^{228}Ac β^- decay 1987Da28

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Khalifeh Abusaleem	NDS 116, 163 (2014)	31-Dec-2012

Parent: ^{228}Ac: E=0; J$^\pi$=3$^+$; $T_{1/2}$=6.15 h *2*; Q(β^-)=2134 *3*; %β^- decay=100.0

^{228}Ac-Q(β^-) from 2012Wa38.

1987Da28: Radiochemically separated ^{228}Ac source. 17% Ge, 10% Ge(Li), and LEPS detectors to measure Eγ, γ-γ, and Iγ.

1984Da05: ^{228}Ac source was prepared using radiochemical separation from ^{228}Ra sources primarily isolated from Th(No3)4. Measured E_γ and I_γ for 242 γ-rays using two HPGe and a planar HPGe detectors. However, neither levels in ^{228}Th nor scheme are presented in this work. These are presented in 1987Da28 (same working group).

2006Xu10: Observed β^-delayed fission of ^{228}Ac. ^{228}Ac source was chemically prepared from Thorium solution, then exposed to mica foils (α-detector) and HPGe (γ-detector) for 720 days. 17 α-events were observed. These were interpreted from ^{228}Ac fission based on analysis of β^- decay energy and fissility systematics. Also, several γ-rays were observed and interpreted from the β^- decay of ^{228}Ac. These γ-rays are presented in figure 2 of 2006Xu10. However, no γ- uncertainty, intensity, or level energies are given. Probability of β^-delayed fission ($N_{\beta DF}/N_\beta$) was found to be 5$\times$10^{-12} *2*.

^{228}Th Levels

2009So02: discussion of log *ft*.
1992Li05: measured absolute Iγ.
1987Da28: measured Eγ, Iγ, $\gamma\gamma$. Earlier report: 1984Da05.
1983Sc13, 1982Sa36: measured absolute Iγ.
1982Ma52, 1960Ar06, 1957Bj56: measured ce.
1979Bo30: measured Eγ; not included in Eγ calculation because five out of twelve Eγ disagree with measurements of 1987Da28 and 1979He10 (deviation>3 x σ).
1979He10: measured Eγ.
1974De14: measured Eγ, Iγ, $\beta\gamma(\theta)$, $\beta\gamma$(circ pol)(θ).
1974Da17: measured Eγ, Iγ, $\gamma\gamma$. Deduced levels and J^π.
1971He23: measured E-conversion electron, I-conversion electron. Deduced J^π and Icc and polarity.
The decay scheme is that proposed by 1987Da28.
CC calculated using BrIcc v2.3S published in 2008Ki07.

E(level)[†]	J$^\pi$[‡]	Comments
0.0[#]	0$^+$	
57.763[#] *4*	2$^+$	
186.827[#] *4*	4$^+$	
328.006[@] *4*	1$^-$	
378.178[#] *11*	6$^+$	
396.083[@] *5*	3$^-$	
519.195[@] *6*	5$^-$	
831.822[&] *10*	0$^+$	
874.48[&] *3*	2$^+$	J$^\pi$: γs to 0$^+$ and 4$^+$ in g.s. band (1987Da28).
938.61[a] *5*	0$^+$	J$^\pi$: 2$^+$ in 1987Da28 while no ruling out of 0$^+$.
944.200 *13*	1$^-$	
968.335[a] *25*	2$^-$	J$^\pi$: γs to 1$^-$ (1987Da28).
968.45	4$^+$	E(level): Level from ε decay.
968.972[b] *5*	2$^+$	
979.507 *14*	2$^+$	J$^\pi$: 0 or 2 from γs to 0$^+$ and 2$^+$ levels in g.s. and 1$^-$ and 3$^-$ levels of the octupole band (1987Da28).
1016.386 *23*	3$^-$	J$^\pi$: (2$^+$) in 1987 Da28 from γ to 0$^+$ g.s.
1022.531[b] *6*	(3)$^+$	

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^{228}Ac β^- decay 1987Da28 (continued)

^{228}Th Levels (continued)

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
1059.94 *7*	4$^-$		
1091.020[b] *9*	4$^+$		
1122.949[c] *6*	2$^-$		J$^\pi$: ≈Member of a rotational band (1987Da28).
1153.465 *10*	2$^+$	0.29 ns *2*	$T_{1/2}$: from 1974De14.
1168.377[c] *5*	3$^-$		
1174.50[b] *7*	(5$^+$)		
1175.45 *5*	2$^+$		J$^\pi$: γs to 0$^+$, 2$^+$, and 4$^+$ in g.s. and to 2$^+$ level (1987Da28).
1200.5 *10*			E(level): Placement suggested by ^{228}Pa decay.
1226.566[c] *8*	4$^-$		
1297.440[c] *11*	(5)$^-$		
1344.082 *11*	3$^-$		J$^\pi$: γs to 1$^-$ and 5$^-$ (1987Da28).
1416.09 *7*	(3$^-$)		
1431.981 *6*	4$^+$		J$^\pi$: E2 and M1 γs K$^\pi$=2$^+$ band (1987Da28). γ-ray to 1$^-$ level supports 3$^+$ rather than 4$^+$ (1987Da28).
1450.35 *3*	4$^-$		
1531.478 *6*	3$^+$		
1539.24 *9*	2$^+$		
1617.78 *7*	4$^+$		
1638.283[d] *10*	2$^+$		Quasiparticle configuration=((π 3/2$^+$[651])(π 1/2$^+$[660])) or configuration=((π 3/2$^+$[651])(π 1/2$^+$[400])) suggested for this level. J$^\pi$: γs to 0$^+$ and 4$^+$ levels of the g.s. (1987Da28).
1643.119 *16*	(3$^-$)		
1646.005 *11*	3$^+$		
1682.754 *19*	(2$^+$,3$^+$,4$^+$)		
1683.71 *7*	(4$^-$)		
1688.398[d] *11*	2$^+$,3$^+$		
1724.288 *6*	2$^+$		
1735.508 *24*	4$^+$		
1743.87 *3*	4$^+$		
1758.24 *12*	2$^+$		
1760.17[d] *3*	2$^{(+)}$,3$^{(+)}$		
1795.65 *8*	4$^+$		
1797.66 *8*	2$^+$		
1893.02 *4*	3$^+$		
1899.97 *6*	(2$^+$)		Quasiparticle configuration=((π 3/2[651])(π 1/2[660])) or configuration=((π 3/2[651])(π 1/2[400])) suggested for this level. J$^\pi$: γs to 0$^+$ and 4$^+$ levels of g.s. (1987Da28).
1906.63 *10*	(2$^+$)		
1928.66 *7*	3$^+$		
1937.18 *9*	2$^+$,3,4$^+$		
1944.83[d] *3*	3$^+$		
1958.72 *22*	(2$^+$)		
1987.46 *10*	4$^+$		
2010.20 *5*	(2$^+$)		1987Da28 suggests that this is the 4$^+$ level of K^π=2$^+$ rotational band built on the 1900.0 level. However, the relatively strong 887.33γ to the 1123-keV level would then have M2 mult.
2013.6 *3*	2$^+$,3,4$^+$		
2022.64 *9*	2$^+$		J$^\pi$: From 1987Da28.
2030.39 *11*	2$^+$		
2037.00 *17*	2$^+$,3,4$^+$		
2123.1 *3*	(2$^+$)		

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^{228}Ac β^- decay 1987Da28 (continued)

^{228}Th Levels (continued)

† From 1971He23 and 1974Da17.
‡ From Adopted Levels.
# Band(A): g.s. Rotational band.
@ Band(B): $K^\pi=0^-$ octupole band.
& Band(C): $K^\pi=0^+$ two octupole phonon band.
[a] Band(D): $K^\pi=1^-$ octupole band.
[b] Band(E): $K^\pi=2^+$ γ-vibrational band.
[c] Band(F): $K^\pi=2^-$ octupole band.
[d] Band(G): $K^\pi=2^+$ rotational band on quasiparticle state.

β^- radiations

E(decay)	E(level)	Iβ^- †‡	Log *ft*	Comments
(11 *3*)	2123.1	0.0042 *10*	4.9 *5*	av Eβ=2.73 *76*
(97 *3*)	2037.00	0.0062 *10*	7.58 *9*	av Eβ=25.15 *81*
(104 *3*)	2030.39	0.019 *3*	7.18 *8*	av Eβ=26.94 *82*
(111 *3*)	2022.64	0.054 *6*	6.82 *6*	av Eβ=29.04 *82*
(120 *3*)	2013.6	0.0029 *9*	8.19 *14*	av Eβ=31.51 *83*
(124 *3*)	2010.20	0.28 *3*	6.25 *6*	av Eβ=32.44 *83*
(147 *3*)	1987.46	0.038 *3*	7.34 *5*	av Eβ=38.72 *84*
(175 *3*)	1958.72	0.0033 *7*	8.64 *10*	av Eβ=46.79 *86*
(189 *3*)	1944.83	0.251 *14*	6.86 *4*	av Eβ=50.75 *86*
(197 *3*)	1937.18	0.046 *5*	7.66 *6*	av Eβ=52.94 *87*
(205 *3*)	1928.66	0.056 *7*	7.63 *6*	av Eβ=55.39 *87*
(227 *3*)	1906.63	0.034 *5*	7.98 *7*	av Eβ=61.79 *88*
(234 *3*)	1899.97	0.077 *6*	7.67 *4*	av Eβ=63.71 *91*
(241 *3*)	1893.02	0.117 *7*	7.53 *4*	av Eβ=65.77 *89*
(336 *3*)	1797.66	0.045 *6*	8.40 *6*	av Eβ=94.51 *93*
(338 *3*)	1795.65	<0.01	>9.1	av Eβ=95.13 *93*
(374 *3*)	1760.17	0.119 *10*	8.13 *4*	av Eβ=106.17 *95*
(376 *3*)	1758.24	0.062 *13*	8.42 *10*	av Eβ=106.77 *95*
(390 *3*)	1743.87	0.389 *18*	7.673 *23*	av Eβ=111.29 *95*
(398 *3*)	1735.508	0.133 *8*	8.17 *3*	av Eβ=113.94 *96*
(410 *3*)	1724.288	1.76 *5*	7.087 *17*	av Eβ=117.50 *96*
(446 *3*)	1688.398	2.43 *15*	7.07 *3*	av Eβ=129.00 *97*
(450 *3*)	1683.71	0.164 *17*	8.25 *5*	av Eβ=130.51 *97*
(451 *3*)	1682.754	1.12 *5*	7.420 *22*	av Eβ=130.82 *97*
(488 *3*)	1646.005	4.19 *19*	6.958 *22*	av Eβ=142.79 *99*
(491 *3*)	1643.119	3.0 *8*	7.11 *12*	av Eβ=143.73 *99*
(496 *3*)	1638.283	1.15 *5*	7.542 *21*	av Eβ=145.32 *99*
(516 *3*)	1617.78	0.095 *9*	8.68 *5*	av Eβ=152.1 *10*
(603 *3*)	1531.478	7.6 *4*	7.003 *24*	av Eβ=181.0 *11*
(684 *3*)	1450.35	0.60 *7*	8.29 *6*	av Eβ=208.9 *11*
(702 *3*)	1431.981	1.2 *4*	8.03 *15*	av Eβ=215.3 *11*
(718 *3*)	1416.09	0.060 *8*	9.36 *6*	av Eβ=220.9 *11*
(790 *3*)	1344.082	0.217 *15*	8.95 *3*	av Eβ=246.4 *11*
(837 *3*)	1297.440	0.058 *13*	9.97[1u] *10*	av Eβ=260.3 *10*
(907 *3*)	1226.566	0.67 *4*	8.66 *3*	av Eβ=288.8 *11*
(959 *3*)	1175.45	0.17 *3*	9.34 *8*	av Eβ=307.6 *11*
(960 *3*)	1174.50	<0.005	>10.9	av Eβ=307.9 *11* Iβ^-: From 1987Da28.
(966 *3*)	1168.377	3.11 *7*	8.091 *11*	av Eβ=310.2 *11*
(981 *3*)	1153.465	5.8 *9*	7.84 *7*	av Eβ=315.7 *12*
(1011 *3*)	1122.949	5.90 *14*	7.883 *12*	av Eβ=327.0 *12*

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^{228}Ac β^- decay 1987Da28 (continued)

β^- radiations (continued)

E(decay)	E(level)	Iβ^- †‡	Log *ft*	Comments
(1043 *3*)	1091.020	0.26 *5*	9.29 *9*	av Eβ=338.9 *12*
(1074 *3*)	1059.94	0.070 *11*	9.90 *7*	av Eβ=350.6 *12*
(1111 *3*)	1022.531	3.11 *15*	8.306 *22*	av Eβ=364.7 *12*
(1118 *3*)	1016.386	0.33 *5*	9.29 *7*	av Eβ=367.0 *12*
(1154 *3*)	979.507	0.14 *4*	9.71 *13*	av Eβ=381.0 *12*
(1165 *3*)	968.972	29.9 *10*	7.395 *16*	av Eβ=385.0 *12*
(1166 *3*)	968.335			av Eβ=385.3 *12*
(1190 *3*)	944.200	0.041 *23*	10.29 *25*	av Eβ=394.4 *12*
(1260 *3*)	874.48	0.21 *8*	9.67 *17*	av Eβ=421.2 *12*
(1615 *3*)	519.195	0.01 *5*	12.2^{1u} *22*	av Eβ=536.9 *12*
(1738 *3*)	396.083	11.65 *24*	8.435 *10*	av Eβ=609.7 *12*
(1756 *3*)	378.178	0.116 *18*	10.45 *7*	av Eβ=616.9 *12*
(1806 *3*)	328.006	0.59 *17*	10.75^{1u} *13*	av Eβ=609.3 *12*
(1947 *3*)	186.827	0.6 *5*	9.9 *4*	av Eβ=694.3 *13*
(2076 *3*)	57.763	7 *5*	8.9 *4*	av Eβ=747.0 *13*

† Deduced from intensity balance in the level scheme.
‡ Absolute intensity per 100 decays.

γ(^{228}Th)

Iγ normalization: From absolute Iγ, based on measurements by 1992Li05, 1983Sc13 and 1982Sa36. This normalization leads to Iβ(g.s.)=6% *6*, although consistent with zero as expected from the spin change ΔJ=3, it may indicate that some g.s. transitions are missing from the level scheme.

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	$I_{(\gamma+ce)}$[l]	Comments
(18.4)	0.014 *4*	1450.35	4⁻	1431.981	4⁺	[E1]		6.47	0.11 *3*	ce(L)/(γ+ce)=0.513 *7*; ce(M)/(γ+ce)=0.268 *5*; ce(N+)/(γ+ce)=0.0851 *15* ce(N)/(γ+ce)=0.0690 *13*; ce(O)/(γ+ce)=0.0141 *3*; ce(P)/(γ+ce)=0.00195 *4*; ce(Q)/(γ+ce)=5.60×10^{-5} *11* $I_{(\gamma+ce)}$,I_γ: deduced from branching ratio in Pa decay.
42.46 *5*	0.009 *3*	1688.398	2⁺,3⁺	1646.005	3⁺	[M1]		46.3		α(L)=35.0 *5*; α(M)=8.43 *13*; α(N+..)=2.89 *5* α(N)=2.25 *4*; α(O)=0.533 *8*; α(P)=0.1034 *15*; α(Q)=0.00986 *15* Mult.: From intensity balance at 1646 level, multipolarity cannot be pure E2. Some E2 admixture, however, cannot be ruled out.
[x]56.96 *5*	0.019 *4*									
57.766[&] *5*	0.47[f] *3*	57.763	2⁺	0.0	0⁺	E2		153.1		α(L)=112.0 *16*; α(M)=30.7 *5*; α(N+..)=10.35 *15* α(N)=8.22 *12*; α(O)=1.83 *3*; α(P)=0.302 *5*; α(Q)=0.000869 *13* Mult.: α(L)exp=124 *11* (1971He23); L12/L3=1.42 (1982Ma52), 1.14 *8* (1960Ar06), 1.15 *15* (1957Bj56); theory: α(K)=114, L12/L3=1.23.
77.34 *3*	0.026 *5*	1168.377	3⁻	1091.020	4⁺	[E1]		0.232		α(L)=0.1747 *25*; α(M)=0.0426 *6*; α(N+..)=0.01416 *20* α(N)=0.01118 *16*; α(O)=0.00252 *4*; α(P)=0.000435 *7*; α(Q)=2.30×10^{-5} *4*
99.509[&] *6*	1.26[f] *7*	1531.478	3⁺	1431.981	4⁺	M1		3.84		α(L)=2.90 *4*; α(M)=0.699 *10*; α(N+..)=0.240 *4* α(N)=0.186 *3*; α(O)=0.0442 *7*; α(P)=0.00857 *12*; α(Q)=0.000815 *12* Mult.: α(L12)exp=3.0 *3* (1971He23), 2.0 *3* (1960Ar06); L3 not seen (1960Ar06).
100.41 *3*	0.093 *13*	1122.949	2⁻	1022.531	(3)⁺	(E1+M2)	≈0.23	≈3.10		α(L)≈2.27; α(M)≈0.615; α(N+..)≈0.215 α(N)≈0.1676; α(O)≈0.0393; α(P)≈0.00738; α(Q)≈0.000589 Mult.,δ: α(L3)exp≈0.43 (1971He23); theory: α(L3)(E1)=0.0213, α(L3)(M2)=8.66. α(L3)exp could also fit M1+E2; however, level scheme requires $\Delta\pi$=yes.
114.56 *7*	0.0098 *21*	1646.005	3⁺	1531.478	3⁺	[M1,E2]		9 *4*		α(K)=5 *5*; α(L)=3.2 *13*; α(M)=0.8 *4*; α(N+..)=0.28 *13* α(N)=0.22 *10*; α(O)=0.051 *22*; α(P)=0.009 *4*; α(Q)=0.00030 *24*
129.065[&] *1*	2.42[c] *9*	186.827	4⁺	57.763	2⁺	E2		3.74		α(K)=0.264 *4*; α(L)=2.54 *4*; α(M)=0.697 *10*;

