=28.9 *4*; α(M)=6.96 *10*; α(N+..)=2.39 *4* α(N)=1.86 *3*; α(O)=0.440 *7*; α(P)=0.0854 *12*; α(Q)=0.00815 *12*
(48.6[#])	0.044[#] *9*	365.8161	(7/2$^+$)	317.1723	(5/2)$^+$	[M1]	31.1	α(L)=23.5 *4*; α(M)=5.66 *8*; α(N+..)=1.95 *3* α(N)=1.511 *22*; α(O)=0.358 *5*; α(P)=0.0695 *10*; α(Q)=0.00662 *10*
52.66 *5*	0.14 *1*	217.1585	(5/2)$^-$	164.5312	(3/2)$^-$	[M1]	24.6	α(L)=18.6 *3*; α(M)=4.47 *7*; α(N+..)=1.536 *22* α(N)=1.194 *17*; α(O)=0.283 *4*; α(P)=0.0549 *8*; α(Q)=0.00523 *8* E_γ: Weighted average of 52.62 *5* (2002Gu15) and 52.71 *5* (2006Ru07).
53.63 *9*	0.12 *1*	125.4154	9/2$^+$	71.8213	7/2$^+$	[M1]	23.3	α(L)=17.6 *3*; α(M)=4.24 *7*; α(N+..)=1.456 *22* α(N)=1.131 *17*; α(O)=0.268 *4*; α(P)=0.0520 *8*; α(Q)=0.00496 *8* E_γ: Weighted average of 53.55 *10* (2002Gu15) and 53.69 *9* (2006Ru07).
54.699[#] *1*	1.94[#] *32*	97.1400	9/2$^+$	42.4393	7/2$^+$	M1+E2		
(55.2[#])	0.006[#] *1*	317.1723	(5/2)$^+$	261.966	1/2$^+$	[E2]	191	α(L)=139.5 *20*; α(M)=38.2 *6*; α(N+..)=12.88 *18* α(N)=10.23 *15*; α(O)=2.27 *4*; α(P)=0.375 *6*; α(Q)=0.001057 *15*
(58.6[#])	0.005[#] *1*	320.5485	(5/2,7/2)$^+$	261.966	1/2$^+$	[E2]	142.8	α(L)=104.5 *15*; α(M)=28.7 *4*; α(N+..)=9.66 *14* α(N)=7.67 *11*; α(O)=1.706 *24*; α(P)=0.282 *4*; α(Q)=0.000817 *12*
67.943[#] *6*	0.17[#] *4*	97.1400	9/2$^+$	29.1915	5/2$^+$	E2		
[x]69.03 *10*	0.20 *1*							
69.1[#] *2*	[#]	638.48		569.256	(3/2,5/2,7/2)$^+$			
71.8159[@] *20*	0.40 *2*	71.8213	7/2$^+$	0.0076	3/2$^+$	[E2]	53.8	α(L)=39.4 *6*; α(M)=10.81 *16*; α(N+..)=3.65 *6* α(N)=2.89 *4*; α(O)=0.644 *9*; α(P)=0.1065 *15*; α(Q)=0.000349 *5*
74.5390[@] *40*	7.2 *2*	146.3498	5/2$^-$	71.8213	7/2$^+$	[E1]	0.255	α(L)=0.193 *3*; α(M)=0.0470 *7*; α(N+..)=0.01561 *22* α(N)=0.01233 *18*; α(O)=0.00277 *4*; α(P)=0.000478 *7*; α(Q)=2.49×10^{-5} *4*
76.3507[@] *27*	0.68 *2*	148.1656	(7/2$^-$)	71.8213	7/2$^+$	[E1]	0.240	α(L)=0.181 *3*; α(M)=0.0441 *7*; α(N+..)=0.01465 *21* α(N)=0.01157 *17*; α(O)=0.00260 *4*; α(P)=0.000450 *7*; α(Q)=2.36×10^{-5} *4*
[x]77.18 *10*	0.38 *2*							

$^{229}_{90}Th_{139}$-5

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ ‡	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α c	Comments
82.957# *30*	0.005# *1*	125.4154	9/2+	42.4393	7/2+	M1+E2		
x83.46 *10*	0.25 *1*							
83.9 *2*		689.01		605.238	(3/2,5/2,7/2)+			
84.8 *1*		653.79		569.256	(3/2,5/2,7/2)+			
x89.0 *1*	1.13 *5*							
(89.2#)	0.050# *16*	237.3711	(7/2−)	148.1656	(7/2−)	[M1]	5.28	α(L)=3.99 *6*; α(M)=0.960 *14*; α(N+..)=0.330 *5* α(N)=0.256 *4*; α(O)=0.0606 *9*; α(P)=0.01176 *17*; α(Q)=0.001119 *16*
90.0a *2*	0.06a *2*	236.35		146.3498	5/2−	[D,E2]		
(91.0#)	0.13# *2*	237.3711	(7/2−)	146.3498	5/2−	[M1]	4.98	α(L)=3.76 *6*; α(M)=0.905 *13*; α(N+..)=0.311 *5* α(N)=0.242 *4*; α(O)=0.0572 *8*; α(P)=0.01110 *16*; α(Q)=0.001056 *15*
91.1a *2*	0.16a *3*	162.92	(11/2+)	71.8213	7/2+	[E2]	17.4 *3*	α(L)=12.75 *23*; α(M)=3.50 *7*; α(N+..)=1.183 *21* α(N)=0.939 *17*; α(O)=0.209 *4*; α(P)=0.0347 *6*; α(Q)=0.0001386 *23*
x91.98 *5*	0.96 *4*							
x94.09 *5*	2.4 *1*							
96.224# *2*	0.04# *1*	125.4154	9/2+	29.1915	5/2+	E2		
97.134# *1*	2.17# *49*	97.1400	9/2+	0	5/2+	E2		
99.93a *8*	0.22a *7*	317.1723	(5/2)+	217.1585	(5/2)−	[E1]	0.1176	α(L)=0.0888 *13*; α(M)=0.0216 *3*; α(N+..)=0.00720 *11* α(N)=0.00567 *8*; α(O)=0.001288 *19*; α(P)=0.000227 *4*; α(Q)=1.310×10^{-5} *19* E_γ: Weighted average of 99.3 *5* (2002Gu15) and 99.95 *8* (2006Ru07).
x109.46 *4*	2.89 *9*							
111.80 *5*	0.37 *3*	237.3711	(7/2−)	125.4154	9/2+	[E1]	0.372	α(K)=0.285 *4*; α(L)=0.0662 *10*; α(M)=0.01605 *23*; α(N+..)=0.00537 *8* α(N)=0.00422 *6*; α(O)=0.000962 *14*; α(P)=0.0001710 *24*; α(Q)=1.022×10^{-5} *15* E_γ: Weighted average of 111.90 *5* (2002Gu15) and 111.4 *1* (2006Ru07).
117.1628@† *9*	15.7 *5*	146.3498	5/2−	29.1915	5/2+	E1	0.336	α(K)=0.259 *4*; α(L)=0.0586 *9*; α(M)=0.01419 *20*; α(N+..)=0.00475 *7* α(N)=0.00374 *6*; α(O)=0.000852 *12*; α(P)=0.0001519 *22*; α(Q)=9.21×10^{-6} *13* Additional information 16.
118.9721@ *15*	6.1 *2*	148.1656	(7/2−)	29.1915	5/2+	E1	0.325	α(K)=0.250 *4*; α(L)=0.0563 *8*; α(M)=0.01363 *19*; α(N+..)=0.00456 *7* α(N)=0.00359 *5*; α(O)=0.000819 *12*; α(P)=0.0001462 *21*; α(Q)=8.90×10^{-6} *13*
119.5 *1*		569.256	(3/2,5/2,7/2)+	449.38	+			Additional information 29. E_γ: from γγ coin data.

$^{229}_{90}Th_{139}$-6

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α[c]	Comments
125.41[#] *6*	0.0018[#] *4*	125.4154	9/2$^+$	0	5/2$^+$	E2		
127.02 *5*	0.57 *2*	576.39		449.38	$^+$	[D,E2]		I_γ: For 127.02+127.6.
127.6 *1*	0.57[&] *2*	605.238	(3/2,5/2,7/2)$^+$	478.577	(5/2,7/2)$^-$	[E1]	0.275	α(K)=0.213 *3*; α(L)=0.0469 *7*; α(M)=0.01135 *16*; α(N+..)=0.00380 *6* α(N)=0.00299 *5*; α(O)=0.000684 *10*; α(P)=0.0001225 *18*; α(Q)=7.62×10^{-6} *11* I_γ: For 127.02+127.6. Additional information 31.
135.3393[@] *5*	37 *1*	164.5312	(3/2)$^-$	29.1915	5/2$^+$	E1	0.239	α(K)=0.186 *3*; α(L)=0.0403 *6*; α(M)=0.00974 *14*; α(N+..)=0.00327 *5* α(N)=0.00257 *4*; α(O)=0.000587 *9*; α(P)=0.0001057 *15*; α(Q)=6.68×10^{-6} *10*
135.55[#] *7*	1.1[#] *2*	424.01		288.597	3/2$^+$	[E1]	0.238	α(K)=0.185 *3*; α(L)=0.0401 *6*; α(M)=0.00970 *14*; α(N+..)=0.00325 *5* α(N)=0.00256 *4*; α(O)=0.000585 *9*; α(P)=0.0001052 *15*; α(Q)=6.66×10^{-6} *10*
145.41 *4*	2.1 *1*	217.1585	(5/2)$^-$	71.8213	7/2$^+$	[E1]	0.201	Intrinsic dipole moment D_0=0.034 *3*. α(K)=0.1572 *22*; α(L)=0.0334 *5*; α(M)=0.00808 *12*; α(N+..)=0.00271 *4* α(N)=0.00213 *3*; α(O)=0.000489 *7*; α(P)=8.83×10^{-5} *13*; α(Q)=5.70×10^{-6} *8* E_γ: Weighted average of 145.34 *5* (2002Gu15) and 145.46 *4* (2006Ru07).
146.3462 *6*	34 *1*	146.3498	5/2$^-$	0	5/2$^+$	E1	0.198	α(K)=0.1549 *22*; α(L)=0.0329 *5*; α(M)=0.00795 *12*; α(N+..)=0.00267 *4* α(N)=0.00210 *3*; α(O)=0.000481 *7*; α(P)=8.69×10^{-5} *13*; α(Q)=5.62×10^{-6} *8* Additional information 17.
148.16 *4*	0.62 *2*	148.1656	(7/2$^-$)	0	5/2$^+$	[E1]	0.193	α(K)=0.1505 *21*; α(L)=0.0319 *5*; α(M)=0.00770 *11*; α(N+..)=0.00259 *4* α(N)=0.00203 *3*; α(O)=0.000466 *7*; α(P)=8.42×10^{-5} *12*; α(Q)=5.47×10^{-6} *8* E_γ: Weighted average of 148.17 *4* (2002Gu15) and 148.14 *7* (2006Ru07).
154.85 *4*	0.37 *2*	303.06		148.1656	(7/2$^-$)	[D,E2]		E_γ: Weighted average of 154.86 *4* (2002Gu15) and 154.85 *4* (2006Ru07).
156.04[#] *9*	0.31[#] *7*	320.5485	(5/2,7/2)$^+$	164.5312	(3/2)$^-$	[E1]	0.1702	α(K)=0.1333 *19*; α(L)=0.0279 *4*; α(M)=0.00674 *10*; α(N+..)=0.00227 *4* α(N)=0.00178 *3*; α(O)=0.000408 *6*; α(P)=7.40×10^{-5} *11*; α(Q)=4.87×10^{-6} *7*
156.3[#†] *1*	1.6[#] *6*	605.238	(3/2,5/2,7/2)$^+$	449.38	$^+$			

$^{229}_{90}Th_{139}$-7

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ ‡	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α c	Comments
157.98 a 11	0.8 a 2	478.577	(5/2,7/2)$^-$	320.5485	(5/2,7/2)$^+$	[E1]	0.1652	α(K)=0.1295 19; α(L)=0.0270 4; α(M)=0.00653 10; α(N+..)=0.00220 3 α(N)=0.001723 25; α(O)=0.000396 6; α(P)=7.18×10^{-5} 11; α(Q)=4.74×10^{-6} 7 E_γ: Weighted average of 158.1 1 (2002Gu15) and 157.88 9 (2006Ru07).
161.46 #† 8	0.53 # 10	449.38	+	288.597	3/2$^+$			
162.01 4	0.64 2	424.01		261.966	1/2$^+$	[D,E2]		
163.38 a 6	≈0.4 a	425.33	+	261.966	1/2$^+$	[M1,E2]	3.0 16	α(K)=1.9 18; α(L)=0.79 10; α(M)=0.20 4; α(N+..)=0.070 12 α(N)=0.055 10; α(O)=0.0126 20; α(P)=0.00225 19; α(Q)=0.00011 9 E_γ: Weighted average of 163.5 1 (2002Gu15) and 163.35 5 (2006Ru07).
164.5240 @ 5	100.0	164.5312	(3/2)$^-$	0.0076	3/2$^+$	E1	0.1500	α(K)=0.1177 17; α(L)=0.0244 4; α(M)=0.00588 9; α(N+..)=0.00198 3 α(N)=0.001553 22; α(O)=0.000357 5; α(P)=6.49×10^{-5} 9; α(Q)=4.33×10^{-6} 6 I_γ: Iγ/100 decays=2.70 17.
165.0 #† 1	0.27 # 7	237.3711	(7/2$^-$)	71.8213	7/2$^+$	[E1]	0.1490	α(K)=0.1169 17; α(L)=0.0242 4; α(M)=0.00584 9; α(N+..)=0.00196 3 α(N)=0.001542 22; α(O)=0.000355 5; α(P)=6.44×10^{-5} 9; α(Q)=4.31×10^{-6} 6
168.97 5	0.20 3	317.1723	(5/2)$^+$	148.1656	(7/2$^-$)	[E1]	0.1407	α(K)=0.1106 16; α(L)=0.0228 4; α(M)=0.00550 8; α(N+..)=0.00185 3 α(N)=0.001451 21; α(O)=0.000334 5; α(P)=6.08×10^{-5} 9; α(Q)=4.09×10^{-6} 6 E_γ: Weighted average of 169.00 5 (2002Gu15) and 168.94 5 (2006Ru07).
170.8091 @† 24	0.37 1	317.1723	(5/2)$^+$	146.3498	5/2$^-$	[E1]	0.1372	α(K)=0.1078 15; α(L)=0.0222 4; α(M)=0.00535 8; α(N+..)=0.00180 3 α(N)=0.001412 20; α(O)=0.000325 5; α(P)=5.92×10^{-5} 9; α(Q)=3.99×10^{-6} 6 Additional information 19.
172.3 a 1	0.26 a 5	320.5485	(5/2,7/2)$^+$	148.1656	(7/2$^-$)	[E1]	0.1343	α(K)=0.1057 15; α(L)=0.0217 3; α(M)=0.00523 8; α(N+..)=0.001760 25 α(N)=0.001381 20; α(O)=0.000318 5; α(P)=5.79×10^{-5} 9; α(Q)=3.91×10^{-6} 6 E_γ: Weighted average of 172.4 1 (2002Gu15) and 171.9 2 (2006Ru07).
174.1919 @† 20	0.43 1	320.5485	(5/2,7/2)$^+$	146.3498	5/2$^-$	[E1]	0.1309	α(K)=0.1030 15; α(L)=0.0211 3; α(M)=0.00509 8;

$^{229}_{90}Th_{139}$-8

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ ‡	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α c	Comments
								α(N+..)=0.001712 *24* α(N)=0.001343 *19*; α(O)=0.000309 *5*; α(P)=5.64×10^{-5} *8*; α(Q)=3.82×10^{-6} *6*
x183.23 *4*	0.24 *1*							
187.9669@ *3*	2.32 *7*	217.1585	(5/2)$^-$	29.1915	5/2$^+$	[E1]	0.1093	α(K)=0.0862 *12*; α(L)=0.01741 *25*; α(M)=0.00420 *6*; α(N+..)=0.001414 *20* α(N)=0.001108 *16*; α(O)=0.000256 *4*; α(P)=4.68×10^{-5} *7*; α(Q)=3.23×10^{-6} *5*
189.60 *4*	0.09 *1*	478.577	(5/2,7/2)$^-$	288.597	3/2$^+$	[E1]	0.1070	α(K)=0.0845 *12*; α(L)=0.01704 *24*; α(M)=0.00411 *6*; α(N+..)=0.001383 *20* α(N)=0.001084 *16*; α(O)=0.000250 *4*; α(P)=4.58×10^{-5} *7*; α(Q)=3.17×10^{-6} *5* E_γ: Weighted average of 189.60 *4* (2002Gu15) and 189.6 *1* (2006Ru07). Additional information 26.
x203.37 *4*	0.62 *2*							
203.47# *6*	0.94# *12*	569.256	(3/2,5/2,7/2)$^+$	365.8161	(7/2$^+$)			
205.8 *1*	0.08 *1*	526.78	–	320.5485	(5/2,7/2)$^+$	[E1]	0.0882	α(K)=0.0699 *10*; α(L)=0.01389 *20*; α(M)=0.00334 *5*; α(N+..)=0.001127 *16* α(N)=0.000883 *13*; α(O)=0.000204 *3*; α(P)=3.75×10^{-5} *6*; α(Q)=2.65×10^{-6} *4* Additional information 28.
208.1795@ *7*	0.61 *2*	237.3711	(7/2$^-$)	29.1915	5/2$^+$	[E1]	0.0859	α(K)=0.0680 *10*; α(L)=0.01350 *19*; α(M)=0.00325 *5*; α(N+..)=0.001096 *16* α(N)=0.000858 *12*; α(O)=0.000198 *3*; α(P)=3.65×10^{-5} *6*; α(Q)=2.58×10^{-6} *4*
217.1519@ *20*	3.7 *1*	217.1585	(5/2)$^-$	0.0076	3/2$^+$	[E1]	0.0778	α(K)=0.0617 *9*; α(L)=0.01216 *17*; α(M)=0.00293 *4*; α(N+..)=0.000987 *14* α(N)=0.000773 *11*; α(O)=0.000179 *3*; α(P)=3.29×10^{-5} *5*; α(Q)=2.36×10^{-6} *4* E_γ: uncertainty of 0.0002 given in 2002Gu15 is a misprint.
217.6a *1*	0.19a *5*	365.8161	(7/2$^+$)	148.1656	(7/2$^-$)	[E1]	0.0774	α(K)=0.0614 *9*; α(L)=0.01210 *17*; α(M)=0.00291 *4*; α(N+..)=0.000982 *14* α(N)=0.000769 *11*; α(O)=0.0001779 *25*; α(P)=3.28×10^{-5} *5*; α(Q)=2.35×10^{-6} *4*
219.50 *5*	0.53 *2*	365.8161	(7/2$^+$)	146.3498	5/2$^-$	[E1]	0.0759	α(K)=0.0602 *9*; α(L)=0.01184 *17*; α(M)=0.00285 *4*; α(N+..)=0.000961 *14* α(N)=0.000753 *11*; α(O)=0.0001741 *25*; α(P)=3.21×10^{-5} *5*; α(Q)=2.30×10^{-6} *4* E_γ: Weighted average of 219.45 *4* (2002Gu15) and 219.55 *4* (2006Ru07).
223.85 *4*	0.66 *2*	526.78	–	303.06		[D,E2]		