From ENSDF

γ(^{228}Th) (continued)

E_γ [‡]	I_γ [#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	δ	α [†]	$I_{(\gamma+ce)}$ [l]	Comments
										α(N+..)=0.236 *4* α(N)=0.187 *3*; α(O)=0.0417 *6*; α(P)=0.00696 *10*; α(Q)=4.23×10^{-5} *6* Mult.: L12/L3=1.94 *14* (1960Ar06), 1.7 *2* (1957Bj56). K/L=0.10 *1* (1971He23), 0.12 *3* (1957Bj56); theory: L12/L3=1.70, K/L=0.10.
135.54 *5*	0.018 *4*	1226.566	4$^-$	1091.020	4$^+$	E1[h]		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)=0.0001053 *15*; α(Q)=6.66×10^{-6} *10* Mult.: α(K)exp≈3 (1971He23); theory: α(K)=0.185, discrepant α(K) for E1 γ-ray.
[x]137.91 *5*	0.024 *5*					M1		7.44		α(K)=5.94 *9*; α(L)=1.135 *16*; α(M)=0.273 *4*; α(N+..)=0.0937 *14* α(N)=0.0728 *11*; α(O)=0.01724 *25*; α(P)=0.00335 *5*; α(Q)=0.000318 *5* Mult.: α(K)exp=5.5 *17*, K/L=5.6 *27* (1971He23).
141.02 *3*	0.050 *8*	519.195	5$^-$	378.178	6$^+$	E1[h]		0.217		α(K)=0.1689 *24*; α(L)=0.0362 *5*; α(M)=0.00875 *13*; α(N+..)=0.00294 *5* α(N)=0.00231 *4*; α(O)=0.000529 *8*; α(P)=9.53×10^{-5} *14*; α(Q)=6.10×10^{-6} *9* Mult.: α(K)exp=0.7 *5* (1971He23); theory: α(K)(E1)=0.171.
145.849 *10*	0.158[f] *8*	1168.377	3$^-$	1022.531	(3)$^+$	E1[h]		0.200		α(K)=0.1561 *22*; α(L)=0.0332 *5*; α(M)=0.00802 *12*; α(N+..)=0.00269 *4* α(N)=0.00212 *3*; α(O)=0.000485 *7*; α(P)=8.76×10^{-5} *13*; α(Q)=5.66×10^{-6} *8* Mult.: α(K)exp=1.3 *4* (1971He23); theory: α(K)=0.158. ce not seen by 1960Ar06.
153.977 *10*	0.722[c] *21*	1122.949	2$^-$	968.972	2$^+$	E1		0.1757		α(K)=0.1375 *20*; α(L)=0.0289 *4*; α(M)=0.00697 *10*; α(N+..)=0.00234 *4* α(N)=0.00184 *3*; α(O)=0.000422 *6*; α(P)=7.65×10^{-5} *11*; α(Q)=5.02×10^{-6} *7* Mult.: α(K)exp=0.095 *16* (1971He23); theory: α(K)=0.129.
168.65[n] *10*	0.010[n] *3*	1344.082	3$^-$	1175.45	2$^+$	[E1]		0.1414		α(K)=0.1111 *16*; α(L)=0.0229 *4*; α(M)=0.00552 *8*; α(N+..)=0.00186 *3* α(N)=0.001458 *21*; α(O)=0.000335 *5*; α(P)=6.11×10^{-5} *9*; α(Q)=4.10×10^{-6} *6* I_γ: Total intensity (Iγ=0.013 *3*) placed from 1344.1 level by 1987Da28. Alternate placement from 1928.6 level suggested by ^{228}Pa decay.
168.65[n] *10*	0.0030[n] *7*	1928.66	3$^+$	1760.17	2$^{(+)}$,3$^{(+)}$	[M1,E2]		2.7 *15*		α(K)=1.8 *16*; α(L)=0.70 *7*; α(M)=0.18 *3*; α(N+..)=0.062 *10* α(N)=0.049 *8*; α(O)=0.0111 *15*; α(P)=0.00200 *12*; α(Q)=0.00010 *8*

From ENSDF

γ(^{228}Th) (continued)

E_γ [‡]	I_γ [#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	δ	α [†]	$I_{(\gamma+ce)}$ [l]	Comments
										I_γ: Total intensity ($I\gamma$=0.013 *3*) placed from 1344.1 level by 1987Da28. Alternate placement from 1928.6 level suggested by ^{228}Pa decay.
173.964[&] *13*	0.035 *5*	1153.465	2$^+$	979.507	2$^+$	M1+E2	1.2 +*11*−*6*	2.2 *9*		α(K)=1.4 *10*; α(L)=0.63 *3*; α(M)=0.166 *14*; α(N+..)=0.056 *5* α(N)=0.044 *4*; α(O)=0.0101 *7*; α(P)=0.00180 *5*; α(Q)=8.E−5 *5* Mult.,δ: from α(K)exp=1.5 *8* (1971He23); also fits E1+M2 with δ=0.35 *12*, level scheme requires $\Delta\pi$=no. Theory: α(K)(E1)=0.104, α(K)(E2)=0.203, α(K)(M1)=3.26, α(K)(M2)=12.9.
184.54 *2*	0.070 *8*	1153.465	2$^+$	968.972	2$^+$	E0+M1		63 *8*	4.5 *8*	α(K)=53 *7*; α(L)=10.2 *13*; α(M)=0.126; α(N+..)=0.0462 Mult.: K/L=4.0 *5*, L1/L2=33 *6*, L1/L3>>50 (1974De14), α(K)exp=53 *7* (1971He23); measured α(K)exp yields an E0 transition with an admixture of: 5.4% M1 with K/L=5.2, L1/L2=30, L1/L3=3300, or 1.4% E2 with K/L=5.0, L1/L2=16.5, L1/L3=58. Thus the ratios support E0+M1 transition. α: from α(K)exp.
191.353 *10*	0.123[f] *8*	378.178	6$^+$	186.827	4$^+$	E2		0.776		α(K)=0.1710 *24*; α(L)=0.443 *7*; α(M)=0.1209 *17*; α(N+..)=0.0409 *6* α(N)=0.0324 *5*; α(O)=0.00726 *11*; α(P)=0.001224 *18*; α(Q)=1.375×10^{-5} *20* Mult.: α(K)exp=0.24 *7*, K/L=1.0 *5*; theory: α(K)(E2)=0.174, K/L(E2)=0.39, α(K)(M1)=2.49, K/L(M1)=5.25.
199.407 *10*	0.315[f] *5*	1168.377	3$^-$	968.972	2$^+$	E1[h]		0.0950		α(K)=0.0752 *11*; α(L)=0.01502 *21*; α(M)=0.00362 *5*; α(N+..)=0.001220 *17* α(N)=0.000956 *14*; α(O)=0.000221 *3*; α(P)=4.05×10^{-5} *6*; α(Q)=2.84×10^{-6} *4* Mult.: ce(K), ce(L) not seen (1971He23,1960Ar06), suggests E1 mult.
204.026 *10*	0.112[f] *15*	1226.566	4$^-$	1022.531	(3)$^+$	E1		0.0900		α(K)=0.0713 *10*; α(L)=0.01419 *20*; α(M)=0.00342 *5*; α(N+..)=0.001152 *17* α(N)=0.000903 *13*; α(O)=0.000208 *3*; α(P)=3.83×10^{-5} *6*; α(Q)=2.70×10^{-6} *4* Mult.: α(L)exp<0.23 (1971He23); theory: α(L)(E1)=0.0143, α(L)(E2)=0.342.
209.253 *6*	3.89[c] *7*	396.083	3$^-$	186.827	4$^+$	E1		0.0848		α(K)=0.0672 *10*; α(L)=0.01333 *19*; α(M)=0.00321 *5*; α(N+..)=0.001082 *16* α(N)=0.000848 *12*; α(O)=0.000196 *3*; α(P)=3.60×10^{-5} *5*; α(Q)=2.55×10^{-6} *4*

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γ(^{228}Th) (continued)

E_γ [‡]	I_γ [#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [@]	δ	α [†]	Comments
									Mult.: from K/L and L subshell ratios in ^{228}Pa ε decay. Other: K/L=2.4 *4* (1971He23).
214.85 *5*	0.76 *11*	1153.465	2$^+$	938.61	0$^+$				E_γ: From figure 4 in 1987Da28.
214.85[a] *10*	0.029 *4*	2010.20	(2$^+$)	1795.65	4$^+$	[E2]		0.516	
223.85 *10*	0.054 *5*	1450.35	4$^-$	1226.566	4$^-$	M1+E2[h]	−0.18[h] *5*	1.85 *4*	α(K)=1.47 *4*; α(L)=0.285 *5*; α(M)=0.0688 *10*; α(N+..)=0.0236 *4* α(N)=0.0184 *3*; α(O)=0.00434 *7*; α(P)=0.000839 *13*; α(Q)=7.80×10^{-5} *18* Mult.: α(K)exp=1.7 *5*, K/L=4.2 *19* (1971He23); theory: α(K)=1.56 *3*, K/L=5.2.
231.42 *10*	0.025 *4*	1175.45	2$^+$	944.200	1$^-$	[D,E2]		1.1 *7*	
257.52 *10*	0.030 *3*	1431.981	4$^+$	1174.50	(5$^+$)	(M1)[h]		1.285	α(K)=1.028 *15*; α(L)=0.194 *3*; α(M)=0.0466 *7*; α(N+..)=0.01600 *23* α(N)=0.01243 *18*; α(O)=0.00294 *5*; α(P)=0.000571 *8*; α(Q)=5.42×10^{-5} *8*
263.58 *10*	0.040 *4*	1431.981	4$^+$	1168.377	3$^-$	E1[h]		0.0498	α(K)=0.0397 *6*; α(L)=0.00760 *11*; α(M)=0.00182 *3*; α(N+..)=0.000617 *9* α(N)=0.000482 *7*; α(O)=0.0001119 *16*; α(P)=2.08×10^{-5} *3*; α(Q)=1.553×10^{-6} *22*
270.245[&] *2*	3.46[c] *6*	328.006	1$^-$	57.763	2$^+$	E1		0.0470	α(K)=0.0376 *6*; α(L)=0.00716 *10*; α(M)=0.001717 *24*; α(N+..)=0.000581 *9* α(N)=0.000454 *7*; α(O)=0.0001054 *15*; α(P)=1.96×10^{-5} *3*; α(Q)=1.473×10^{-6} *21* Mult.: α(K)exp=0.029 *4* (1971He23); theory: α(K)=0.0379.
278.95[n] *5*	0.160[n] *21*	1153.465	2$^+$	874.48	2$^+$	(M1,E2)		0.6 *4*	α(K)=0.5 *4*; α(L)=0.12 *3*; α(M)=0.031 *6*; α(N+..)=0.0107 *22* α(N)=0.0083 *16*; α(O)=0.0019 *5*; α(P)=0.00036 *10*; α(Q)=2.4×10^{-5} *19* Mult.: α(K)exp(doublet)=0.18 *4* (1960Ar06), α(L)exp(279γ+282γ)=0.37 *7* (1971He23); theory: α(K)(M1)=0.872, α(K)(E2)=0.0854.
278.95[na] *5*	0.031[n] *5*	1431.981	4$^+$	1153.465	2$^+$	[E2]		0.211	α(K)=0.0842 *12*; α(L)=0.0935 *14*; α(M)=0.0252 *4*; α(N+..)=0.00853 *12* α(N)=0.00675 *10*; α(O)=0.001521 *22*; α(P)=0.000261 *4*; α(Q)=5.39×10^{-6} *8* γ not placed here by 1987Da28; this alternate placement is suggested in ^{228}Pa decay.
282.00[&] *3*	0.072[f] *19*	1450.35	4$^-$	1168.377	3$^-$	M1+E2[h]	−0.51[h] *12*	0.83 *7*	α(K)=0.65 *6*; α(L)=0.138 *6*; α(M)=0.0337 *11*; α(N+..)=0.0115 *4* α(N)=0.0090 *3*; α(O)=0.00211 *7*; α(P)=0.000403 *16*; α(Q)=3.4×10^{-5} *3*
321.646[&] *8*	0.226[b] *11*	1153.465	2$^+$	831.822	0$^+$	[E2]		0.1369	α(K)=0.0635 *9*; α(L)=0.0540 *8*; α(M)=0.01444 *21*; α(N+..)=0.00490 *7* α(N)=0.00387 *6*; α(O)=0.000875 *13*; α(P)=0.0001514 *22*;

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	Comments
									α(Q)=3.88×10^{-6} *6* Mult.: α(K)exp=0.49 *8* (1971He23) indicating mainly M1 transition (α(K)(M1)=0.590) which is not in agreement with the level scheme. 1960Ar06 did not see ce(K) suggesting that the α(K)exp may be unreliable.
326.04 *20*	0.033 *5*	1758.24	2$^+$	1431.981	4$^+$	[E2]		0.13	
(327.44)	0.12 *4*	1450.35	4$^-$	1122.949	2$^-$	[E2]		0.1299	α(K)=0.0613 *9*; α(L)=0.0505 *7*; α(M)=0.01349 *19*; α(N+..)=0.00458 *7* α(N)=0.00361 *5*; α(O)=0.000818 *12*; α(P)=0.0001417 *20*; α(Q)=3.72×10^{-6} *6* E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay. γ may be masked by strong 328.000γ. E_γ: Eγ from E(level).
328.000 *6*	2.95[f] *12*	328.006	1$^-$	0.0	0$^+$	E1		0.0305	α(K)=0.0245 *4*; α(L)=0.00455 *7*; α(M)=0.001089 *16*; α(N+..)=0.000369 *6* α(N)=0.000288 *4*; α(O)=6.71×10^{-5} *10*; α(P)=1.256×10^{-5} *18*; α(Q)=9.82×10^{-7} *14* Mult.: α(K)exp=0.037 *8* (1971He23); theory α(K)=0.0245.
332.370[&] *4*	0.40[c] *4*	519.195	5$^-$	186.827	4$^+$	E1[h]		0.0297	α(K)=0.0238 *4*; α(L)=0.00441 *7*; α(M)=0.001056 *15*; α(N+..)=0.000358 *5* α(N)=0.000280 *4*; α(O)=6.51×10^{-5} *10*; α(P)=1.219×10^{-5} *17*; α(Q)=9.56×10^{-7} *14* Mult.: ce(K) not seen by 1960Ar06. α(K)exp=0.41 *8* (1971He23) does not agree with [E1] required by the level scheme or E1 measured in ^{228}Pa decay.
338.320[&] *3*	11.27[b] *19*	396.083	3$^-$	57.763	2$^+$	E1		0.0285	α(K)=0.0229 *4*; α(L)=0.00424 *6*; α(M)=0.001014 *15*; α(N+..)=0.000344 *5* α(N)=0.000269 *4*; α(O)=6.25×10^{-5} *9*; α(P)=1.172×10^{-5} *17*; α(Q)=9.22×10^{-7} *13* Mult.: α(K)exp=0.019 *2* (1960Ar06); theory: α(K)=0.0231.
340.96 *5*	0.369[c] *21*	1431.981	4$^+$	1091.020	4$^+$	E2+M1[h]	−5.2[h] *18*	0.133 *21*	α(K)=0.072 *19*; α(L)=0.0451 *21*; α(M)=0.0119 *5*; α(N+..)=0.00405 *16* α(N)=0.00319 *13*; α(O)=0.00073 *3*; α(P)=0.000127 *7*; α(Q)=4.2×10^{-6} *10* Mult.: α(K)exp=0.66 *7* (1971He23) suggests an M1 transition. However, ce(K) not seen by 1960Ar06.
356.94 *10*	0.0170 *18*	1531.478	3$^+$	1174.50	(5$^+$)	[E2]		0.1015	α(K)=0.0517 *8*; α(L)=0.0368 *6*; α(M)=0.00977 *14*; α(N+..)=0.00331 *5* α(N)=0.00261 *4*; α(O)=0.000593 *9*; α(P)=0.0001033 *15*; α(Q)=3.07×10^{-6} *5*