$^{229}_{90}Th_{139}$-9

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ ‡	I_γ ‡ b	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α c	Comments
237.4 a 2	≈0.6 a	237.3711	(7/2$^-$)	0	5/2$^+$	[E1]		0.0632	α(K)=0.0503 8; α(L)=0.00978 14; α(M)=0.00235 4; α(N+..)=0.000794 12 α(N)=0.000621 9; α(O)=0.0001439 21; α(P)=2.66×10^{-5} 4; α(Q)=1.94×10^{-6} 3
239.41 4	8.9 3	605.238	(3/2,5/2,7/2)$^+$	365.8161	(7/2$^+$)	M1+E2	0.82 6	1.08 5	α(K)=0.80 5; α(L)=0.212 4; α(M)=0.0530 9; α(N+..)=0.0181 3 α(N)=0.01416 22; α(O)=0.00329 6; α(P)=0.000612 12; α(Q)=4.29×10^{-5} 22
240.51 4	1.17 3	365.8161	(7/2$^+$)	125.4154	9/2$^+$	M1+E2	0.79 7	1.09 6	α(K)=0.81 5; α(L)=0.210 4; α(M)=0.0524 9; α(N+..)=0.0179 3 α(N)=0.01400 23; α(O)=0.00326 6; α(P)=0.000607 13; α(Q)=4.3×10^{-5} 3 E_γ: Weighted average of 240.51 4 (2002Gu15) and 240.5 1 (2006Ru07).
241.18 # 9	0.55 # 9	478.577	(5/2,7/2)$^-$	237.3711	(7/2$^-$)	[M1]		1.542	α(K)=1.233 18; α(L)=0.233 4; α(M)=0.0560 8; α(N+..)=0.0192 3 α(N)=0.01493 21; α(O)=0.00354 5; α(P)=0.000686 10; α(Q)=6.51×10^{-5} 10
245.3498 @ 11	10.9 3	317.1723	(5/2)$^+$	71.8213	7/2$^+$	M1+E2	0.76 5	1.05 4	α(K)=0.79 4; α(L)=0.198 4; α(M)=0.0493 8; α(N+..)=0.0169 3 α(N)=0.01318 21; α(O)=0.00307 5; α(P)=0.000574 11; α(Q)=4.20×10^{-5} 18
248.4 a † 1	3.9 a 10	320.5485	(5/2,7/2)$^+$	71.8213	7/2$^+$	[M1]		1.420	α(K)=1.136 16; α(L)=0.215 3; α(M)=0.0515 8; α(N+..)=0.01770 25 α(N)=0.01375 20; α(O)=0.00326 5; α(P)=0.000632 9; α(Q)=5.99×10^{-5} 9 E_γ: Weighted average of 248.4 1 (2002Gu15) and 248.74 6 (2006Ru07). Additional information 21.
248.8 a 1	9.5 a 9	569.256	(3/2,5/2,7/2)$^+$	320.5485	(5/2,7/2)$^+$	M1+E2	0.87 7	0.94 5	α(K)=0.69 5; α(L)=0.185 4; α(M)=0.0464 8; α(N+..)=0.0159 3 α(N)=0.01241 22; α(O)=0.00288 6; α(P)=0.000535 12; α(Q)=3.70×10^{-5} 22
252.07 4	29.5 9	569.256	(3/2,5/2,7/2)$^+$	317.1723	(5/2)$^+$	M1+E2	0.84 6	0.92 4	α(K)=0.68 4; α(L)=0.179 4; α(M)=0.0447 8; α(N+..)=0.0153 3 α(N)=0.01194 20; α(O)=0.00278 5; α(P)=0.000517 11; α(Q)=3.66×10^{-5} 19
x255.52 4	0.27 1								
259.32 4	9.4 & 4	288.597	3/2$^+$	29.1915	5/2$^+$	[M1,E2]		0.8 5	α(K)=0.6 5; α(L)=0.16 4; α(M)=0.040 6; α(N+..)=0.0136 22 α(N)=0.0106 16; α(O)=0.0025 5; α(P)=0.00045 11; α(Q)=3.0×10^{-5} 24

$^{229}_{90}Th_{139}$-10

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ [‡]	I_γ [‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α [c]	Comments
									E_γ: Weighted average of 259.33 *4* (2002Gu15) and 259.30 *4* (2006Ru07). E_γ: level-energy difference=259.49.
259.37[a] *11*	1.6[a] *3*	424.01		164.5312	$(3/2)^-$	[D,E2]			E_γ: Weighted average of 259.0 *1* (2002Gu15) and 259.40 *3* (2006Ru07). Additional information 23.
261.80[#†] *9*	0.58[#] *8*	478.577	$(5/2,7/2)^-$	217.1585	$(5/2)^-$	[M1]		1.227	α(K)=0.982 *14*; α(L)=0.185 *3*; α(M)=0.0445 *7*; α(N+..)=0.01528 *22* α(N)=0.01187 *17*; α(O)=0.00281 *4*; α(P)=0.000545 *8*; α(Q)=5.17×10^{-5} *8*
261.958[@] *4*	38 *1*	261.966	$1/2^+$	0.0076	$3/2^+$	M1+E2	0.93 *7*	0.78 *4*	α(K)=0.57 *4*; α(L)=0.155 *4*; α(M)=0.0389 *8*; α(N+..)=0.01327 *25* α(N)=0.01038 *19*; α(O)=0.00241 *5*; α(P)=0.000447 *11*; α(Q)=3.06×10^{-5} *18*
268.6747[@] *21*	1.04 *3*	365.8161	$(7/2^+)$	97.1400	$9/2^+$	M1+E2	0.75 *7*	0.82 *5*	α(K)=0.62 *4*; α(L)=0.149 *4*; α(M)=0.0370 *8*; α(N+..)=0.0127 *3* α(N)=0.00989 *20*; α(O)=0.00231 *5*; α(P)=0.000434 *11*; α(Q)=3.29×10^{-5} *19*
274.7347[@] *13*	1.22 *4*	317.1723	$(5/2)^+$	42.4393	$7/2^+$	M1+E2	1.07 *10*	0.62 *5*	α(K)=0.45 *4*; α(L)=0.129 *4*; α(M)=0.0324 *8*; α(N+..)=0.0111 *3* α(N)=0.00866 *20*; α(O)=0.00201 *5*; α(P)=0.000370 *11*; α(Q)=2.41×10^{-5} *20* E_γ: 274.7247 given in 2002Gu15 is a misprint.
277.21[#] *6*	0.31[#] *4*	425.33	$^+$	148.1656	$(7/2^-)$	[E2]		0.216	α(K)=0.0852 *12*; α(L)=0.0959 *14*; α(M)=0.0258 *4*; α(N+..)=0.00875 *13* α(N)=0.00692 *10*; α(O)=0.001560 *22*; α(P)=0.000267 *4*; α(Q)=5.47×10^{-6} *8* E_γ: 277.33 *5* (2002Gu15).
278.1080[@] *9*	2.55 *8*	320.5485	$(5/2,7/2)^+$	42.4393	$7/2^+$	M1+E2	1.14 *10*	0.57 *4*	α(K)=0.41 *4*; α(L)=0.122 *4*; α(M)=0.0308 *7*; α(N+..)=0.01050 *25* α(N)=0.00822 *19*; α(O)=0.00190 *5*; α(P)=0.000350 *11*; α(Q)=2.21×10^{-5} *18*
278.7[#] *1*	0.49[#] *7*	425.33	$^+$	146.3498	$5/2^-$	[M1]		1.032	α(K)=0.826 *12*; α(L)=0.1557 *22*; α(M)=0.0374 *6*; α(N+..)=0.01283 *18* α(N)=0.00997 *14*; α(O)=0.00236 *4*; α(P)=0.000458 *7*; α(Q)=4.35×10^{-5} *7*
280.72 *4*	0.95 *3*	569.256	$(3/2,5/2,7/2)^+$	288.597	$3/2^+$	[M1,E2]		0.6 *4*	α(K)=0.4 *4*; α(L)=0.12 *3*; α(M)=0.031 *6*; α(N+..)=0.0105 *22* α(N)=0.0082 *16*; α(O)=0.0019 *5*; α(P)=0.00035 *10*; α(Q)=2.4×10^{-5} *19* Additional information 30.