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γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	Comments
									Mult.: α(K)exp=1.9 *9* (1971He23) does not agree with multipolarity deduced from level scheme. Theory: α(K)=0.0523.
372.57[a] *20*	0.0067 *15*	2010.20	(2$^+$)	1638.283	2$^+$	[D,E2]		0.28 *19*	
377.99 *10*	0.025 *3*	1531.478	3$^+$	1153.465	2$^+$	[M1,E2]		0.27 *18*	α(K)=0.20 *16*; α(L)=0.049 *19*; α(M)=0.012 *5*; α(N+..)=0.0041 *15* α(N)=0.0032 *11*; α(O)=0.0007 *3*; α(P)=0.00014 *6*; α(Q)=1.1×10^{-5} *8*
384.63 *20*	0.0067 *15*	2022.64	2$^+$	1638.283	2$^+$	[D,E2]		0.25 *18*	
389.12 *15*	0.0103 *15*	1928.66	3$^+$	1539.24	2$^+$	[M1,E2]		0.25 *17*	α(K)=0.19 *15*; α(L)=0.044 *18*; α(M)=0.011 *4*; α(N+..)=0.0038 *14* α(N)=0.0029 *11*; α(O)=0.0007 *3*; α(P)=0.00013 *6*; α(Q)=1.0×10^{-5} *8*
397.94 *10*	0.027 *3*	1937.18	2$^+$,3,4$^+$	1539.24	2$^+$	[D,E2]			
399.62 *10*	0.029 *3*	1743.87	4$^+$	1344.082	3$^-$	[E1]		0.0200	α(K)=0.01613 *23*; α(L)=0.00292 *4*; α(M)=0.000697 *10*; α(N+..)=0.000236 *4* α(N)=0.000185 *3*; α(O)=4.31×10^{-5} *6*; α(P)=8.11×10^{-6} *12*; α(Q)=6.58×10^{-7} *10*
409.462[&] *6*	1.92[c] *4*	1431.981	4$^+$	1022.531	(3)$^+$	E2+M1	−5.4[h] *8*	0.080 *4*	α(K)=0.048 *3*; α(L)=0.0236 *5*; α(M)=0.00618 *12*; α(N+..)=0.00210 *5* α(N)=0.00165 *4*; α(O)=0.000378 *8*; α(P)=6.69×10^{-5} *15*; α(Q)=2.69×10^{-6} *16* Mult.: α(K)exp=0.058 *9*, K/L=2.0 *4* (1971He23), α(K)exp=0.049 *4* (1960Ar06). Theory: α(K)=0.049 *4*, K/L=2.02 *14*.
416.30 *20*	0.0132 *21*	1539.24	2$^+$	1122.949	2$^-$	[E1]		0.0183	α(K)=0.01482 *21*; α(L)=0.00267 *4*; α(M)=0.000637 *9*; α(N+..)=0.000216 *3* α(N)=0.0001686 *24*; α(O)=3.94×10^{-5} *6*; α(P)=7.43×10^{-6} *11*; α(Q)=6.07×10^{-7} *9*
419.42 *10*	0.021 *3*	1646.005	3$^+$	1226.566	4$^-$	[E1]		0.0181	α(K)=0.01460 *21*; α(L)=0.00262 *4*; α(M)=0.000626 *9*; α(N+..)=0.000213 *3* α(N)=0.0001659 *24*; α(O)=3.88×10^{-5} *6*; α(P)=7.31×10^{-6} *11*; α(Q)=5.98×10^{-7} *9*
440.44 *5*	0.121 *8*	1531.478	3$^+$	1091.020	4$^+$	M1		0.295	α(K)=0.237 *4*; α(L)=0.0442 *7*; α(M)=0.01061 *15*; α(N+..)=0.00364 *5* α(N)=0.00283 *4*; α(O)=0.000670 *10*; α(P)=0.0001300 *19*; α(Q)=1.234×10^{-5} *18* Mult.: α(K)exp=0.26 *9* (1971He23); theory: α(K)=0.252. Limit of E2 admixture δ<0.8.
449.15[&] *5*	0.048 *5*	968.45	4$^+$	519.195	5$^-$				α(K)=0.0331 *5*; α(L)=0.01653 *24*; α(M)=0.00432 *6*; α(N+..)=0.001469 *21* α(N)=0.001157 *17*; α(O)=0.000264 *4*; α(P)=4.68×10^{-5} *7*; α(Q)=1.86×10^{-6} *3* E_γ: Placement from ε decay.
452.47 *10*	0.015 *5*	1431.981	4$^+$	979.507	2$^+$	[E2]		0.0544	α(K)=0.0326 *5*; α(L)=0.01613 *23*; α(M)=0.00422 *6*;

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γ(^{228}Th) (continued)

E$_\gamma$[‡]	I$_\gamma$[#l]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[@]	δ	α[†]	I$_{(\gamma+ce)}$[l]	Comments
										α(N+..)=0.001433 *20* α(N)=0.001128 *16*; α(O)=0.000258 *4*; α(P)=4.57×10^{-5} *7*; α(Q)=1.83×10^{-6} *3*
457.17 *15*	0.0150 *23*	1683.71	(4$^-$)	1226.566	4$^-$	[M1,E2]		0.16 *11*		α(K)=0.12 *10*; α(L)=0.028 *13*; α(M)=0.007 *3*; α(N+..)=0.0023 *10* α(N)=0.0018 *8*; α(O)=0.00043 *18*; α(P)=8.E−5 *4*; α(Q)=6.E−6 *5*
463.004[&] *6*	4.40[c] *7*	1431.981	4$^+$	968.972	2$^+$	E2		0.0514		α(K)=0.0312 *5*; α(L)=0.01495 *21*; α(M)=0.00390 *6*; α(N+..)=0.001326 *19* α(N)=0.001044 *15*; α(O)=0.000238 *4*; α(P)=4.24×10^{-5} *6*; α(Q)=1.744×10^{-6} *25* Mult.: α(K)exp=0.036 *4*, K/L=3.0 *7* (1971He23); α(K)exp=0.028 *3* (1960Ar06); theory: α(K)=0.0316, K/L=2.1.
[x]466.40 *10*	0.029 *3*									
470.25 *20*	0.013 *3*	1638.283	2$^+$	1168.377	3$^-$	[E1]		0.01428		α(K)=0.01157 *17*; α(L)=0.00205 *3*; α(M)=0.000489 *7*; α(N+..)=0.0001661 *24* α(N)=0.0001295 *19*; α(O)=3.03×10^{-5} *5*; α(P)=5.74×10^{-6} *8*; α(Q)=4.79×10^{-7} *7*
471.76 *15*	0.033 *3*	1416.09	(3$^-$)	944.200	1$^-$	[E2]		0.049		
474.75 *10*	0.022 *3*	1643.119	(3$^-$)	1168.377	3$^-$	[M1,E2]		0.14 *10*		α(K)=0.11 *9*; α(L)=0.025 *12*; α(M)=0.006 *3*; α(N+..)=0.0021 *9* α(N)=0.0016 *7*; α(O)=0.00038 *17*; α(P)=7.E−5 *4*; α(Q)=6.E−6 *5*
478.33[a] *5*	0.209 *15*	874.48	2$^+$	396.083	3$^-$	E1		0.01380		α(K)=0.01119 *16*; α(L)=0.00198 *3*; α(M)=0.000471 *7*; α(N+..)=0.0001601 *23* α(N)=0.0001249 *18*; α(O)=2.92×10^{-5} *4*; α(P)=5.54×10^{-6} *8*; α(Q)=4.63×10^{-7} *7*
480.94[i] *20*	0.023 *5*	1450.35	4$^-$	968.972	2$^+$	[M2]		0.645		α(K)=0.484 *7*; α(L)=0.1200 *17*; α(M)=0.0300 *5*; α(N+..)=0.01038 *15* α(N)=0.00807 *12*; α(O)=0.00191 *3*; α(P)=0.000367 *6*; α(Q)=3.29×10^{-5} *5* Not reported in ^{228}Pa decay.
490.33 *15*	0.0111 *23*	1906.63	(2$^+$)	1416.09	(3$^-$)					
492.37 *10*	0.0235 *23*	1646.005	3$^+$	1153.465	2$^+$	[M1,E2]		0.13 *9*		α(K)=0.10 *8*; α(L)=0.022 *11*; α(M)=0.0055 *24*; α(N+..)=0.0019 *8* α(N)=0.0015 *7*; α(O)=0.00034 *15*; α(P)=7.E−5 *3*; α(Q)=5.E−6 *4*
497.49[i] *15*	0.0059 *18*	1724.288	2$^+$	1226.566	4$^-$	[M2]		0.581		α(K)=0.438 *7*; α(L)=0.1075 *15*; α(M)=0.0269 *4*; α(N+..)=0.00928 *13* α(N)=0.00722 *11*; α(O)=0.001705 *24*; α(P)=0.000328 *5*; α(Q)=2.95×10^{-5} *5* E$_\gamma$,I$_\gamma$: In ^{228}Pa decay this γ is assigned to this level based on the level scheme, and is given an intensity upper limit.

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^{228}Ac β^- decay 1987Da28 (continued)

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[†]	$I_{(\gamma+ce)}$[l]	Comments
503.823[&] *13*	0.182[e] *12*	831.822	0^+	328.006	1^-	(E1)		0.01243		α(K)=0.01009 *15*; α(L)=0.001775 *25*; α(M)=0.000422 *6*; α(N+..)=0.0001435 *20*

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[†]	Comments
									α(N)=0.0001119 *16*; α(O)=2.62×10^{-5} *4*; α(P)=4.97×10^{-6} *7*; α(Q)=4.19×10^{-7} *6* Mult.: Ice not seen (1971He23), upper limit in Ice suggests E1.
508.959[&] *17*	0.45 *5*	1531.478	3$^+$	1022.531	(3)$^+$	E2(+M1)	>+1.1	0.08 *4*	α(K)=0.06 *3*; α(L)=0.015 *5*; α(M)=0.0038 *10*; α(N+..)=0.0013 *4* α(N)=0.0010 *3*; α(O)=0.00024 *7*; α(P)=4.4×10^{-5} *13*; α(Q)=3.0×10^{-6} *16* Mult.,δ: α(K)exp=0.06 *3* (1971He23); theory: α(K)(E2)=0.0264, α(K)(M1)=0.171.
515.06 *10*	0.049 *5*	1638.283	2$^+$	1122.949	2$^-$	[E1]		0.01190	α(K)=0.00966 *14*; α(L)=0.001695 *24*; α(M)=0.000403 *6*; α(N+..)=0.0001371 *20* α(N)=0.0001069 *15*; α(O)=2.50×10^{-5} *4*; α(P)=4.75×10^{-6} *7*; α(Q)=4.02×10^{-7} *6*
520.151[&] *16*	0.067 *5*	1643.119	(3$^-$)	1122.949	2$^-$	(M1)		0.189	α(K)=0.1516 *22*; α(L)=0.0282 *4*; α(M)=0.00676 *10*; α(N+..)=0.00232 *4* α(N)=0.00180 *3*; α(O)=0.000426 *6*; α(P)=8.27×10^{-5} *12*; α(Q)=7.86×10^{-6} *11* Mult.: α(K)exp=0.31 *12* (1971He23); theory: α(K)=0.161.
523.131[&a] *16*	0.103 *8*	1646.005	3$^+$	1122.949	2$^-$	[E1]		0.01153	α(K)=0.00937 *14*; α(L)=0.001641 *23*; α(M)=0.000390 *6*; α(N+..)=0.0001327 *19* α(N)=0.0001035 *15*; α(O)=2.42×10^{-5} *4*; α(P)=4.60×10^{-6} *7*; α(Q)=3.91×10^{-7} *6* Mult.: α(K)exp≤0.08 (1971He23); theory: α(K)(E1)=0.0094, α(K)(E2)=0.0251, α(K)(E3)=0.0610, α(K)(M1)=0.158.
540.76 *10*	0.026 *3*	1059.94	4$^-$	519.195	5$^-$	[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)=0.00026 *12*; α(P)=5.0×10^{-5} *25*; α(Q)=4.E−6 *3*
546.47 *5*	0.201 *13*	874.48	2$^+$	328.006	1$^-$	[E1]		0.01058	α(K)=0.00860 *12*; α(L)=0.001500 *21*; α(M)=0.000357 *5*; α(N+..)=0.0001212 *17* α(N)=9.45×10^{-5} *14*; α(O)=2.22×10^{-5} *4*; α(P)=4.21×10^{-6} *6*; α(Q)=3.60×10^{-7} *5*
548.73 *15*	0.023 *3*	1724.288	2$^+$	1175.45	2$^+$	[M1,E2]		0.10 *7*	α(K)=0.08 *6*; α(L)=0.017 *8*; α(M)=0.0041 *18*; α(N+..)=0.0014 *7* α(N)=0.0011 *5*; α(O)=0.00025 *12*; α(P)=4.8×10^{-5} *24*; α(Q)=4.E−6 *3*
555.12 *10*	0.046 *5*	1646.005	3$^+$	1091.020	4$^+$	[M1,E2]		0.10 *7*	α(K)=0.07 *6*; α(L)=0.016 *8*; α(M)=0.0039 *18*; α(N+..)=0.0013 *6* α(N)=0.0010 *5*; α(O)=0.00025 *12*; α(P)=4.7×10^{-5} *23*; α(Q)=4.E−6 *3*
562.500[&] *4*	0.87[c] *3*	1531.478	3$^+$	968.972	2$^+$	E2+M1	+1.6[h] *6*	0.07 *3*	α(K)=0.050 *23*; α(L)=0.012 *4*; α(M)=0.0030 *8*; α(N+..)=0.0010 *3* α(N)=0.00081 *20*; α(O)=0.00019 *5*; α(P)=3.5×10^{-5} *10*; α(Q)=2.6×10^{-6} *12* Mult.: α(K)exp=0.048 *10* (1971He23); E1+M2 mixture requires δ=0.39.

$\gamma(^{228}Th)$ (continued)

E_γ [‡]	I_γ [#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	α [†]	Comments
570.91 *10*	0.182[e] *24*	1724.288	2+	1153.465	2+	(M1)	0.1472	α(K)=0.1182 *17*; α(L)=0.0219 *3*; α(M)=0.00525 *8*; α(N+..)=0.00180 *3* α(N)=0.001401 *20*; α(O)=0.000332 *5*; α(P)=6.44×10^{-5} *9*; α(Q)=6.12×10^{-6} *9* Mult.: α(K)exp=0.20 *8* (1971He23); theory: α(K)=0.125. 1987Da28 assigns this γ to be the 1539.2 to 968.4 transition on the basis of coin with 911.2γ. However, the E(level) difference is 570.25 *9*. In ^{228}Pa decay this γ is assigned to the 1724.3 level; energy, intensity, multipolarity, and coin results agree with this assignment.
572.14[&] *8*	0.150 *16*	968.335	2−	396.083	3−	[M1,E2]	0.09 *6*	α(K)=0.07 *5*; α(L)=0.015 *7*; α(M)=0.0036 *17*; α(N+..)=0.0012 *6* α(N)=0.0010 *5*; α(O)=0.00023 *11*; α(P)=4.3×10^{-5} *21*; α(Q)=3.6×10^{-6} *25*
583.41 *5*	0.111 *10*	979.507	2+	396.083	3−	[E1]	0.00932 *13*	α=0.00932 *13*; α(K)=0.00759 *11*; α(L)=0.001313 *19*; α(M)=0.000312 *5*; α(N+..)=0.0001061 α(N)=8.27×10^{-5} *12*; α(O)=1.94×10^{-5} *3*; α(P)=3.69×10^{-6} *6*; α(Q)=3.18×10^{-7} *5*
(590.4)	0.017 *3*	1743.87	4+	1153.465	2+	[E2]	0.0292	α(K)=0.0197 *3*; α(L)=0.00703 *10*; α(M)=0.00180 *3*; α(N+..)=0.000613 *9* α(N)=0.000481 *7*; α(O)=0.0001107 *16*; α(P)=2.00×10^{-5} *3*; α(Q)=1.056×10^{-6} *15* E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
610.64 *10*	0.023 *5*	938.61	0+	328.006	1−	[E1]	0.00853 *12*	α=0.00853 *12*; α(K)=0.00695 *10*; α(L)=0.001198 *17*; α(M)=0.000284 *4*; α(N+..)=9.67×10^{-5} *14* α(N)=7.54×10^{-5} *11*; α(O)=1.769×10^{-5} *25*; α(P)=3.37×10^{-6} *5*; α(Q)=2.93×10^{-7} *4*
616.22[&] *3*	0.080 *5*	944.200	1−	328.006	1−			
620.38 *5*	0.080 *5*	1016.386	3−	396.083	3−			
623.27[a] *20*	0.011 *3*	1646.005	3+	1022.531	(3)+	[M1,E2]	0.07 *5*	α(K)=0.06 *4*; α(L)=0.012 *6*; α(M)=0.0028 *13*; α(N+..)=0.0010 *5* α(N)=0.0008 *4*; α(O)=0.00018 *9*; α(P)=3.4×10^{-5} *17*; α(Q)=2.9×10^{-6} *20*
627.23 *20*	0.014 *3*	1643.119	(3−)	1016.386	3−			
629.40 *5*	0.045 *5*	1646.005	3+	1016.386	3−	[D,E2]	0.07 *5*	
[x]634.18 *10*	0.0106 *21*							
640.34[&] *3*	0.054 *5*	968.335	2−	328.006	1−	[E2]	0.0245	α(K)=0.01700 *24*; α(L)=0.00556 *8*; α(M)=0.001416 *20*; α(N+..)=0.000482 *7* α(N)=0.000378 *6*; α(O)=8.73×10^{-5} *13*; α(P)=1.589×10^{-5} *23*; α(Q)=8.98×10^{-7} *13*
648.84[ma] *10*	0.040[m] *4*	1168.377	3−	519.195	5−	[E2]	0.0238	α(K)=0.01659 *24*; α(L)=0.00536 *8*; α(M)=0.001363 *19*; α(N+..)=0.000464 *7* α(N)=0.000364 *5*; α(O)=8.40×10^{-5} *12*; α(P)=1.532×10^{-5} *22*; α(Q)=8.75×10^{-7} *13*
648.84[m] *10*	0.040[m] *4*	1617.78	4+	968.972	2+			
651.51[&] *3*	0.090 *8*	979.507	2+	328.006	1−	[E1]	0.00754 *11*	α=0.00754 *11*; α(K)=0.00615 *9*; α(L)=0.001053 *15*; α(M)=0.000250 *4*; α(N+..)=8.50×10^{-5} *12*

From ENSDF

$^{228}_{90}Th_{138}$-14

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[†]	Comments
								α(N)=6.62×10^{-5} *10*; α(O)=1.555×10^{-5} *22*; α(P)=2.97×10^{-6} *5*; α(Q)=2.60×10^{-7} *4*
660.1 *3*	≈0.005	1682.754	(2$^+$,3$^+$,4$^+$)	1022.531	(3)$^+$	[M1,E2]	0.06 *4*	α(K)=0.05 *4*; α(L)=0.010 *5*; α(M)=0.0024 *12*; α(N+..)=0.0008 *4* α(N)=0.0006 *3*; α(O)=0.00015 *8*; α(P)=2.9×10^{-5} *15*; α(Q)=2.5×10^{-6} *17*
663.82 *10*	0.028 *6*	1059.94	4$^-$	396.083	3$^-$	(M1+E2)[h]	0.06 *4*	α(K)=0.05 *4*; α(L)=0.010 *5*; α(M)=0.0024 *12*; α(N+..)=0.0008 *4* α(N)=0.0006 *3*; α(O)=0.00015 *8*; α(P)=2.9×10^{-5} *15*; α(Q)=2.5×10^{-6} *17*
666.45[n] *10*	0.057[n] *6*	1646.005	3$^+$	979.507	2$^+$	[M1,E2]	0.06 *4*	α(K)=0.05 *4*; α(L)=0.010 *5*; α(M)=0.0024 *11*; α(N+..)=0.0008 *4* α(N)=0.0006 *3*; α(O)=0.00015 *7*; α(P)=2.8×10^{-5} *15*; α(Q)=2.4×10^{-6} *16* I_γ: Intensity of the doublet divided by evaluator by comparison with branching ratios and the intensities of the doublet as measured in both ^{228}Ac and ^{228}Pa decays. Iγ(doublet)=0.052 *5*. All of intensity placed here by 1987Da28,
666.45[n] *10*	0.005[n] *2*	1893.02	3$^+$	1226.566	4$^-$	[E1]	0.00722 *11*	α=0.00722 *11*; α(K)=0.00590 *9*; α(L)=0.001007 *15*; α(M)=0.000239 *4*; α(N+..)=8.13×10^{-5} *12* α(N)=6.33×10^{-5} *9*; α(O)=1.487×10^{-5} *21*; α(P)=2.84×10^{-6} *4*; α(Q)=2.50×10^{-7} *4* I_γ: Intensity of the doublet divided by evaluator by comparison with branching ratios and the intensities of the doublet as measured in both ^{228}Ac and ^{228}Pa decays. This placement of the γ suggested by ^{228}Pa decay.
672.00 *15*	0.026 *8*	1688.398	2$^+$,3$^+$	1016.386	3$^-$			γ listed in table I of 1987Da28 as deexciting the 1683.8 level; however, on level scheme (fig. 4) shown as deexciting the 1688.4 level.
674.16[j]	≤0.109	1643.119	(3$^-$)	968.972	2$^+$	[E1]	0.00707 *10*	α=0.00707 *10*; α(K)=0.00577 *8*; α(L)=0.000985 *14*; α(M)=0.000233 *4*; α(N+..)=7.95×10^{-5} *12* α(N)=6.19×10^{-5} *9*; α(O)=1.454×10^{-5} *21*; α(P)=2.78×10^{-6} *4*; α(Q)=2.44×10^{-7} *4* E_γ: deduced from E(level).
674.75[j]	2.1 *7*	1643.119	(3$^-$)	968.335	2$^-$	[M1,E2]	0.06 *4*	α(K)=0.05 *3*; α(L)=0.009 *5*; α(M)=0.0023 *11*; α(N+..)=0.0008 *4* α(N)=0.0006 *3*; α(O)=0.00014 *7*; α(P)=2.7×10^{-5} *14*; α(Q)=2.4×10^{-6} *16* I_γ: From ^{228}Pa decay with respect to I1247.07=8.2 *4*. E_γ: deduced from E(level).
677.11 *10*	0.062 *5*	1646.005	3$^+$	968.972	2$^+$	[M1,E2]	0.06 *4*	α(K)=0.05 *3*; α(L)=0.009 *5*; α(M)=0.0023 *11*; α(N+..)=0.0008 *4* α(N)=0.0006 *3*; α(O)=0.00014 *7*; α(P)=2.7×10^{-5} *14*; α(Q)=2.3×10^{-6} *16*
(684.0)	0.019 *5*	1743.87	4$^+$	1059.94	4$^-$	[E1]	0.00688 *10*	α=0.00688 *10*; α(K)=0.00562 *8*; α(L)=0.000957 *14*;

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	α[†]	Comments
								α(M)=0.000227 *4*; α(N+..)=7.72×10^{-5} *11* α(N)=6.02×10^{-5} *9*; α(O)=1.413×10^{-5} *20*; α(P)=2.70×10^{-6} *4*; α(Q)=2.38×10^{-7} *4* E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
688.10[ao] *5*	0.067 *5*	874.48	2$^+$	186.827	4$^+$	[E2]	0.0210	α(K)=0.01490 *21*; α(L)=0.00455 *7*; α(M)=0.001153 *17*; α(N+..)=0.000393 *6* α(N)=0.000308 *5*; α(O)=7.12×10^{-5} *10*; α(P)=1.303×10^{-5} *19*; α(Q)=7.79×10^{-7} *11*
688.10[a] *5*	0.067 *5*	1016.386	3$^-$	328.006	1$^-$			γ not placed here by 1987Da28; this placement of the γ suggested in ^{228}Pa decay. Poor fit in the level scheme. Ignored in the intensity balance.
(692.5)	0.0056 *7*	1893.02	3$^+$	1200.5		(M1+E2+E0)	0.05 *4*	α(K)=0.04 *3*; α(L)=0.009 *5*; α(M)=0.0021 *10*; α(N+..)=0.0007 *4* α(N)=0.0006 *3*; α(O)=0.00013 *7*; α(P)=2.6×10^{-5} *13*; α(Q)=2.2×10^{-6} *15* Mult.: α(K)exp=0.17 *3* (1973Ku09), 0.13 (1960Ar06); theory: α(K)(E2)=0.0148, α(K)(M1)=0.0751. α(K)exp may indicate E0 presence. E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
699.08 *15*	0.037 *5*	1643.119	(3$^-$)	944.200	1$^-$	[E2]	0.020	
701.747[&] *14*	0.173 *10*	1724.288	2$^+$	1022.531	(3)$^+$	(M1)[h]	0.0850	α(K)=0.0684 *10*; α(L)=0.01261 *18*; α(M)=0.00302 *5*; α(N+..)=0.001036 *15* α(N)=0.000805 *12*; α(O)=0.000191 *3*; α(P)=3.70×10^{-5} *6*; α(Q)=3.52×10^{-6} *5*
707.41 *5*	0.155[f] *15*	1226.566	4$^-$	519.195	5$^-$	(E2)[h]	0.0198	α(K)=0.01417 *20*; α(L)=0.00422 *6*; α(M)=0.001067 *15*; α(N+..)=0.000364 *5* α(N)=0.000285 *4*; α(O)=6.59×10^{-5} *10*; α(P)=1.209×10^{-5} *17*; α(Q)=7.38×10^{-7} *11*
718.48 *15*	0.019 *4*	1944.83	3$^+$	1226.566	4$^-$	(E1)[h]	0.00628 *9*	α=0.00628 *9*; α(K)=0.00513 *8*; α(L)=0.000870 *13*; α(M)=0.000206 *3*; α(N+..)=7.02×10^{-5} *10* α(N)=5.46×10^{-5} *8*; α(O)=1.284×10^{-5} *18*; α(P)=2.46×10^{-6} *4*; α(Q)=2.18×10^{-7} *3*
726.863 *15*	0.62 *8*	1122.949	2$^-$	396.083	3$^-$	(E2)	0.0187	α(K)=0.01349 *19*; α(L)=0.00393 *6*; α(M)=0.000990 *14*; α(N+..)=0.000337 *5* α(N)=0.000264 *4*; α(O)=6.12×10^{-5} *9*; α(P)=1.125×10^{-5} *16*; α(Q)=7.00×10^{-7} *10* Mult.: α(K)exp≈0.012 (1971He23); theory: α(K)=0.0136.
737.72 *5*	0.037 *4*	1760.17	2$^{(+)}$,3$^{(+)}$	1022.531	(3)$^+$	[M1,E2]	0.05 *3*	α(K)=0.037 *24*; α(L)=0.007 *4*; α(M)=0.0018 *9*; α(N+..)=0.0006 *3* α(N)=0.00048 *23*; α(O)=0.00011 *6*; α(P)=2.2×10^{-5} *11*; α(Q)=1.9×10^{-6} *12* Mult.: α(K)exp=0.28 *14* (1971He23); theory: α(K)(M1)=0.0637,

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[†]	Comments
									α(K)(E2)=0.0133, α(K)(M2)=0.147. Unconfirmed α(K)exp seems to indicate E0 admixture.
755.315[&] 4	1.00[b] 3	1724.288	2$^+$	968.972	2$^+$	M1		0.0700	α(K)=0.0563 8; α(L)=0.01036 15; α(M)=0.00248 4; α(N+..)=0.000851 12 α(N)=0.000661 10; α(O)=0.0001566 22; α(P)=3.04×10^{-5} 5; α(Q)=2.90×10^{-6} 4 Mult.: α(K)exp=0.055 9 (1971He23), 0.057 8 (1960Ar06); theory: α(K)(M1)=0.0599.
(770.04)	0.0063 8	1893.02	3$^+$	1122.949	2$^-$	[E1]		0.00552 8	α=0.00552 8; α(K)=0.00452 7; α(L)=0.000762 11; α(M)=0.000180 3; α(N+..)=6.14×10^{-5} 9 α(N)=4.78×10^{-5} 7; α(O)=1.124×10^{-5} 16; α(P)=2.15×10^{-6} 3; α(Q)=1.93×10^{-7} 3 E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
772.291[&] 5	1.49[c] 3	1168.377	3$^-$	396.083	3$^-$	E2+M1	−3.4[h] +8−27	0.021 3	α(K)=0.0154 22; α(L)=0.0039 4; α(M)=0.00096 9; α(N+..)=0.00033 3 α(N)=0.000256 22; α(O)=6.0×10^{-5} 6; α(P)=1.11×10^{-5} 11; α(Q)=7.9×10^{-7} 12 Mult.: α(K)exp=0.016 7 (1971He23), 0.019 3 (1960Ar06); theory: α(K)=0.0157 24.
774.1 2	≈0.06	831.822	0$^+$	57.763	2$^+$	[E2]		0.01649	α(K)=0.01204 17; α(L)=0.00333 5; α(M)=0.000835 12; α(N+..)=0.000285 4 α(N)=0.000223 4; α(O)=5.17×10^{-5} 8; α(P)=9.54×10^{-6} 14; α(Q)=6.19×10^{-7} 9
776.56 10	0.019 6	1944.83	3$^+$	1168.377	3$^-$				
(778.23)	0.022 6	1297.440	(5)$^-$	519.195	5$^-$	[M1,E2]		0.040 25	α(K)=0.032 20; α(L)=0.006 4; α(M)=0.0016 8; α(N+..)=0.0005 3 α(N)=0.00042 20; α(O)=0.00010 5; α(P)=1.9×10^{-5} 10; α(Q)=1.6×10^{-6} 11 E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
782.142[&] 5	0.485[c] 19	968.972	2$^+$	186.827	4$^+$	[E2]		0.01615	α(K)=0.01182 17; α(L)=0.00324 5; α(M)=0.000812 12; α(N+..)=0.000277 4 α(N)=0.000217 3; α(O)=5.03×10^{-5} 7; α(P)=9.29×10^{-6} 13; α(Q)=6.07×10^{-7} 9 Mult.: α(K)exp=0.024 3 (1960Ar06), 0.07 3 (1971He23) inconsistent with each other and with E2 assignment required by level scheme.
791.49[n] 25	0.010[n] 3	1760.17	2$^{(+)}$,3$^{(+)}$	968.972	2$^+$	[M1,E2]		0.039 23	α(K)=0.031 19; α(L)=0.006 3; α(M)=0.0015 7; α(N+..)=0.00051 25

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[†]	Comments
									α(N)=0.00040 *19*; α(O)=9.E−5 *5*; α(P)=1.8×10^{-5} *9*; α(Q)=1.6×10^{-6} *10* γ placed here with Iγ=0.023 *7* by 1987Da28.
791.49[n] *25*	0.013[n] *3*	1944.83	3$^+$	1153.465	2$^+$	(M1)		0.0618	α(K)=0.0497 *7*; α(L)=0.00915 *13*; α(M)=0.00219 *3*; α(N+..)=0.000751 *11* α(N)=0.000584 *9*; α(O)=0.0001382 *20*; α(P)=2.68×10^{-5} *4*; α(Q)=2.56×10^{-6} *4* I$_\gamma$: Intensity of the doublet divided by evaluator by comparison with branching ratios and the intensities of the doublet as measured in both ^{228}Ac and ^{228}Pa decays. This placement suggested by ^{228}Pa decay. Mult.: α(K)exp(doublet)=0.054 *11* (1973Ku09), Iγ(doublet)=3.8; theory: α(K)(M1)=0.0497.
792.8	≈0.08	979.507	2$^+$	186.827	4$^+$	[E2]		0.01572	α(K)=0.01154 *17*; α(L)=0.00313 *5*; α(M)=0.000784 *11*; α(N+..)=0.000267 *4* α(N)=0.000209 *3*; α(O)=4.85×10^{-5} *7*; α(P)=8.98×10^{-6} *13*; α(Q)=5.91×10^{-7} *9*
794.947[&] *5*	4.25[b] *7*	1122.949	2$^-$	328.006	1$^-$	E2+M1	−4.4[h] *10*	0.0179 *14*	α(K)=0.0133 *12*; α(L)=0.00340 *19*; α(M)=0.00085 *5*; α(N+..)=0.000289 *16* α(N)=0.000226 *12*; α(O)=5.3×10^{-5} *3*; α(P)=9.8×10^{-6} *6*; α(Q)=6.8×10^{-7} *6* Mult.: α(K)exp=0.0118 *20*, K/L=1.6 *7* (1971He23), α(K)exp=0.0139 *19* (1960Ar06); theory: α(K)(E2)=0.0116, α(K)(M1)=0.0524.
813.77 *15*	0.0070 *16*	1688.398	2$^+$,3$^+$	874.48	2$^+$	[M1,E2]		0.036 *22*	α(K)=0.029 *18*; α(L)=0.006 *3*; α(M)=0.0014 *7*; α(N+..)=0.00047 *23* α(N)=0.00037 *18*; α(O)=9.E−5 *5*; α(P)=1.7×10^{-5} *9*; α(Q)=1.5×10^{-6} *9*
816.71 *10*	0.030 *3*	874.48	2$^+$	57.763	2$^+$	[M1,E2]		0.036 *21*	α(K)=0.028 *18*; α(L)=0.006 *3*; α(M)=0.0014 *7*; α(N+..)=0.00047 *23* α(N)=0.00037 *18*; α(O)=9.E−5 *5*; α(P)=1.7×10^{-5} *9*; α(Q)=1.5×10^{-6} *9*
824.934[&] *23*	0.050 *5*	1344.082	3$^-$	519.195	5$^-$	[E2]		0.01452	α(K)=0.01074 *15*; α(L)=0.00283 *4*; α(M)=0.000706 *10*; α(N+..)=0.000241 *4* α(N)=0.000188 *3*; α(O)=4.38×10^{-5} *7*; α(P)=8.12×10^{-6} *12*; α(Q)=5.48×10^{-7} *8*
830.486[&] *8*	0.540[d] *21*	1226.566	4$^-$	396.083	3$^-$	E2(+M1)[h]	−7.7[h] *9*	0.0150 *3*	α(K)=0.01117 *22*; α(L)=0.00287 *5*; α(M)=0.000715 *12*; α(N+..)=0.000244 *4* α(N)=0.000191 *3*; α(O)=4.43×10^{-5} *8*; α(P)=8.24×10^{-6} *14*; α(Q)=5.69×10^{-7} *12* Mult.: α(K)exp=0.020 *11* (1971He23); theory: α(K)=0.0113 *2*.