$^{229}_{90}Th_{139}$-11

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ [‡]	I_γ [‡ b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α [c]	Comments
284.67 *4*	5.2 *2*	605.238	(3/2,5/2,7/2,7/2)$^+$	320.5485	(5/2,7/2)$^+$	M1+E2	1.00 *8*	0.59 *4*	α(K)=0.43 *3*; α(L)=0.117 *3*; α(M)=0.0292 *7*; α(N+..)=0.00999 *23* α(N)=0.00781 *18*; α(O)=0.00182 *5*; α(P)=0.000337 *10*; α(Q)=2.31×10^{-5} *16*
287.1 *1*	1.7[&] *3*	605.238	(3/2,5/2,7/2,7/2)$^+$	317.1723	(5/2)$^+$	[M1,E2]		0.6 *4*	α(K)=0.4 *4*; α(L)=0.11 *3*; α(M)=0.028 *6*; α(N+..)=0.0097 *21* α(N)=0.0076 *16*; α(O)=0.0018 *4*; α(P)=0.00033 *10*; α(Q)=2.3×10^{-5} *18* Additional information 32.
288.08 *4*	≈4[&]	317.1723	(5/2)$^+$	29.1915	5/2$^+$	[M1,E2]		0.6 *4*	α(K)=0.4 *4*; α(L)=0.11 *3*; α(M)=0.028 *6*; α(N+..)=0.0096 *21* α(N)=0.0075 *16*; α(O)=0.0017 *4*; α(P)=0.00032 *10*; α(Q)=2.2×10^{-5} *18* E_γ: Weighted average of 288.3 *1* (2002Gu15) and 288.04 *4* (2006Ru07). Additional information 20.
288.5[a] *1*	≈4[a]	288.597	3/2$^+$	0	5/2$^+$	[M1,E2]		0.6 *4*	α(K)=0.4 *4*; α(L)=0.11 *3*; α(M)=0.028 *6*; α(N+..)=0.0096 *21* α(N)=0.0075 *16*; α(O)=0.0017 *4*; α(P)=0.00032 *10*; α(Q)=2.2×10^{-5} *18*
291.3561[@] *9*	11.0 *3*	320.5485	(5/2,7/2)$^+$	29.1915	5/2$^+$	M1+E2	0.80 *6*	0.63 *3*	α(K)=0.476 *25*; α(L)=0.115 *3*; α(M)=0.0284 *6*; α(N+..)=0.00972 *21* α(N)=0.00759 *16*; α(O)=0.00177 *4*; α(P)=0.000333 *9*; α(Q)=2.53×10^{-5} *13*
293.995[@] *9*	0.53 *2*	365.8161	(7/2$^+$)	71.8213	7/2$^+$	M1		0.890	α(K)=0.713 *10*; α(L)=0.1342 *19*; α(M)=0.0322 *5*; α(N+..)=0.01106 *16* α(N)=0.00860 *12*; α(O)=0.00204 *3*; α(P)=0.000395 *6*; α(Q)=3.75×10^{-5} *6*
[x]302.45 *7*	0.26 *1*								
303.55 *7*	0.25 *1*	303.06		0	5/2$^+$	[D,E2]			Additional information 18.
307.29 *4*	2.20 *7*	569.256	(3/2,5/2,7/2,7/2)$^+$	261.966	1/2$^+$	[M1,E2]		0.5 *4*	α(K)=0.4 *3*; α(L)=0.09 *3*; α(M)=0.023 *6*; α(N+..)=0.0078 *20* α(N)=0.0061 *15*; α(O)=0.0014 *4*; α(P)=0.00026 *9*; α(Q)=1.9×10^{-5} *15*
309.54 *4*	0.52 *2*	526.78	$^-$	217.1585	(5/2)$^-$	[M1,E2]		0.5 *3*	α(K)=0.3 *3*; α(L)=0.09 *3*; α(M)=0.022 *6*; α(N+..)=0.0076 *20* α(N)=0.0060 *15*; α(O)=0.0014 *4*; α(P)=0.00026 *9*; α(Q)=1.8×10^{-5} *15*
[x]314.10 *4*	0.27 *1*								
314.12[#] *5*	0.78[#] *10*	478.577	(5/2,7/2)$^-$	164.5312	(3/2)$^-$	[M1]		0.742	α(K)=0.594 *9*; α(L)=0.1117 *16*; α(M)=0.0268 *4*; α(N+..)=0.00921 *13*

$^{229}_{90}Th_{139}$-12

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α[c]	Comments
									α(N)=0.00715 *10*; α(O)=0.001694 *24*; α(P)=0.000329 *5*; α(Q)=3.12×10^{-5} *5*
317.1689[@] *15*	23.4 *7*	317.1723	(5/2)$^+$	0.0076	3/2$^+$	M1+E2	1.24 *9*	0.371 *22*	α(K)=0.268 *20*; α(L)=0.0774 *22*; α(M)=0.0195 *5*; α(N+..)=0.00666 *17* α(N)=0.00522 *13*; α(O)=0.00121 *4*; α(P)=0.000223 *7*; α(Q)=1.44×10^{-5} *10*
320.5471[@†] *13*	5.9 *2*	320.5485	(5/2,7/2)$^+$	0.0076	3/2$^+$	M1+E2	1.37 *12*	0.334 *25*	α(K)=0.237 *22*; α(L)=0.0724 *24*; α(M)=0.0184 *6*; α(N+..)=0.00626 *19* α(N)=0.00491 *14*; α(O)=0.00114 *4*; α(P)=0.000208 *8*; α(Q)=1.28×10^{-5} *11* Additional information 22.
323.3806[@] *14*	3.3 *1*	365.8161	(7/2$^+$)	42.4393	7/2$^+$	M1+E2	1.67 *12*	0.280 *17*	α(K)=0.191 *15*; α(L)=0.0662 *18*; α(M)=0.0169 *4*; α(N+..)=0.00577 *14* α(N)=0.00453 *11*; α(O)=0.00104 *3*; α(P)=0.000189 *6*; α(Q)=1.04×10^{-5} *8*
330.51 *4*	0.49 *2*	478.577	(5/2,7/2)$^-$	148.1656	(7/2$^-$)	[M1,E2]		0.4 *3*	α(K)=0.29 *23*; α(L)=0.073 *25*; α(M)=0.018 *6*; α(N+..)=0.0062 *18* α(N)=0.0049 *14*; α(O)=0.0011 *4*; α(P)=0.00021 *8*; α(Q)=1.5×10^{-5} *12* E_γ: Weighted average of 330.47 *4* (2002Gu15) and 330.54 *4* (2006Ru07).
332.52 *4*	0.09 *1*	478.577	(5/2,7/2)$^-$	146.3498	5/2$^-$	[M1,E2]		0.4 *3*	α(K)=0.28 *23*; α(L)=0.072 *24*; α(M)=0.018 *6*; α(N+..)=0.0061 *18* α(N)=0.0048 *14*; α(O)=0.0011 *4*; α(P)=0.00021 *8*; α(Q)=1.5×10^{-5} *12* Additional information 27.
336.6195[@†] *16*	2.35 *7*	365.8161	(7/2$^+$)	29.1915	5/2$^+$	M1+E2	1.59 *24*	0.26 *4*	α(K)=0.18 *3*; α(L)=0.059 *4*; α(M)=0.0150 *8*; α(N+..)=0.0051 *3* α(N)=0.00401 *20*; α(O)=0.00092 *5*; α(P)=0.000169 *11*; α(Q)=9.8×10^{-6} *16*
343.3[#] *1*	0.18[#] *4*	605.238	(3/2,5/2,7/2)$^+$	261.966	1/2$^+$				
352.07 *4*	1.82 *6*	569.256	(3/2,5/2,7/2)$^+$	217.1585	(5/2)$^-$	[E1]		0.0262	α(K)=0.0211 *3*; α(L)=0.00387 *6*; α(M)=0.000926 *13*; α(N+..)=0.000314 *5* α(N)=0.000245 *4*; α(O)=5.71×10^{-5} *8*; α(P)=1.072×10^{-5} *15*; α(Q)=8.50×10^{-7} *12*
365.77 *4*	3.2 *1*	365.8161	(7/2$^+$)	0	5/2$^+$	[M1]		0.489	α(K)=0.392 *6*; α(L)=0.0735 *11*; α(M)=0.01763 *25*; α(N+..)=0.00605 *9* α(N)=0.00470 *7*; α(O)=0.001113 *16*; α(P)=0.000216 *3*; α(Q)=2.05×10^{-5} *3* E_γ: Weighted average of 365.79 *4* (2002Gu15) and 365.75 *4* (2006Ru07).
367.83 *4*	0.91 *3*	605.238	(3/2,5/2,7/2)$^+$	237.3711	(7/2$^-$)	[E1]		0.0238	α(K)=0.0192 *3*; α(L)=0.00351 *5*; α(M)=0.000838