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[†]	Comments
835.710[&] 6	1.61[c] 6	1022.531	(3)$^+$	186.827	4$^+$	E2[h]	0.01415	α(K)=0.01050 15; α(L)=0.00274 4; α(M)=0.000683 10; α(N+..)=0.000233 4 α(N)=0.000182 3; α(O)=4.24×10^{-5} 6; α(P)=7.86×10^{-6} 11; α(Q)=5.34×10^{-7} 8 Mult.: α(K)exp≤0.015 (1971He23); theory: α(K)=0.0106.
840.377[&] 7	0.91[c] 4	1168.377	3$^-$	328.006	1$^-$	E2[h]	0.01400	α(K)=0.01039 15; α(L)=0.00270 4; α(M)=0.000673 10; α(N+..)=0.000230 4 α(N)=0.000180 3; α(O)=4.18×10^{-5} 6; α(P)=7.75×10^{-6} 11; α(Q)=5.29×10^{-7} 8 Mult.: α(K)exp≤0.026 (1971He23); theory: α(K)=0.0105.
[x]853.17 10	0.0088[k] 18							
853.17[a] 10	0.0031[k] 4	1944.83	3$^+$	1091.020	4$^+$	[M1,E2]	0.032 19	α(K)=0.025 16; α(L)=0.0050 25; α(M)=0.0012 6; α(N+..)=0.00042 20 α(N)=0.00033 16; α(O)=8.E−5 4; α(P)=1.5×10^{-5} 8; α(Q)=1.3×10^{-6} 8 I_γ: from branching ratio in ^{228}Pa decay.
870.46[&] 4	0.044 4	1893.02	3$^+$	1022.531	(3)$^+$	M1[h]	0.0481	α(K)=0.0387 6; α(L)=0.00710 10; α(M)=0.001699 24; α(N+..)=0.000583 9 α(N)=0.000453 7; α(O)=0.0001073 15; α(P)=2.08×10^{-5} 3; α(Q)=1.99×10^{-6} 3
873.17 15	0.031 6	1059.94	4$^-$	186.827	4$^+$	[E1]	0.00440 7	α=0.00440 7; α(K)=0.00361 5; α(L)=0.000601 9; α(M)=0.0001421 20; α(N+..)=4.84×10^{-5} 7 α(N)=3.77×10^{-5} 6; α(O)=8.87×10^{-6} 13; α(P)=1.704×10^{-6} 24; α(Q)=1.546×10^{-7} 22
874.44[&] 7	0.047 10	874.48	2$^+$	0.0	0$^+$	[E2]	0.01294	α(K)=0.00968 14; α(L)=0.00245 4; α(M)=0.000608 9; α(N+..)=0.000208 3 α(N)=0.0001623 23; α(O)=3.78×10^{-5} 6; α(P)=7.03×10^{-6} 10; α(Q)=4.90×10^{-7} 7
877.46 10	0.014 3	1899.97	(2$^+$)	1022.531	(3)$^+$	[M1,E2]	0.030 18	α(K)=0.024 15; α(L)=0.0047 23; α(M)=0.0011 6; α(N+..)=0.00039 19 α(N)=0.00030 15; α(O)=7.E−5 4; α(P)=1.4×10^{-5} 7; α(Q)=1.2×10^{-6} 8
880.76 10	0.0062 18	938.61	0$^+$	57.763	2$^+$	[E2]	0.01276	α(K)=0.00956 14; α(L)=0.00240 4; α(M)=0.000597 9; α(N+..)=0.000204 3 α(N)=0.0001594 23; α(O)=3.71×10^{-5} 6; α(P)=6.90×10^{-6} 10; α(Q)=4.83×10^{-7} 7
887.33 10	0.027 3	2010.20	(2$^+$)	1122.949	2$^-$			
901.23 15	0.016 3	1297.440	(5)$^-$	396.083	3$^-$	[E2]	0.01220	α(K)=0.00917 13; α(L)=0.00227 4; α(M)=0.000564 8; α(N+..)=0.000192 3 α(N)=0.0001504 21; α(O)=3.50×10^{-5} 5; α(P)=6.53×10^{-6} 10; α(Q)=4.63×10^{-7} 7
904.20[&] 4	0.77[d] 3	1091.020	4$^+$	186.827	4$^+$	E2[h]	0.01212	α(K)=0.00912 13; α(L)=0.00225 4; α(M)=0.000559 8; α(N+..)=0.000191 3 α(N)=0.0001492 21; α(O)=3.47×10^{-5} 5; α(P)=6.48×10^{-6} 9; α(Q)=4.60×10^{-7} 7 Mult.: α(K)exp=0.027 10 (1971He23), ce(K) not seen (1960Ar06); α(K)exp does not agree with α(K)exp measured in ^{228}Pa ε decay.

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	Comments
911.204[&] *4*	25.8[b] *4*	968.972	2$^+$	57.763	2$^+$	E2		0.01194	α(K)=0.00900 *13*; α(L)=0.00221 *3*; α(M)=0.000549 *8*; α(N+..)=0.000187 *3* α(N)=0.0001463 *21*; α(O)=3.41×10^{-5} *5*; α(P)=6.36×10^{-6} *9*; α(Q)=4.53×10^{-7} *7* Mult.: α(K)exp=0.0104 *10*, K/L=4.6 *5* (1971He23), α(K)exp=0.0092 *9* (1960Ar06); theory: α(K)=0.0091, K/L=4.04. δ=+24 *8* from ^{228}Pa decay.
918.97 *10*	0.027 *3*	2010.20	(2$^+$)	1091.020	4$^+$				Mult.: α(K)exp=1.1 *2* (1971He23) indicates E0 component; however, then the relatively strong 887.33 γ to 1123 2- level must be M2.
921.98[ma] *10*	0.0147[m] *21*	979.507	2$^+$	57.763	2$^+$	[M1,E2]		0.027 *15*	α(K)=0.021 *13*; α(L)=0.0041 *20*; α(M)=0.0010 *5*; α(N+..)=0.00034 *16* α(N)=0.00027 *13*; α(O)=6.E−5 *3*; α(P)=1.2×10^{-5} *6*; α(Q)=1.1×10^{-6} *7* Mult.: α(K)exp=2.0 *4* (1971He23) may indicate an E0 component. Total intensity placed here by 1987Da28.
921.98[ma] *10*	0.0147[m] *21*	1944.83	3$^+$	1022.531	(3)$^+$				This placement suggested by ^{228}Pa decay.
(924.03)	0.0075 *10*	1893.02	3$^+$	968.972	2$^+$	[M1,E2]		0.026 *15*	α(K)=0.021 *13*; α(L)=0.0041 *20*; α(M)=0.0010 *5*; α(N+..)=0.00034 *16* α(N)=0.00026 *13*; α(O)=6.E−5 *3*; α(P)=1.2×10^{-5} *6*; α(Q)=1.1×10^{-6} *7* E_γ,I_γ: γ not reported in this decay. Placement suggested by ^{228}Pa decay. Iγ deduced from branching ratio in ^{228}Pa decay.
930.93[m] *10*	0.0124[m] *18*	1450.35	4$^-$	519.195	5$^-$				
930.93[m] *10*	0.0124[m] *18*	1899.97	(2$^+$)	968.972	2$^+$				This placement of γ suggested in ^{228}Pa decay.
939.87[a] *15*	0.009 *3*	2030.39	2$^+$	1091.020	4$^+$				
944.196[&] *14*	0.095 *8*	944.200	1$^-$	0.0	0$^+$				
947.982[&] *11*	0.106 *8*	1344.082	3$^-$	396.083	3$^-$	[M1,E2]		0.025 *14*	α(K)=0.020 *12*; α(L)=0.0038 *19*; α(M)=0.0009 *5*; α(N+..)=0.00032 *15* α(N)=0.00025 *12*; α(O)=6.E−5 *3*; α(P)=1.1×10^{-5} *6*; α(Q)=1.0×10^{-6} *6*
958.61[&] *4*	0.28[f] *4*	1016.386	3$^-$	57.763	2$^+$				
964.766[&] *10*	4.99[c] *9*	1022.531	(3)$^+$	57.763	2$^+$	E2+M1	−7.2[h] *10*	0.01119 *23*	α(K)=0.00853 *19*; α(L)=0.00199 *4*; α(M)=0.000492 *9*; α(N+..)=0.000168 *3* α(N)=0.0001312 *23*; α(O)=3.06×10^{-5} *6*; α(P)=5.74×10^{-6} *11*; α(Q)=4.28×10^{-7} *10* Mult.: α(K)exp=0.0084 *9* (1971He23); theory: α(K)=0.00821.
968.971[&] *17*	15.8[b] *3*	968.972	2$^+$	0.0	0$^+$	E2		0.01061	α(K)=0.00806 *12*; α(L)=0.00191 *3*; α(M)=0.000472 *7*;

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[†]	Comments
								α(N+..)=0.0001610 *23* α(N)=0.0001258 *18*; α(O)=2.93×10^{-5} *5*; α(P)=5.49×10^{-6} *8*; α(Q)=4.04×10^{-7} *6* Mult.: α(L)exp=0.0016 *3* (1971He23); theory: α(K)=0.00815, α(L)=0.0194; α(K)exp used in normalization of the ce spectra.
975.96 *5*	0.050 *5*	1944.83	3$^+$	968.972	2$^+$	M1[h]	0.0356	α(K)=0.0287 *4*; α(L)=0.00524 *8*; α(M)=0.001254 *18*; α(N+..)=0.000430 *6* α(N)=0.000334 *5*; α(O)=7.91×10^{-5} *11*; α(P)=1.537×10^{-5} *22*; α(Q)=1.468×10^{-6} *21*
979.48 *10*	0.026 *3*	979.507	2$^+$	0.0	0$^+$	[E2]	0.01039	α(K)=0.00791 *11*; α(L)=0.00186 *3*; α(M)=0.000460 *7*; α(N+..)=0.0001568 *22* α(N)=0.0001225 *18*; α(O)=2.86×10^{-5} *4*; α(P)=5.36×10^{-6} *8*; α(Q)=3.96×10^{-7} *6*
987.71 *20*	0.077 *13*	1174.50	(5$^+$)	186.827	4$^+$	[M1,E2]	0.022 *13*	α(K)=0.018 *10*; α(L)=0.0035 *17*; α(M)=0.0008 *4*; α(N+..)=0.00029 *14* α(N)=0.00022 *11*; α(O)=5.2×10^{-5} *25*; α(P)=1.0×10^{-5} *5*; α(Q)=9.E−7 *6*
988.63 *20*	0.077 *13*	1175.45	2$^+$	186.827	4$^+$	[E2]	0.01021	α(K)=0.00778 *11*; α(L)=0.00182 *3*; α(M)=0.000449 *7*; α(N+..)=0.0001534 *22* α(N)=0.0001198 *17*; α(O)=2.79×10^{-5} *4*; α(P)=5.24×10^{-6} *8*; α(Q)=3.89×10^{-7} *6*
1000.69 *15*	0.005	1944.83	3$^+$	944.200	1$^-$			γ not seen in ^{228}Pa decay. Iγ<0.002 from upper limit in ^{228}Pa decay.
1013.58 *20*	0.0046 *13*	2030.39	2$^+$	1016.386	3$^-$			
1016.44[mo] *15*	0.019[m] *3*	1016.386	3$^-$	0.0	0$^+$			
1016.44[m] *15*	0.019[m] *3*	1344.082	3$^-$	328.006	1$^-$			
1017.92 *20*	0.0057 *13*	1987.46	4$^+$	968.972	2$^+$			
1019.86 *10*	0.021 *4*	1416.09	(3$^-$)	396.083	3$^-$			
1033.248[&] *9*	0.201 *13*	1091.020	4$^+$	57.763	2$^+$	E2[h]	0.00938 *14*	α=0.00938 *14*; α(K)=0.00720 *10*; α(L)=0.001643 *23*; α(M)=0.000404 *6*; α(N+..)=0.0001380 α(N)=0.0001078 *15*; α(O)=2.52×10^{-5} *4*; α(P)=4.73×10^{-6} *7*; α(Q)=3.58×10^{-7} *5*
1039.65 *15*	0.044 *9*	1226.566	4$^-$	186.827	4$^+$			
1040.92 *15*	0.044 *9*	2010.20	(2$^+$)	968.972	2$^+$			
1053.09[a] *20*	0.013 *4*	2022.64	2$^+$	968.972	2$^+$			
1054.11 *20*	0.018 *5*	1450.35	4$^-$	396.083	3$^-$			
1062.55 *15*	0.010 *3*	1937.18	2$^+$,3,4$^+$	874.48	2$^+$			
1065.18[&] *4*	0.132 *10*	1122.949	2$^-$	57.763	2$^+$			
1074.71 *15*	0.010 *3*	1906.63	(2$^+$)	831.822	0$^+$			
1088.18 *15*	0.0059 *13*	1416.09	(3$^-$)	328.006	1$^-$			
1095.679[&] *20*	0.129 *10*	1153.465	2$^+$	57.763	2$^+$	[M1,E2]	0.017 *9*	α(K)=0.014 *8*; α(L)=0.0026 *13*; α(M)=0.0006 *3*; α(N+..)=0.00022 *10* α(N)=0.00017 *8*; α(O)=4.0×10^{-5} *19*; α(P)=8.E−6 *4*; α(Q)=7.E−7 *4*
1103.41[ai] *10*	0.0150 *23*	1431.981	4$^+$	328.006	1$^-$	[E3]	0.0195	α(K)=0.01377 *20*; α(L)=0.00429 *6*; α(M)=0.001090 *16*; α(N+..)=0.000373 *6*

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[†]	Comments
								α(N)=0.000292 *4*; α(O)=6.78×10^{-5} *10*; α(P)=1.256×10^{-5} *18*; α(Q)=8.16×10^{-7} *12*; α(IPF)=3.24×10^{-8} *5*
1110.610[n&] *10*	0.285[n] *23*	1168.377	3$^-$	57.763	2$^+$	E1[h]	0.00288 *4*	α=0.00288 *4*; α(K)=0.00237 *4*; α(L)=0.000388 *6*; α(M)=9.15×10^{-5} *13*; α(N+..)=3.20×10^{-5} *5* α(N)=2.43×10^{-5} *4*; α(O)=5.73×10^{-6} *8*; α(P)=1.104×10^{-6} *16*; α(Q)=1.025×10^{-7} *15*; α(IPF)=7.72×10^{-7} *11* I_γ: Intensity of the doublet divided by evaluator by comparison with branching ratios and the intensities of the doublet as measured in both ^{228}Ac and ^{228}Pa decays.
1110.610[n] *10*	0.019[n] *10*	1297.440	(5)$^-$	186.827	4$^+$	E1[h]	0.00288 *4*	α=0.00288 *4*; α(K)=0.00237 *4*; α(L)=0.000388 *6*; α(M)=9.15×10^{-5} *13*; α(N+..)=3.20×10^{-5} *5* α(N)=2.43×10^{-5} *4*; α(O)=5.73×10^{-6} *8*; α(P)=1.104×10^{-6} *16*; α(Q)=1.025×10^{-7} *15*; α(IPF)=7.72×10^{-7} *11* I_γ: Intensity of the doublet divided by evaluator by comparison with branching ratios and the intensities of the doublet as measured in both ^{228}Ac and ^{228}Pa decays.
1117.63 *10*	0.054 *8*	1175.45	2$^+$	57.763	2$^+$			
1135.24 *15*	0.0098 *15*	1531.478	3$^+$	396.083	3$^-$			
1142.85 *15*	0.0103 *21*	1539.24	2$^+$	396.083	3$^-$			
1148.12 *15*	0.0059 *13*	2022.64	2$^+$	874.48	2$^+$			
1153.52[&] *4*	0.139 *10*	1153.465	2$^+$	0.0	0$^+$			
1157.14 *15*	0.0070 *13*	1344.082	3$^-$	186.827	4$^+$			
1164.50 *8*	0.065 *5*	1683.71	(4$^-$)	519.195	5$^-$	(M1+E2)[h]	0.015 *8*	α(K)=0.012 *7*; α(L)=0.0023 *11*; α(M)=0.00055 *24*; α(N+..)=0.00019 *9* α(N)=0.00015 *7*; α(O)=3.4×10^{-5} *16*; α(P)=7.E−6 *3*; α(Q)=6.E−7 *4*; α(IPF)=2.2×10^{-6} *10*
1175.31 *10*	0.024 *3*	1175.45	2$^+$	0.0	0$^+$			
1190.81 *20*	0.0062 *16*	2022.64	2$^+$	831.822	0$^+$			
1217.03[a] *10*	0.021 *3*	1735.508	4$^+$	519.195	5$^-$			
1229.40 *15*	0.0075 *23*	1416.09	(3$^-$)	186.827	4$^+$			
1245.05[a] *20*	0.095 *18*	1431.981	4$^+$	186.827	4$^+$	[M1,E2]	0.013 *6*	α(K)=0.010 *5*; α(L)=0.0019 *9*; α(M)=0.00046 *20*; α(N+..)=0.00017 *8* α(N)=0.00012 *6*; α(O)=2.9×10^{-5} *13*; α(P)=5.6×10^{-6} *25*; α(Q)=5.E−7 *3*; α(IPF)=1.2×10^{-5} *5*
1247.08[&a] *4*	0.50[g] *3*	1643.119	(3$^-$)	396.083	3$^-$	(M1)	0.0187	α(K)=0.01505 *21*; α(L)=0.00274 *4*; α(M)=0.000654 *10*; α(N+..)=0.000242 *4* α(N)=0.0001743 *25*; α(O)=4.13×10^{-5} *6*; α(P)=8.02×10^{-6} *12*; α(Q)=7.69×10^{-7} *11*; α(IPF)=1.771×10^{-5} *2*
1250.04[&] *10*	0.062 *5*	1646.005	3$^+$	396.083	3$^-$			
1276.69 *10*	0.014 *3*	1795.65	4$^+$	519.195	5$^-$			
1286.27 *20*	0.050 *10*	1344.082	3$^-$	57.763	2$^+$			
1287.68 *20*	0.080 *15*	1683.71	(4$^-$)	396.083	3$^-$	(M1+E2)[h]	0.012 *6*	α(K)=0.009 *5*; α(L)=0.0018 *8*; α(M)=0.00042 *18*; α(N+..)=0.00017 *7*

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	$I_{(\gamma+ce)}$[l]	Comments
										α(N)=0.00011 5; α(O)=2.7×10^{-5} 12; α(P)=5.1×10^{-6} 23; α(Q)=4.7×10^{-7} 24; α(IPF)=2.0×10^{-5} 9 γ listed in table I of 1987Da28 as deexciting the 1682.8 level; however, on level scheme (fig. 4) shown as deexciting the 1683.8 level. The energy fit is much better from the 1683.8 level.
1309.71 20	0.019 6	1638.283	2$^+$	328.006	1$^-$					
1315.34 10	0.015 3	1643.119	(3$^-$)	328.006	1$^-$	[E2]		0.006		
[x]1337.33 20	0.0049 15									
1344.59 15	0.0090 18	1531.478	3$^+$	186.827	4$^+$					
1347.50 15	0.015 3	1743.87	4$^+$	396.083	3$^-$					γ is uncertain in ^{228}Pa decay with Iγ= 0.16 5.
1357.78[a] 15	0.020 4	1735.508	4$^+$	378.178	6$^+$					
1365.70 15	0.014 3	1743.87	4$^+$	378.178	6$^+$					
1374.19 10	0.014 4	1431.981	4$^+$	57.763	2$^+$	[E2]				
[x]1378.23 10	0.0059 18									
[x]1385.39 10	0.0106 21									
1401.49 10	0.012 3	1797.66	2$^+$	396.083	3$^-$					
1415.66[i] 10	0.021 4	1743.87	4$^+$	328.006	1$^-$	[E3]		0.01141		α(K)=0.00849 12; α(L)=0.00217 3; α(M)=0.000543 8; α(N+..)=0.000202 3 α(N)=0.0001450 21; α(O)=3.39×10^{-5} 5; α(P)=6.36×10^{-6} 9; α(Q)=4.71×10^{-7} 7; α(IPF)=1.604×10^{-5} 23
1430.95 10	0.035 7	1617.78	4$^+$	186.827	4$^+$					
[x]1434.22 15	0.0080 23									
[x]1438.01 10	0.0059 15									
1451.40 15	0.0106 21	1638.283	2$^+$	186.827	4$^+$					
1459.138[&] 15	0.83[g] 8	1646.005	3$^+$	186.827	4$^+$	E2[h]		0.00498 7		α=0.00498 7; α(K)=0.00391 6; α(L)=0.000771 11; α(M)=0.000187 3; α(N+..)=0.0001108 16 α(N)=4.97×10^{-5} 7; α(O)=1.167×10^{-5} 17; α(P)=2.23×10^{-6} 4; α(Q)=1.89×10^{-7} 3; α(IPF)=4.71×10^{-5} 7
1469.71 15	0.020 4	1797.66	2$^+$	328.006	1$^-$					
[x]1480.37 15	0.016 3									
1495.910[&] 20	0.86[g] 4	1682.754	(2$^+$,3$^+$,4$^+$)	186.827	4$^+$	(E2)[h]		0.00477 7		α=0.00477 7; α(K)=0.00374 6; α(L)=0.000732 11; α(M)=0.0001769 25; α(N+..)=0.0001177 α(N)=4.71×10^{-5} 7; α(O)=1.107×10^{-5} 16; α(P)=2.11×10^{-6} 3; α(Q)=1.81×10^{-7} 3; α(IPF)=5.72×10^{-5} 8
1501.57 5	0.46[e] 3	1688.398	2$^+$,3$^+$	186.827	4$^+$					
[x]1529.05 10	0.057 6									
1537.89[a] 10	0.047 5	1724.288	2$^+$	186.827	4$^+$					
1548.65[&] 4	0.038 4	1735.508	4$^+$	186.827	4$^+$					

From ENSDF

γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	Comments
1557.11[&] *4*	0.178 *13*	1743.87	4+	186.827	4+	(E2+M1)[h]	+1.2[h] *2*	0.0070 *6*	α=0.0070 *6*; α(K)=0.0055 *5*; α(L)=0.00102 *8*; α(M)=0.000245 *19*; α(N+..)=0.000198 *15* α(N)=6.5×10^{-5} *5*; α(O)=1.54×10^{-5} *12*; α(P)=2.98×10^{-6} *23*; α(Q)=2.75×10^{-7} *24*; α(IPF)=0.000114 *9*
1559.85 *20*	0.020 *4*	1617.78	4+	57.763	2+				
1571.52 *20*	0.0057 *16*	1758.24	2+	186.827	4+				
1573.26[&] *5*	0.033 *3*	1760.17	2$^{(+)}$,3$^{(+)}$	186.827	4+	(E2)[h]		0.00438 *7*	α=0.00438 *7*; α(K)=0.00342 *5*; α(L)=0.000660 *10*; α(M)=0.0001592 *23*; α(N+..)=0.0001356 α(N)=4.24×10^{-5} *6*; α(O)=9.97×10^{-6} *14*; α(P)=1.91×10^{-6} *3*; α(Q)=1.650×10^{-7} *24*; α(IPF)=8.12×10^{-5} *12*
1580.53[&] *3*	0.60[g] *4*	1638.283	2+	57.763	2+	(M1,E2)		0.007 *3*	α=0.007 *3*; α(K)=0.0057 *24*; α(L)=0.0011 *4*; α(M)=0.00025 *10*; α(N+..)=0.00022 *9* α(N)=7.E−5 *3*; α(O)=1.6×10^{-5} *6*; α(P)=3.1×10^{-6} *12*; α(Q)=2.9×10^{-7} *13*; α(IPF)=0.00013 *5* Mult.: α(K)exp=0.012 *7* (1971He23); theory: α(K)(M1)=0.0087, α(K)(E2)=0.00343.
1588.20[&] *3*	3.22[g] *8*	1646.005	3+	57.763	2+	E2[h]		0.00431 *6*	α=0.00431 *6*; α(K)=0.00337 *5*; α(L)=0.000647 *9*; α(M)=0.0001561 *22*; α(N+..)=0.0001396 *2* α(N)=4.15×10^{-5} *6*; α(O)=9.77×10^{-6} *14*; α(P)=1.87×10^{-6} *3*; α(Q)=1.622×10^{-7} *23*; α(IPF)=8.62×10^{-5} *12* Mult.: α(K)exp=0.0050 *16* (1971He23); theory: α(K)=0.00340.
1609.41 *15*	0.0077 *15*	1987.46	4+	378.178	6+				
1625.06[&] *5*	0.255 *18*	1682.754	(2+,3+,4+)	57.763	2+				
1630.627[&] *10*	1.51[g] *4*	1688.398	2+,3+	57.763	2+	(M1,E2)		0.007 *3*	α=0.007 *3*; α(K)=0.0053 *22*; α(L)=0.0010 *4*; α(M)=0.00023 *9*; α(N+..)=0.00024 *9* α(N)=6.2×10^{-5} *24*; α(O)=1.5×10^{-5} *6*; α(P)=2.9×10^{-6} *11*; α(Q)=2.7×10^{-7} *12*; α(IPF)=0.00016 *6* Mult.: from α(K)exp(1625γ+1630γ)=0.0062 *20* (1971He23); theory: α(K)(M1)=0.0090, α(K)(E2)=0.0034.
1638.281[&] *10*	0.47[g] *3*	1638.283	2+	0.0	0+	(E2)[h]		0.00410 *6*	α=0.00410 *6*; α(K)=0.00319 *5*; α(L)=0.000608 *9*; α(M)=0.0001463 *21*; α(N+..)=0.0001539 *2* α(N)=3.89×10^{-5} *6*; α(O)=9.16×10^{-6} *13*; α(P)=1.755×10^{-6} *25*; α(Q)=1.533×10^{-7} *22*; α(IPF)=0.0001039
1666.523[&] *13*	0.178 *13*	1724.288	2+	57.763	2+	M1[h]		0.00895 *13*	α=0.00895 *13*; α(K)=0.00702 *10*; α(L)=0.001269 *18*; α(M)=0.000303 *5*; α(N+..)=0.000351 *5*

γ(^{228}Th) (continued)

E_γ ‡	I_γ #l	E_i(level)	J^π_i	E_f	J^π_f	Mult. @	δ	α †	Comments
									α(N)=8.08×10^{-5} *12*; α(O)=1.91×10^{-5} *3*; α(P)=3.72×10^{-6} *6*; α(Q)=3.58×10^{-7} *5*; α(IPF)=0.000247 *4*
^{x}1671.64 *15*	0.0041 *13*								
1677.67& *3*	0.054 *5*	1735.508	4$^+$	57.763	2$^+$				
^{x}1684.01 *20*	0.015 *5*								
1686.09& *7*	0.095 *8*	1743.87	4$^+$	57.763	2$^+$	(E2)h		0.00391 *6*	α=0.00391 *6*; α(K)=0.00303 *5*; α(L)=0.000573 *8*; α(M)=0.0001378 *20*; α(N+..)=0.0001688 *2* α(N)=3.67×10^{-5} *6*; α(O)=8.64×10^{-6} *12*; α(P)=1.655×10^{-6} *24*; α(Q)=1.455×10^{-7} *21*; α(IPF)=0.0001217
1700.59 *20*	0.0101 *23*	1758.24	2$^+$	57.763	2$^+$				
1702.43& *5*	0.048 *5*	1760.17	2$^{(+)}$,3$^{(+)}$	57.763	2$^+$				
1706.19 *10*	0.0085 *10*	1893.02	3$^+$	186.827	4$^+$	M1+E2h	+0.42h *4*	0.00776 *16*	α=0.00776 *16*; α(K)=0.00605 *13*; α(L)=0.001097 *22*; α(M)=0.000262 *6*; α(N+..)=0.000346 *7* α(N)=6.99×10^{-5} *14*; α(O)=1.65×10^{-5} *4*; α(P)=3.21×10^{-6} *7*; α(Q)=3.07×10^{-7} *7*; α(IPF)=0.000256 *6*
1713.47 *20*	0.0054 *10*	1899.97	(2$^+$)	186.827	4$^+$				γ not seen in ^{228}Pa decay. Iγ<0.002 from upper limit in ^{228}Pa decay.
^{x}1721.4 *3*	0.0057 *21*								
1724.21& *4*	0.029 *3*	1724.288	2$^+$	0.0	0$^+$				
1738.22 *25*	0.018 *4*	1795.65	4$^+$	57.763	2$^+$				
1740.4 *3*	0.011 *3*	1797.66	2$^+$	57.763	2$^+$				
1742.0 *3*	0.0080 *23*	1928.66	3$^+$	186.827	4$^+$				
^{x}1745.28 *20*	0.0065 *8*								
1750.54 *20*	0.0080 *8*	1937.18	2$^+$,3,4$^+$	186.827	4$^+$				
1758.11 *10*	0.035 *4*	1944.83	3$^+$	186.827	4$^+$	E2+M1h	−9h *1*	0.00371 *6*	α=0.00371 *6*; α(K)=0.00285 *5*; α(L)=0.000533 *8*; α(M)=0.0001281 *19*; α(N+..)=0.000195 *3* α(N)=3.41×10^{-5} *5*; α(O)=8.03×10^{-6} *12*; α(P)=1.542×10^{-6} *23*; α(Q)=1.369×10^{-7} *20*; α(IPF)=0.0001515
1772.2 *3*	0.0018 *5*	1958.72	(2$^+$)	186.827	4$^+$				
^{x}1784.4 *3*	0.0059 *10*								
^{x}1787.3 *5*	0.0013 *5*								
1795.1 *5*	0.0021 *8*	2123.1	(2$^+$)	328.006	1$^-$				
1797.5 *5*	0.0021 *8*	1797.66	2$^+$	0.0	0$^+$	[E2]			
1800.86 *20*	0.0044 *8*	1987.46	4$^+$	186.827	4$^+$				
1823.22 *10*	0.044 *4*	2010.20	(2$^+$)	186.827	4$^+$				
1826.7 *3*	0.0021 *8*	2013.6	2$^+$,3,4$^+$	186.827	4$^+$				
1835.43 *10*	0.038 *4*	1893.02	3$^+$	57.763	2$^+$	E2+M1h	+2.9h *3*	0.00382 *10*	α=0.00382 *10*; α(K)=0.00291 *8*; α(L)=0.000536 *14*; α(M)=0.000128 *4*; α(N+..)=0.000246 *7* α(N)=3.42×10^{-5} *9*; α(O)=8.06×10^{-6} *21*; α(P)=1.55×10^{-6} *4*; α(Q)=1.41×10^{-7} *4*; α(IPF)=0.000202 *6*

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γ(^{228}Th) (continued)

E_γ[‡]	I_γ[#l]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ	α[†]	Comments
1842.13 *10*	0.042 *4*	1899.97	(2$^+$)	57.763	2$^+$	M1+E2[h]	−0.86[h] *14*	0.0055 *4*	α=0.0055 *4*; α(K)=0.00420 *25*; α(L)=0.00076 *5*; α(M)=0.000182 *11*; α(N+..)=0.000363 *21* α(N)=4.9×10^{-5} *3*; α(O)=1.15×10^{-5} *7*; α(P)=2.23×10^{-6} *13*; α(Q)=2.10×10^{-7} *13*; α(IPF)=0.000301 *18*
1850.13 *20*	0.0044 *8*	2037.00	2$^+$,3,4$^+$	186.827	4$^+$				
1870.83 *10*	0.0243 *23*	1928.66	3$^+$	57.763	2$^+$	(M1+E2)[h]		0.0051 *18*	α=0.0051 *18*; α(K)=0.0038 *14*; α(L)=0.00070 *24*; α(M)=0.00017 *6*; α(N+..)=0.00036 *13* α(N)=4.4×10^{-5} *15*; α(O)=1.1×10^{-5} *4*; α(P)=2.0×10^{-6} *7*; α(Q)=1.9×10^{-7} *8*; α(IPF)=0.00030 *11*
1879.6 *3*	0.0013 *5*	1937.18	2$^+$,3,4$^+$	57.763	2$^+$				
1887.10 *5*	0.090 *8*	1944.83	3$^+$	57.763	2$^+$	E2+M1[h]	−9.1[h] *1*	0.00333 *5*	α=0.00333 *5*; α(K)=0.00251 *4*; α(L)=0.000462 *7*; α(M)=0.0001107 *16*; α(N+..)=0.000243 *4* α(N)=2.95×10^{-5} *5*; α(O)=6.95×10^{-6} *10*; α(P)=1.336×10^{-6} *19*; α(Q)=1.201×10^{-7} *17*; α(IPF)=0.000205 *3*
1900.07 *20*	0.0028 *5*	1899.97	(2$^+$)	0.0	0$^+$				
1907.18 *20*	0.0119 *10*	1906.63	(2$^+$)	0.0	0$^+$				
^{x}1915.9 *4*	0.0008 *3*								
^{x}1919.5 *3*	0.0021 *5*								
1929.78 *20*	0.0199 *21*	1987.46	4$^+$	57.763	2$^+$				
1936.3 *3*	0.0021 *5*	2123.1	(2$^+$)	186.827	4$^+$				
^{x}1944.20 *20*	0.0021 *5*								
1952.33 *15*	0.059 *5*	2010.20	(2$^+$)	57.763	2$^+$				
1955.9 *5*	0.0008 *3*	2013.6	2$^+$,3,4$^+$	57.763	2$^+$				
1958.4 *3*	0.0015 *5*	1958.72	(2$^+$)	0.0	0$^+$				
1965.24 *20*	0.0204 *18*	2022.64	2$^+$	57.763	2$^+$				
1971.9 *3*	0.0036 *8*	2030.39	2$^+$	57.763	2$^+$				
1979.3 *3*	0.0018 *5*	2037.00	2$^+$,3,4$^+$	57.763	2$^+$				
^{x}2000.9 *5*	0.0010 *3*								
2029.4 *5*	0.0018 *5*	2030.39	2$^+$	0.0	0$^+$				

† Additional information 1.

‡ From 1987Da28, unless otherwise noted.

From 1987Da28, unless otherwise noted. The relative Iγ of 1987Da28 have been normalized to the absolute measurements of 1992Li05, 1983Sc13 and 1982Sa36 at the three γ's with Iγ>10 % (338.324γ Iγ=11.27% *19*, 911.205γ Iγ=25.8% *4* and 968.987γ Iγ=15.8% *3*, giving a normalization factor of 0.0258 *5*).

@ From adopted Iγ and the Ice data of 1960Ar06 and 1971He23 (as noted with α(exp)) normalized to theoretical values for: α(L)(E2) for 129.065γ, α(K)(E1) for 209.253γ and α(K)(E2) for 968.971γ.

& Weighted average of measurements by 1987Da28, 1979He10. The measurements of 1979He10 have been corrected by using the calibration line Eγ from 1995HeZZ.