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α[c]	Comments
									12; α(N+..)=0.000284 *4* α(N)=0.000222 *4*; α(O)=5.18×10^{-5} *8*; α(P)=9.73×10^{-6} *14*; α(Q)=7.78×10^{-7} *11*
370.44 *5*	0.65 *3*	534.97	1/2$^-$	164.5312	(3/2)$^-$	[M1,E2]		0.28 *19*	α(K)=0.21 *17*; α(L)=0.052 *20*; α(M)=0.013 *5*; α(N+..)=0.0044 *15* α(N)=0.0034 *12*; α(O)=0.0008 *3*; α(P)=0.00015 *6*; α(Q)=1.1×10^{-5} *9* This γ also shown as unplaced in 2002Gu15.
[x]381.07 *4*	0.32 *1*								
[x]384.25 *4*	0.28 *1*								
388.05 *4*	1.32 *4*	605.238	(3/2,5/2,7/2,7/2)$^+$	217.1585	(5/2)$^-$	[E1]		0.0213	α(K)=0.01715 *24*; α(L)=0.00311 *5*; α(M)=0.000744 *11*; α(N+..)=0.000252 *4* α(N)=0.000197 *3*; α(O)=4.60×10^{-5} *7*; α(P)=8.65×10^{-6} *13*; α(Q)=6.98×10^{-7} *10*
404.72 *4*	7.8 *2*	569.256	(3/2,5/2,7/2,7/2)$^+$	164.5312	(3/2)$^-$	[E1]		0.0195	α(K)=0.01571 *22*; α(L)=0.00284 *4*; α(M)=0.000677 *10*; α(N+..)=0.000230 *4* α(N)=0.000179 *3*; α(O)=4.19×10^{-5} *6*; α(P)=7.89×10^{-6} *11*; α(Q)=6.42×10^{-7} *9*
406.45 *4*	4.0 *1*	449.38	$^+$	42.4393	7/2$^+$	M1+E2	1.04 *14*	0.213 *22*	α(K)=0.162 *19*; α(L)=0.0385 *24*; α(M)=0.0095 *6*; α(N+..)=0.00326 *19* α(N)=0.00254 *14*; α(O)=0.00059 *4*; α(P)=0.000112 *8*; α(Q)=8.6×10^{-6} *10* Additional information 24.
406.53[#] *8*	3.5[#] *6*	478.577	(5/2,7/2)$^-$	71.8213	7/2$^+$	[E1]		0.0193	α(K)=0.01557 *22*; α(L)=0.00281 *4*; α(M)=0.000671 *10*; α(N+..)=0.000228 *4* α(N)=0.0001777 *25*; α(O)=4.15×10^{-5} *6*; α(P)=7.82×10^{-6} *11*; α(Q)=6.36×10^{-7} *9*
420.70 *5*	0.24 *1*	449.38	$^+$	29.1915	5/2$^+$				Additional information 25.
[x]422.37 *5*	1.72 *7*								
422.94 *4*	6.0 *2*	569.256	(3/2,5/2,7/2,7/2)$^+$	146.3498	5/2$^-$	[E1]		0.01775	α(K)=0.01435 *20*; α(L)=0.00258 *4*; α(M)=0.000615 *9*; α(N+..)=0.000209 *3* α(N)=0.0001629 *23*; α(O)=3.81×10^{-5} *6*; α(P)=7.18×10^{-6} *10*; α(Q)=5.89×10^{-7} *9*
425.36 *5*	0.27 *1*	425.33	$^+$	0	5/2$^+$	M1		0.325	α(K)=0.260 *4*; α(L)=0.0486 *7*; α(M)=0.01167 *17*; α(N+..)=0.00400 *6* α(N)=0.00311 *5*; α(O)=0.000736 *11*; α(P)=0.0001429 *20*; α(Q)=1.356×10^{-5} *19*
436.20 *4*	5.6 *2*	478.577	(5/2,7/2)$^-$	42.4393	7/2$^+$	E1		0.01665	α(K)=0.01347 *19*; α(L)=0.00241 *4*; α(M)=0.000575 *8*; α(N+..)=0.000195 *3* α(N)=0.0001523 *22*; α(O)=3.56×10^{-5} *5*; α(P)=6.72×10^{-6} *10*; α(Q)=5.54×10^{-7} *8*
440.71 *4*	1.51 *5*	605.238	(3/2,5/2,7/2,7/2)$^+$	164.5312	(3/2)$^-$	[E1]		0.01630	α(K)=0.01319 *19*; α(L)=0.00236 *4*; α(M)=0.000562 *8*;

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α[c]	Comments
									α(N+..)=0.000191 *3* α(N)=0.0001489 *21*; α(O)=3.48×10^{-5} *5*; α(P)=6.58×10^{-6} *10*; α(Q)=5.43×10^{-7} *8*
444.40 *4*	0.97 *3*	661.780		217.1585	(5/2)$^-$	[D,E2]			Additional information 33.
449.17[#] *9*	3.7[#] *6*	478.577	(5/2,7/2)$^-$	29.1915	5/2$^+$	[E1]		0.01568	α(K)=0.01269 *18*; α(L)=0.00226 *4*; α(M)=0.000539 *8*; α(N+..)=0.000183 *3* α(N)=0.0001429 *20*; α(O)=3.34×10^{-5} *5*; α(P)=6.32×10^{-6} *9*; α(Q)=5.23×10^{-7} *8* E_γ: 449.45 *5* (2002Gu15). E_γ: Eγ for the doublet is 449.44 *4*.
449.4 *2*	≈14[&]	449.38	$^+$	0	5/2$^+$	M1+E2	1.30 *16*	0.139 *15*	α(K)=0.104 *13*; α(L)=0.0259 *17*; α(M)=0.0064 *4*; α(N+..)=0.00220 *13* α(N)=0.00172 *10*; α(O)=0.000401 *24*; α(P)=7.5×10^{-5} *5*; α(Q)=5.5×10^{-6} *7*
457.07 *4*	2.9 *1*	605.238	(3/2,5/2,7/2)$^+$	148.1656	(7/2$^-$)	[E1]		0.01513	α(K)=0.01225 *18*; α(L)=0.00218 *3*; α(M)=0.000520 *8*; α(N+..)=0.0001765 *25* α(N)=0.0001377 *20*; α(O)=3.22×10^{-5} *5*; α(P)=6.09×10^{-6} *9*; α(Q)=5.06×10^{-7} *7*
458.87 *5*	0.16 *1*	605.238	(3/2,5/2,7/2)$^+$	146.3498	5/2$^-$	[E1]		0.01501	α(K)=0.01216 *17*; α(L)=0.00216 *3*; α(M)=0.000515 *8*; α(N+..)=0.0001750 *25* α(N)=0.0001365 *20*; α(O)=3.19×10^{-5} *5*; α(P)=6.04×10^{-6} *9*; α(Q)=5.02×10^{-7} *7*
[x]471.33 *4*	1.08 *3*								
474.10 *4*	0.41 *1*	638.48		164.5312	(3/2)$^-$	[D,E2]			
478.64 *4*	17.5 *5*	478.577	(5/2,7/2)$^-$	0	5/2$^+$	E1		0.01378	α(K)=0.01117 *16*; α(L)=0.00198 *3*; α(M)=0.000471 *7*; α(N+..)=0.0001599 *23* α(N)=0.0001247 *18*; α(O)=2.92×10^{-5} *4*; α(P)=5.53×10^{-6} *8*; α(Q)=4.63×10^{-7} *7*
[x]484.17 *4*	0.25 *1*								
489.21 *4*	0.18 *1*	653.79		164.5312	(3/2)$^-$	[D,E2]			
492.22 *4*	0.28 *1*	638.48		146.3498	5/2$^-$	[D,E2]			
497.35 *4*	0.67 *2*	661.780		164.5312	(3/2)$^-$	[D,E2]			
[x]508.23 *7*	0.74 *2*								
515.25 *7*	1.15 *3*	661.780		146.3498	5/2$^-$	[D,E2]			
[x]523.82 *7*	0.27 *1*								
526.4[#] *4*	2.1[#] *8*	569.256	(3/2,5/2,7/2)$^+$	42.4393	7/2$^+$				
526.89 *7*	6.7 *2*	526.78	$^-$	0	5/2$^+$	E1		0.01137	α(K)=0.00924 *13*; α(L)=0.001617 *23*; α(M)=0.000385 *6*; α(N+..)=0.0001307 *19* α(N)=0.0001019 *15*; α(O)=2.39×10^{-5} *4*; α(P)=4.53×10^{-6} *7*; α(Q)=3.85×10^{-7} *6*
533.47 *7*	4.0 *1*	605.238	(3/2,5/2,7/2)$^+$	71.8213	7/2$^+$	M1+E2	1.13 *20*	0.098 *14*	α(K)=0.076 *12*; α(L)=0.0169 *17*; α(M)=0.0042 *4*; α(N+..)=0.00142 *13*

$^{229}_{90}Th_{139}$-15

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

E_γ[‡]	I_γ[‡b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α[c]	Comments
									α(N)=0.00111 *10*; α(O)=0.000260 *25*; α(P)=4.9×10^{-5} *5*; α(Q)=4.0×10^{-6} *6*
540.08 *7*	2.9[&] *9*	569.256	(3/2,5/2,7/2)$^+$	29.1915	5/2$^+$	[M1,E2]		0.10 *7*	α(K)=0.08 *6*; α(L)=0.017 *9*; α(M)=0.0042 *19*; α(N+..)=0.0014 *7*
									α(N)=0.0011 *5*; α(O)=0.00027 *12*; α(P)=5.0×10^{-5} *25*; α(Q)=4.E−6 *3*
x540.15 *7*	17.4[&] *10*								
540.9 *2*	0.56[&] *5*	689.01		148.1656	(7/2$^-$)	[D,E2]			
542.68 *7*	0.43 *1*	689.01		146.3498	5/2$^-$	[D,E2]			
562.84 *7*	7.7 *2*	605.238	(3/2,5/2,7/2)$^+$	42.4393	7/2$^+$	M1+E2	1.36 *16*	0.075 *8*	α(K)=0.057 *6*; α(L)=0.0133 *9*; α(M)=0.00327 *21*; α(N+..)=0.00112 *7*
									α(N)=0.00087 *6*; α(O)=0.000204 *13*; α(P)=3.8×10^{-5} *3*; α(Q)=3.0×10^{-6} *3*
569.30 *7*	86 *2*	569.256	(3/2,5/2,7/2)$^+$	0	5/2$^+$	M1+E2	1.66 *12*	0.063 *4*	α(K)=0.047 *3*; α(L)=0.0116 *5*; α(M)=0.00289 *11*; α(N+..)=0.00099 *4*
									α(N)=0.00077 *3*; α(O)=0.000180 *7*; α(P)=3.36×10^{-5} *14*; α(Q)=2.48×10^{-6} *16*
576.04 *7*	≈2.6[&]	605.238	(3/2,5/2,7/2)$^+$	29.1915	5/2$^+$	M1+E2	1.55 *22*	0.064 *8*	α(K)=0.049 *7*; α(L)=0.0116 *10*; α(M)=0.00288 *22*; α(N+..)=0.00098 *8*
									α(N)=0.00077 *6*; α(O)=0.000179 *14*; α(P)=3.4×10^{-5} *3*; α(Q)=2.5×10^{-6} *4*
576.2 *3*	≈3.5[&]	576.39		0	5/2$^+$				E_γ: Eγ for doublet=576.08 *7*.
x578.49 *7*	1.09 *3*								
x591.72 *7*	0.20 *2*								
605.26 *7*	24.0 *7*	605.238	(3/2,5/2,7/2)$^+$	0	5/2$^+$	M1+E2	1.10 *13*	0.072 *7*	α(K)=0.056 *6*; α(L)=0.0121 *8*; α(M)=0.00295 *19*; α(N+..)=0.00101 *7*
									α(N)=0.00079 *5*; α(O)=0.000185 *12*; α(P)=3.51×10^{-5} *24*; α(Q)=2.9×10^{-6} *3*
614.82 *7*	0.16 *1*	779.29		164.5312	(3/2)$^-$	[D,E2]			
x620.90 *7*	0.48 *2*					M1(+E2+E0)			α(K)exp=1.52 *17*
x632.47 *7*	0.28 *1*								
653.86 *10*	0.02 *1*	653.79		0	5/2$^+$	[D,E2]			
x657.60 *7*	0.22 *1*								
661.59 *7*	0.34 *1*	661.780		0	5/2$^+$	[D,E2]			
x669.27 *10*	0.13 *1*								
688.96 *8*	0.16 *1*	689.01		0	5/2$^+$	[D,E2]			
x700.61 *10*	0.11 *1*								
x707.52 *15*	0.21 *1*								
779.00 *15*	0.05 *1*	779.29		0.0076	3/2$^+$	[D,E2]			
x782.23 *15*	0.12 *1*								
x898.05 *8*	0.22 *1*								

$^{229}_{90}Th_{139}$-16

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)

$\gamma(^{229}Th)$ (continued)

† Additional information 34.
‡ From 2002Gu15, unless othewise specified.
# From 2006Ru07.
@ From ^{233}U α decay (1994He08).
& from $\gamma\gamma$ coin data (2002Gu15).
a from $\gamma\gamma$ coin data (2002Gu15).
b For absolute intensity per 100 decays, multiply by 0.0270 *17*.
c Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
d Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

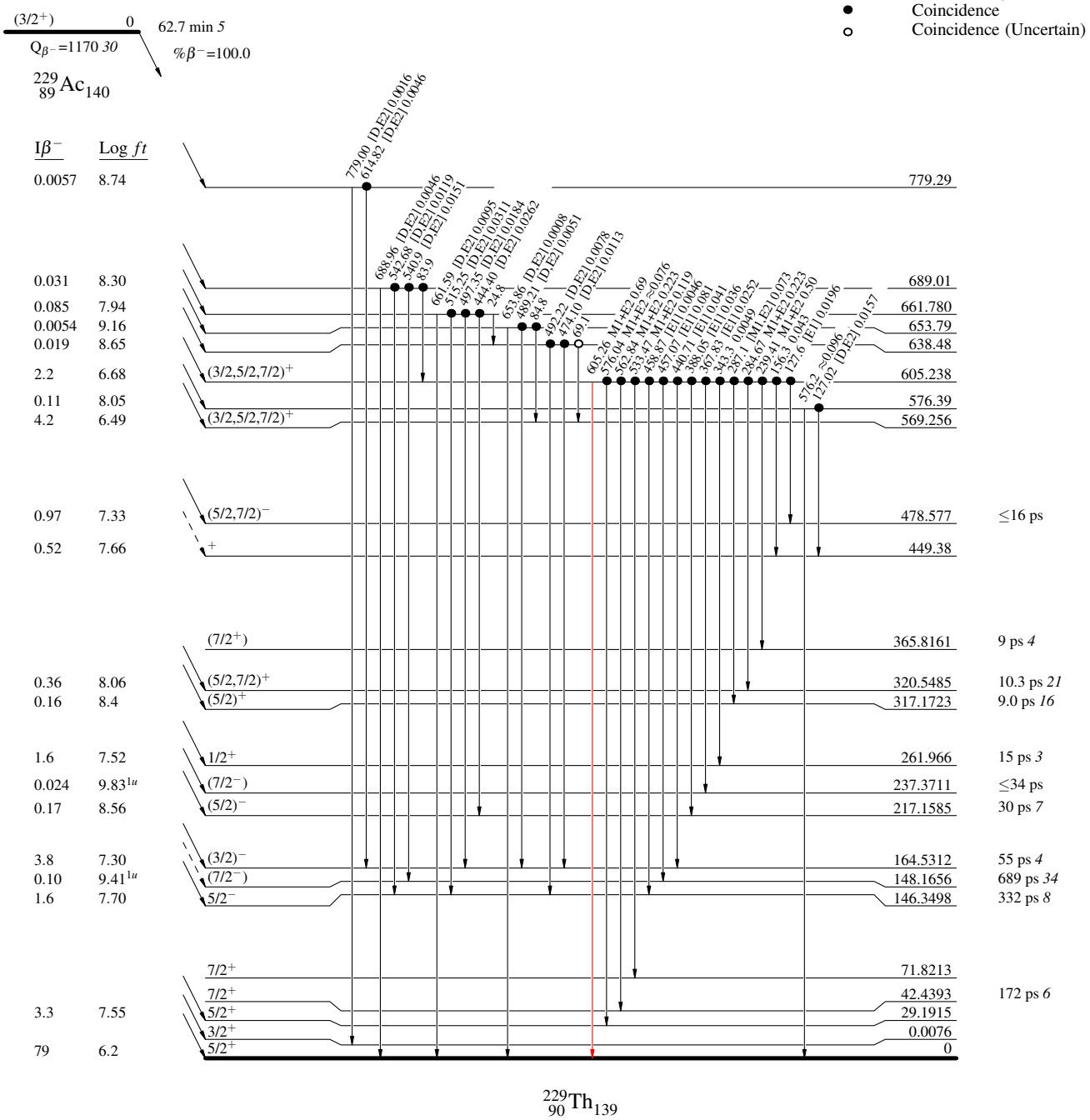
$^{229}_{90}Th_{139}$-17

^{229}Ac β^- decay 2002Gu15,2006Ru07

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- Coincidence
- Coincidence (Uncertain)