γ(^{228}Th) (continued)

[a] Energy fit poor, Eγ not included in the least squares fit to obtain E(level).
[b] Weighted average of absolute intensity measurements of 1992Li05, 1983Sc13, 1982Sa36.
[c] Weighted average of measurements by 1992Li05, 1987Da28, 1983Sc13, 1982Sa36.
[d] Weighted average of measurements by 1987Da28, 1983Sc13, 1982Sa36.
[e] Weighted average of measurements by 1987Da28, 1983Sc13.
[f] Weighted average of measurements by 1987Da28, 1982Sa36.
[g] Weighted average of measurements by 1992Li05, 1987Da28, 1983Sc13.
[h] From ^{228}Pa ε decay.
[i] The adopted J^π require that this γ have an unreasonable multipolarity (M2 or E3). The placement of this transition is therefore questionable.
[j] γ's of approximately same energy and intensity are reported in both ^{228}Ac and ^{228}Pa decays. On the basis of coin with 911.2γ, it is suggested in ^{228}Ac decay that the γ feeds the 2^+ 968.97 level. In ^{228}Pa decay, the γ is placed feeding the 3^- 968.37 level. The energy of the γ (Eγ=674.65 *5*) agrees with decay to the 968.37 level. Possibly the γ is a doublet feeding both the 968.97 and 968.37 levels. Iγ(doublet)=0.101 *8*.
[k] The energy of the 853-keV transition from the 1944.9 level is expected to be 853.877 *12* from E(level); the expected intensity is Iγ=0.0031 *4* from branching ratio in ^{228}Pa decay. Therefore, the 853.17 *10* γ with Iγ=0.0119 *18* reported by 1987Da28 seems to be a doublet with part of the intensity belonging to a γ unplaced in level scheme.
[l] Absolute intensity per 100 decays.
[m] Multiply placed with undivided intensity.
[n] Multiply placed with intensity suitably divided.
[o] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

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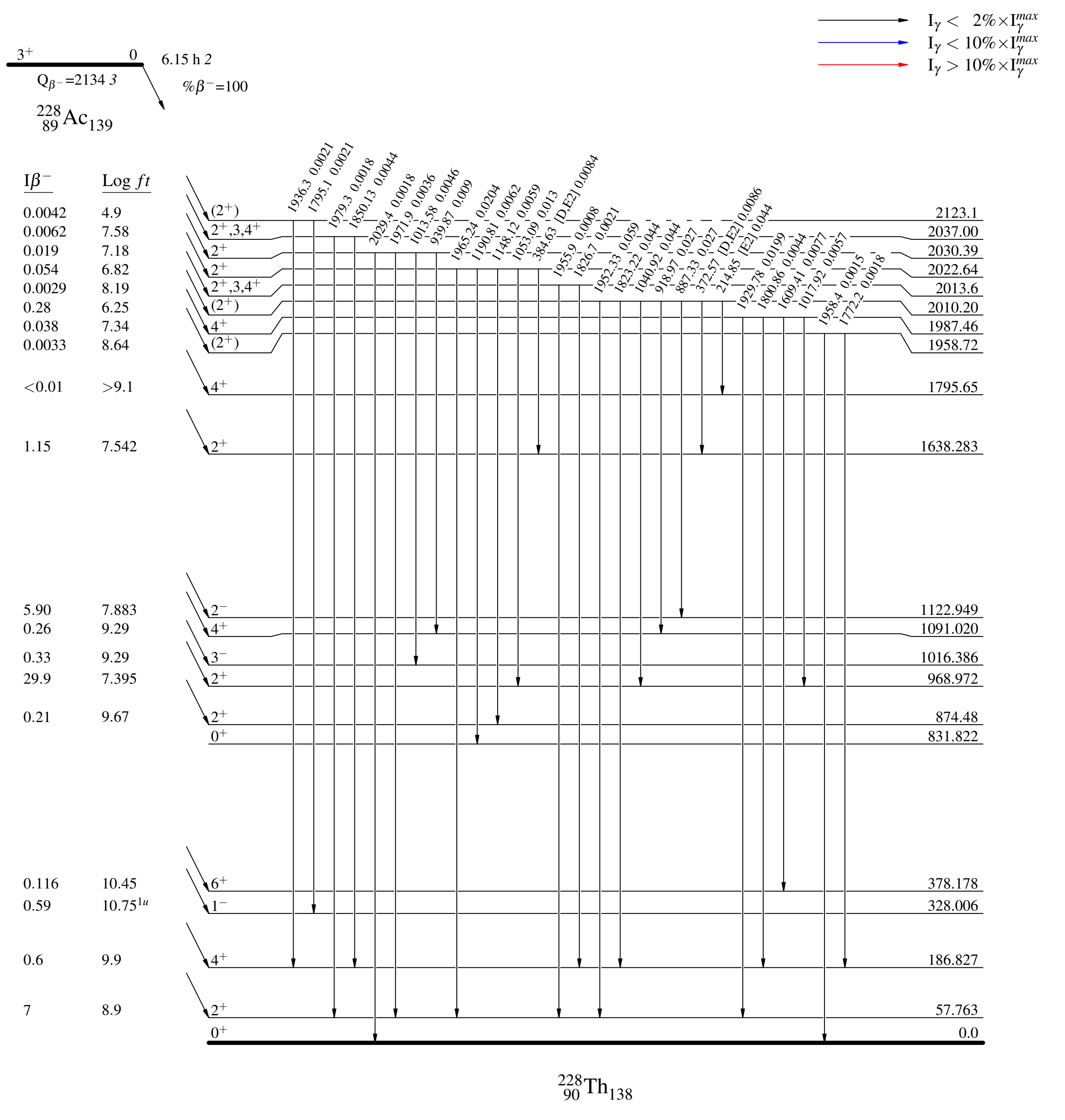
^{228}Ac β^- decay 1987Da28

Decay Scheme

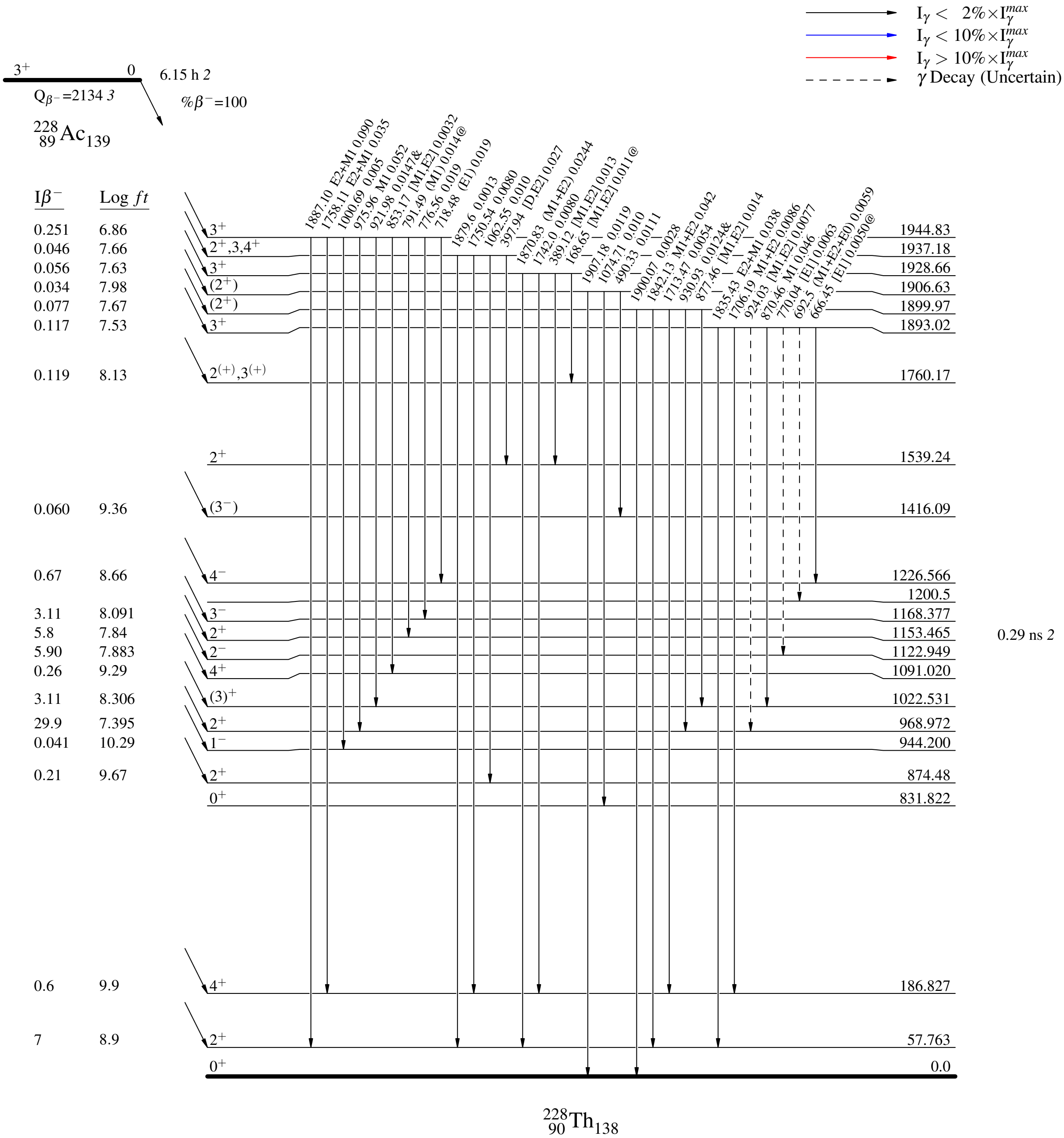
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

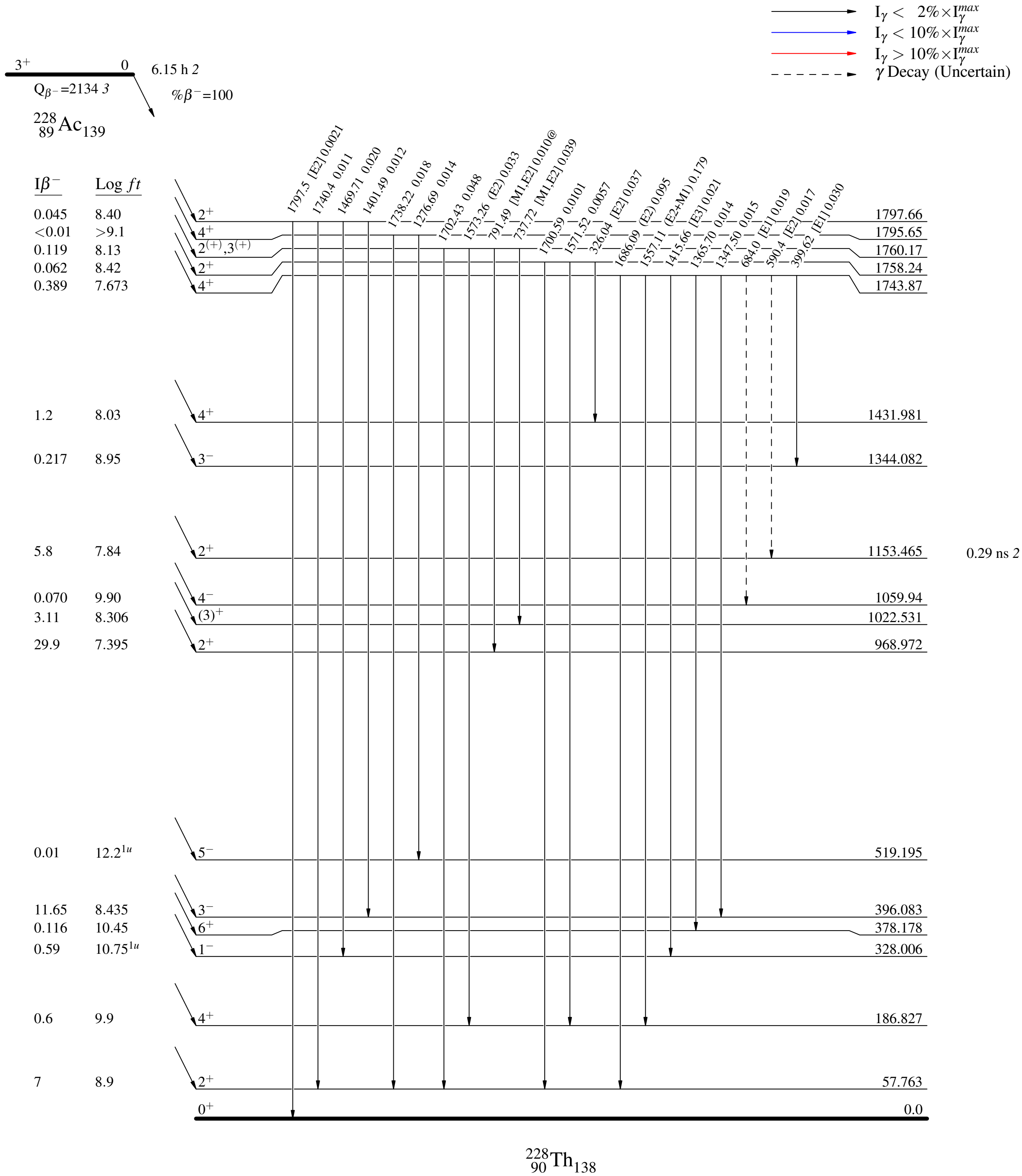
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

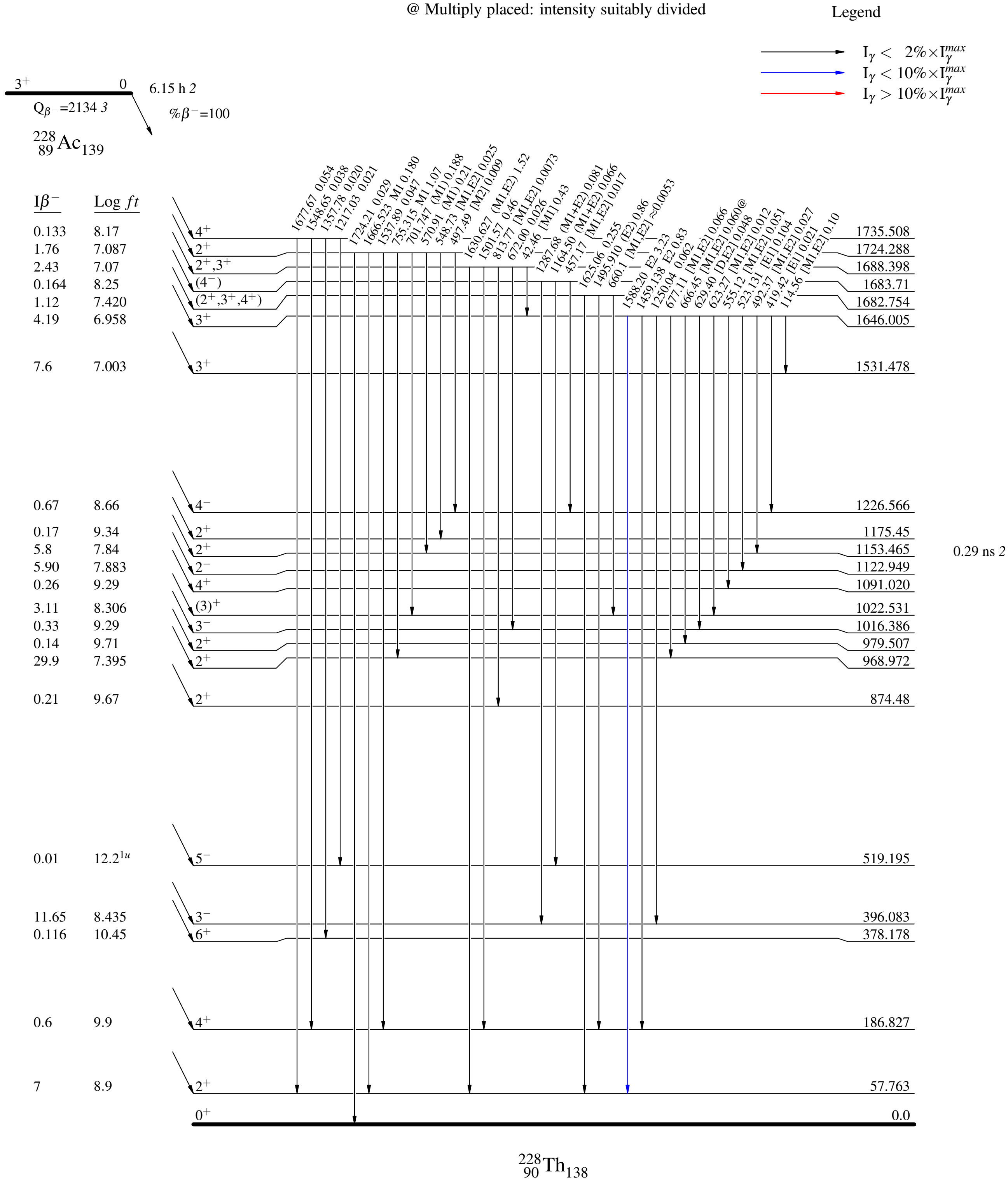
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