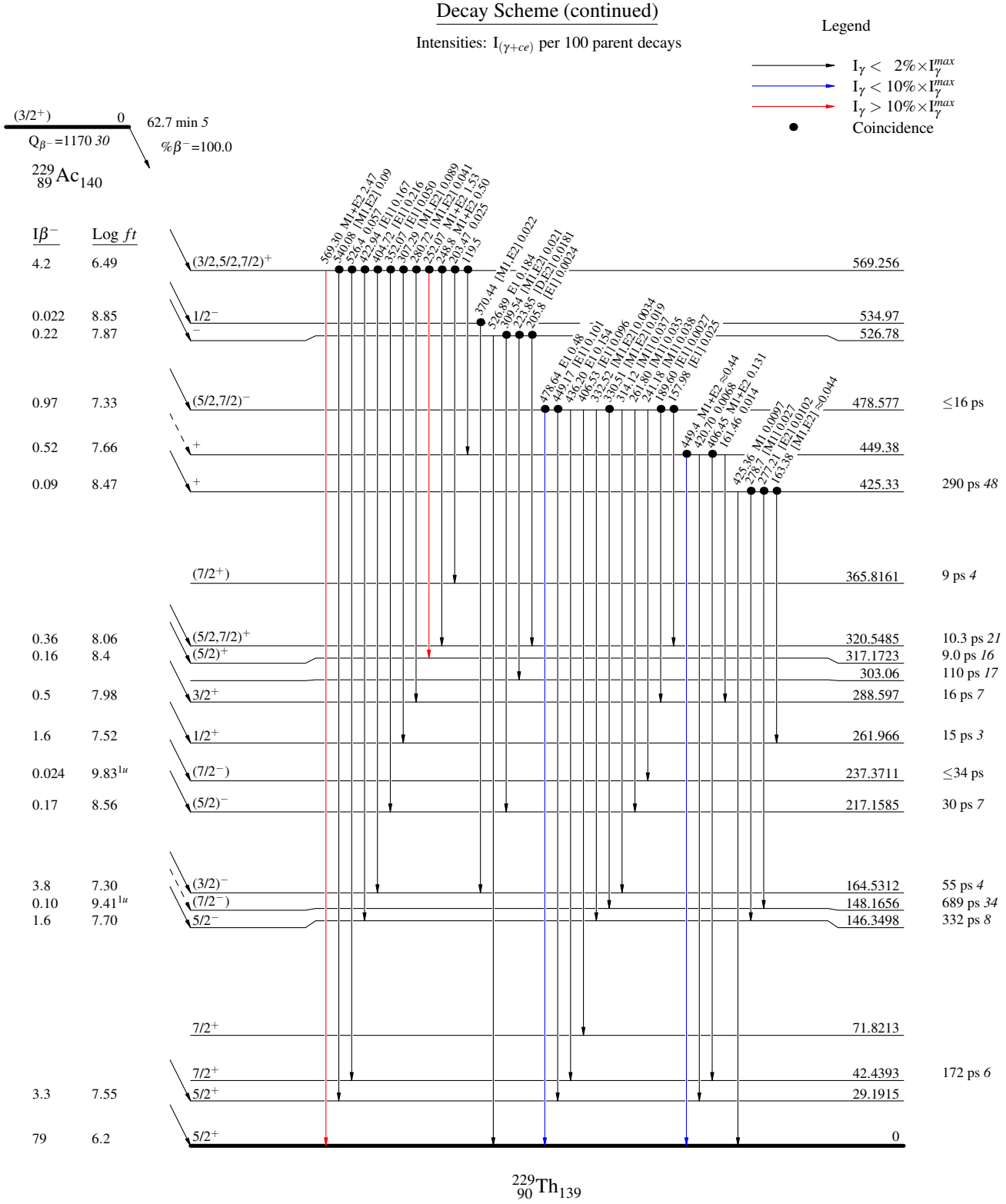


$^{229}_{90}Th_{139}$

^{229}Ac β^- decay 2002Gu15,2006Ru07

Decay Scheme (continued)

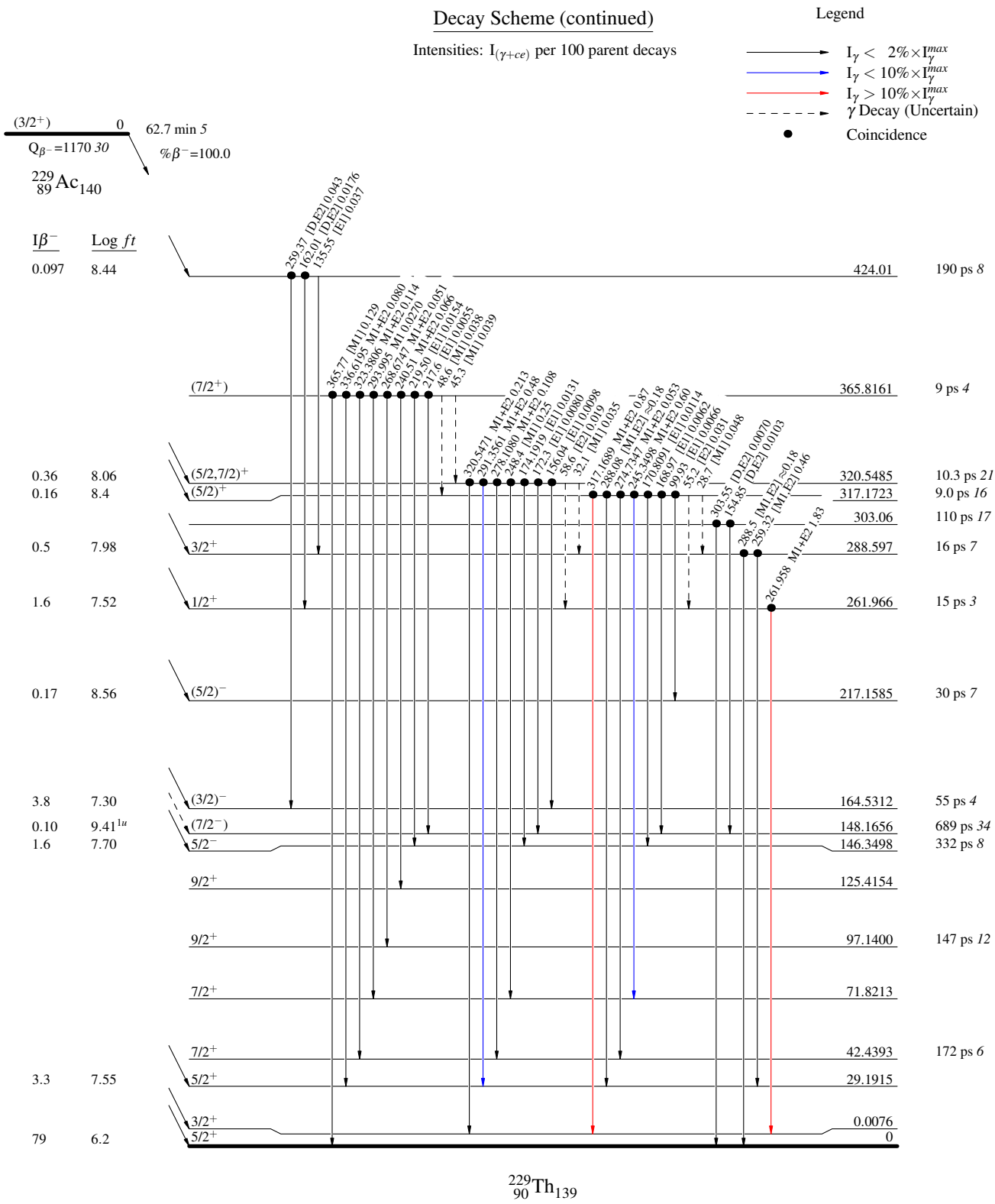
Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