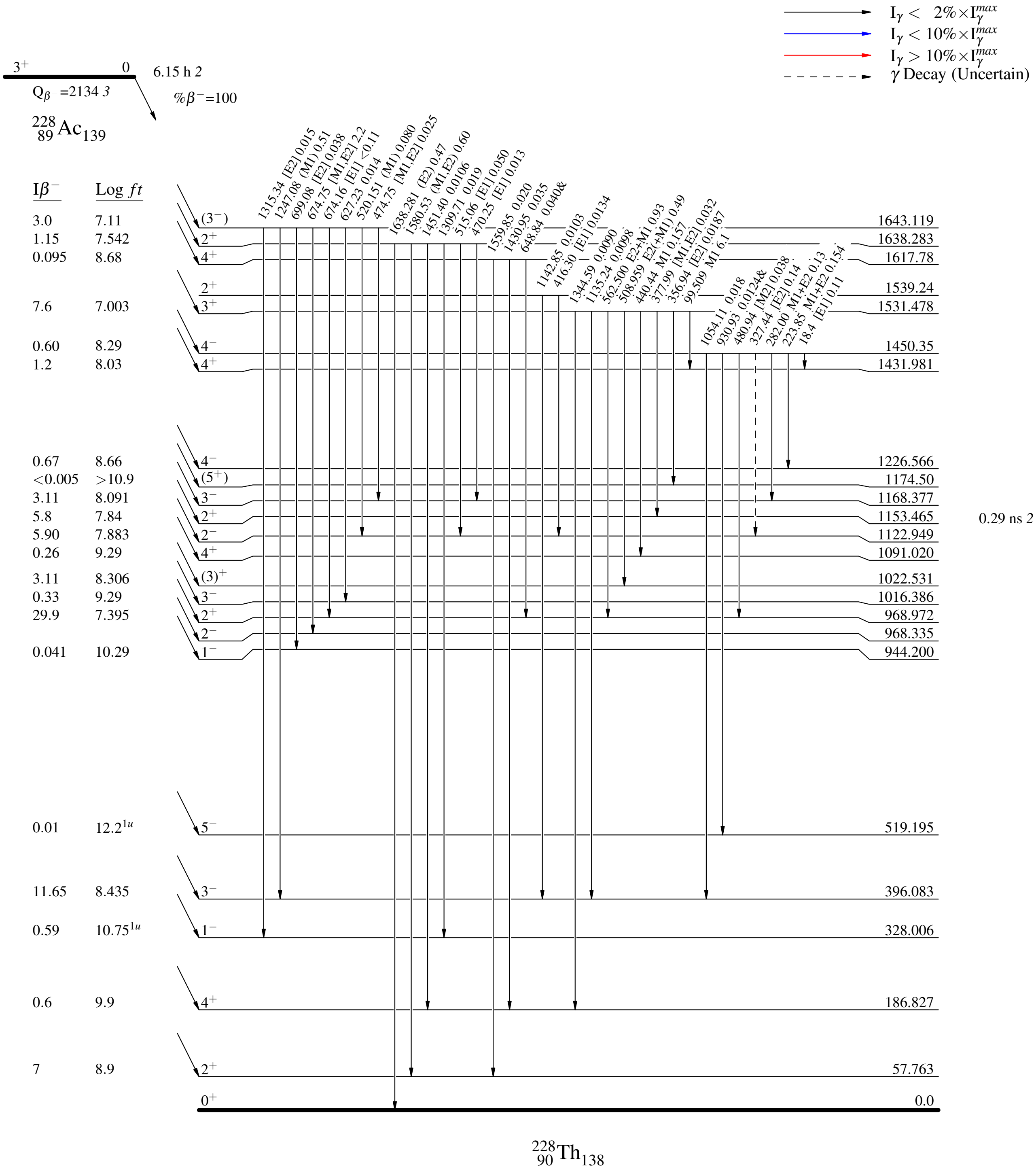
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

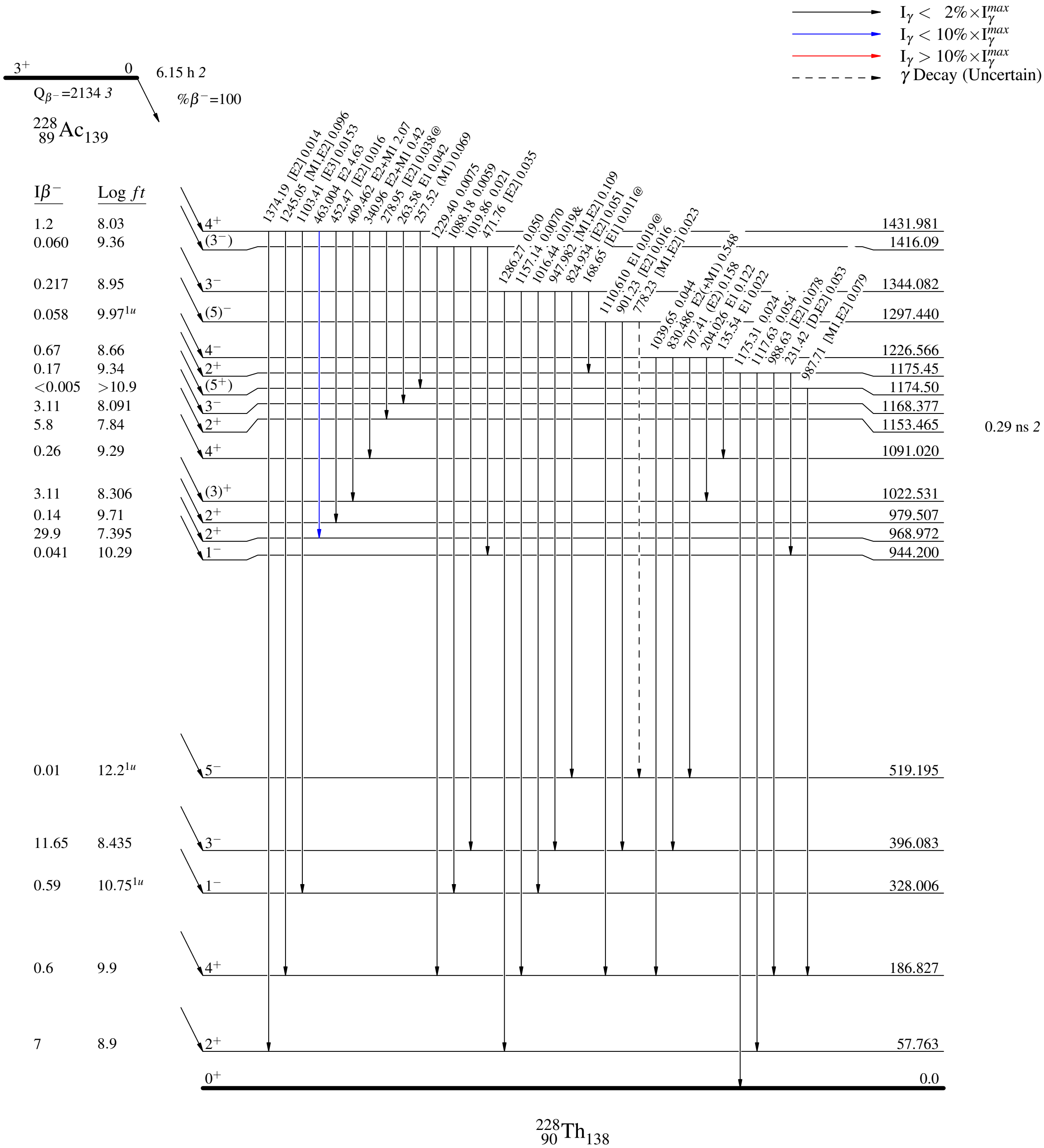
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

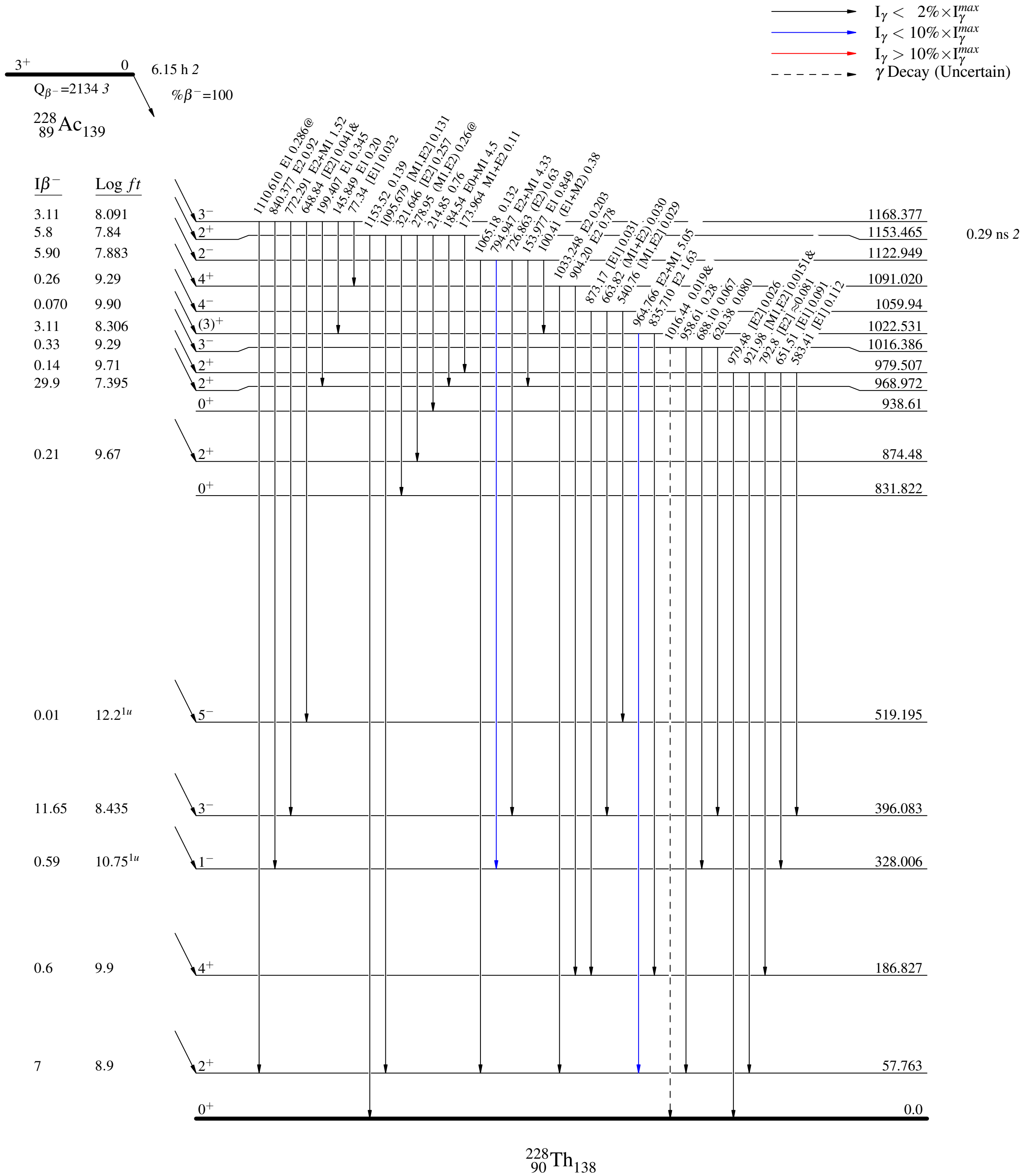
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

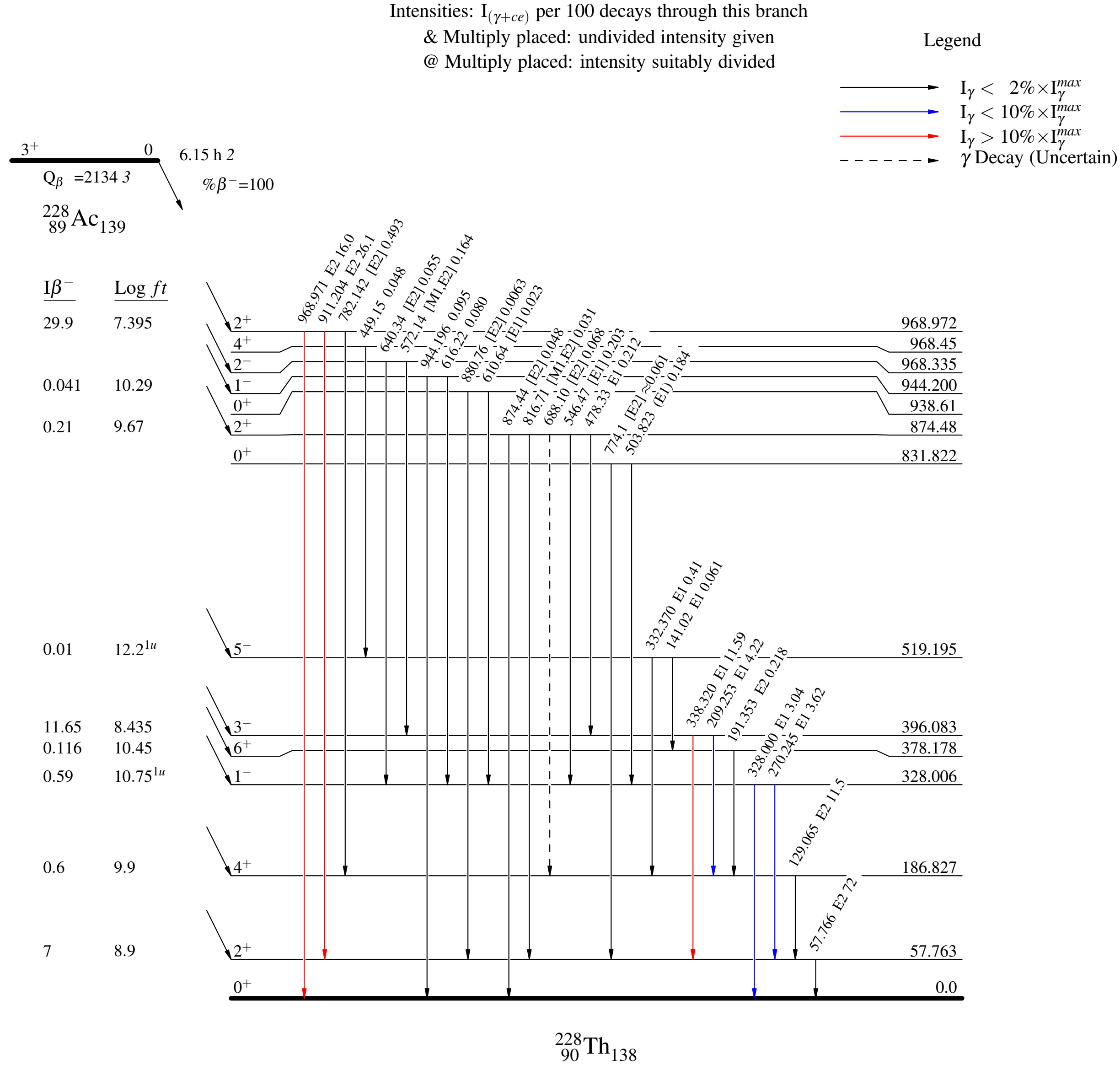
Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



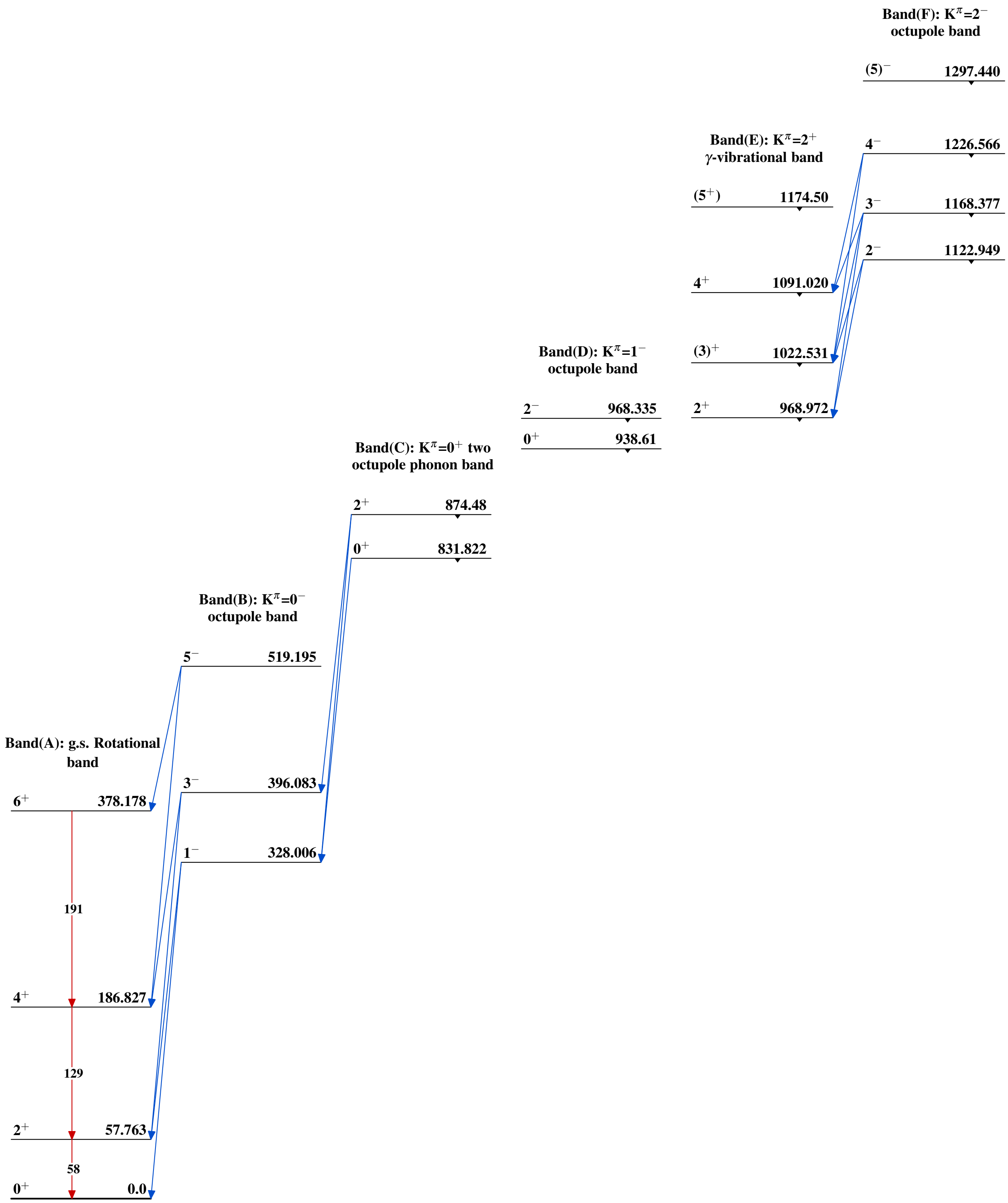
^{228}Ac β^- decay 1987Da28

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{228}Ac β^- decay 1987Da28



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$^{228}Ac\ \beta^-$ decay 1987Da28 (continued)

$^{228}_{90}Th_{138}$