^{229}Ac β^- decay 2002Gu15,2006Ru07

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays



^{229}Ac β^- decay 2002Gu15,2006Ru07

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)
- Coincidence

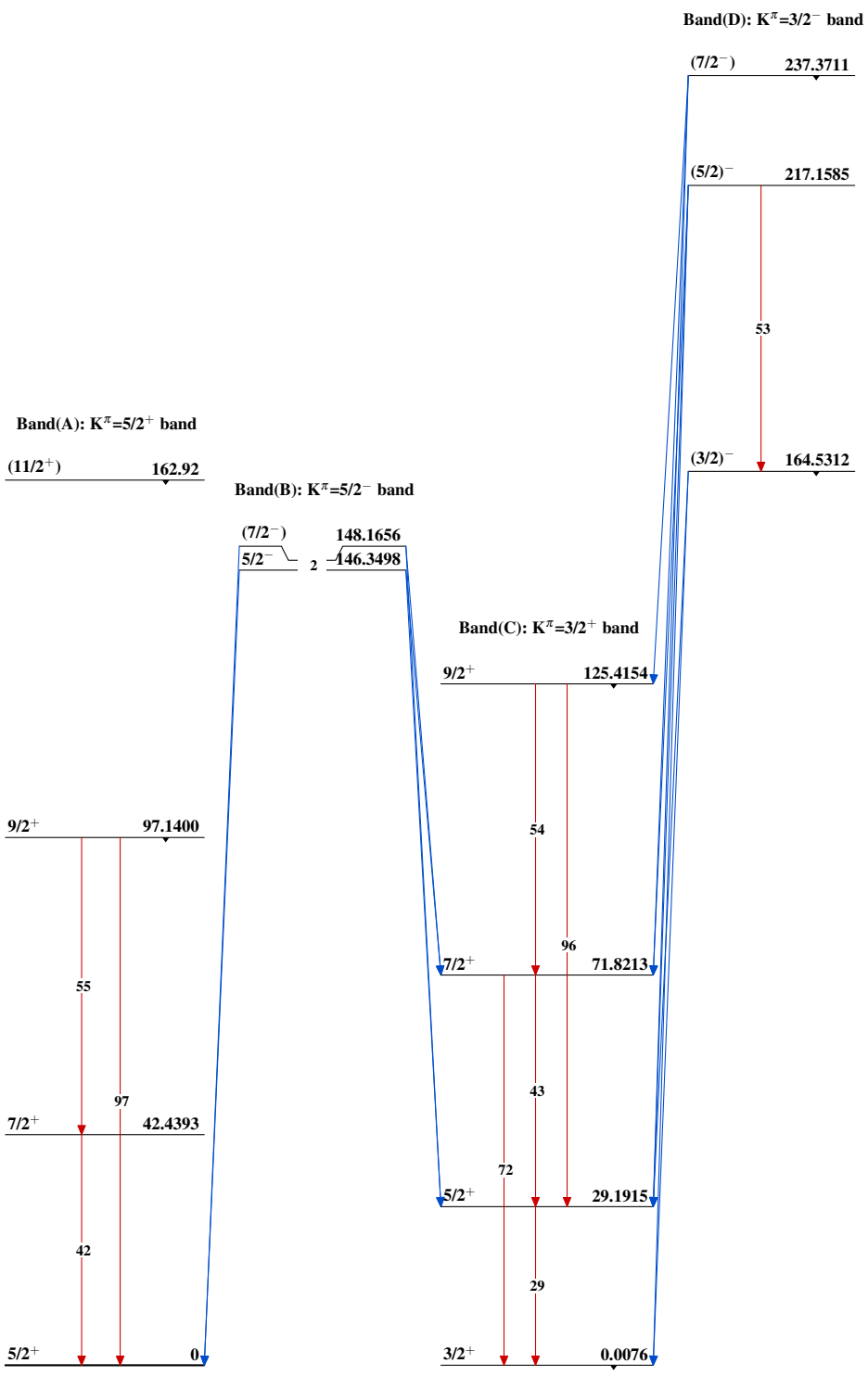
$(3/2^+)$ 0 62.7 min 5
Q_{β^-}=1170 30 $\%\beta^-$=100.0
$^{229}_{89}Ac_{140}$

Iβ⁻	Log *ft*			
0.024	9.83 lu	$(7/2^-)$	237.3711	≤34 ps
0.016	9.56		236.35	
0.17	8.56	$(5/2)^-$	217.1585	30 ps *7*
3.8	7.30	$(3/2)^-$	164.5312	55 ps *4*
		$(11/2^+)$	162.92	
0.10	9.41 lu	$(7/2^-)$	148.1656	689 ps *34*
1.6	7.70	$5/2^-$	146.3498	332 ps *8*
		$9/2^+$	125.4154	
		$9/2^+$	97.1400	147 ps *12*
		$7/2^+$	71.8213	
		$7/2^+$	42.4393	172 ps *6*
3.3	7.55	$5/2^+$	29.1915	
		$3/2^+$	0.0076	
79	6.2	$5/2^+$	0	

237.4 [E1] ≤0.018; 208.1795 [E1] 0.0179; 165.0 [E1] 0.0084; 111.80 [E1] 0.0137; 91.0 [M1] 0.021; 89.2 [M1] 0.008; 90.0 [D,E2] 0.0019
217.1519 [E1] 0.108; 187.9669 [E1] 0.069; 145.41 [E1] 0.068; 52.66 [M1] 0.097
164.5240 E1 3.10; 35.3393 E1 1.24; 18.17 [M1] 0.0023; 16.36 [E2] 0.000035
91.1 [E2] 0.079
148.16 [E1] 0.0200; 118.9721 E1 0.218; 76.3507 [E1] 0.0228; 1.81 [M1] 0.0000103
146.3462 E1 1.10; 117.1628 E1 0.57; 74.5390 [E1] 0.244
125.41 E2 0.000049; 96.224 E2 0.0014; 82.957 M1+E2 0.00016; 53.63 [M1] 0.079
97.134 E2 0.059; 67.943 E2 0.0046; 54.699 M1+E2 0.052; 25.14 [M1] 3.8
71.8159 [E2] 0.59; 42.66 M1 ≤0.63
42.43 M1 ≤0.57; 29.1846 M1 7.5
0.0076

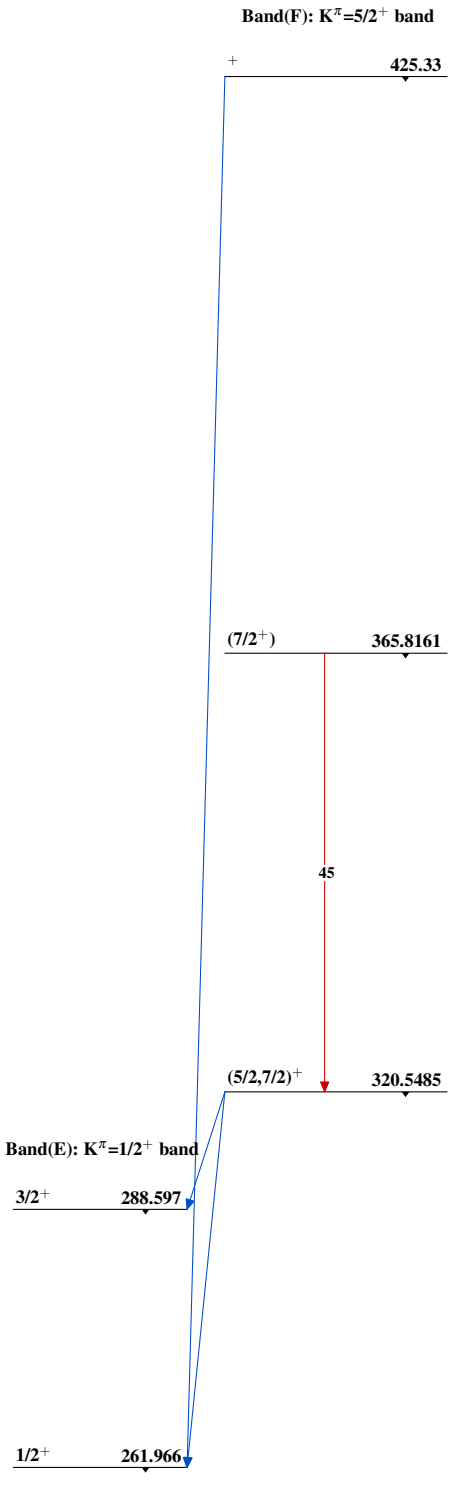
$^{229}_{90}Th_{139}$

^{229}Ac β^- decay 2002Gu15,2006Ru07



$^{229}_{90}Th_{139}$

^{229}Ac β^- decay 2002Gu15,2006Ru07 (continued)



$^{229}_{90}Th_{139}$