^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Sukhjeet Singh	ENSDF	08-Mar-2022

Parent: ^{228}Pa: E=0; $J^\pi=3^+$; $T_{1/2}$=19.5 h *4*; Q(α)=6264.5 *15*; %α decay=2.0 *2*

^{228}Pa-J^π: From ^{228}Pa Adopted Levels in ENSDF database (Dec 2012 update). 1989He07 discuss π7/2[633]⊗ν1/2[631] configuration for this state and conclude that it is not probable due to energy mismatch even though the measured magnetic moment is in agreement with theoretical value for this configuration, and that π5/2⊗ν1/2 octupole deformed configuration is more likely.

^{228}Pa-$T_{1/2}$: from 2021Km01 (γ-decay curves, uncertainty is statistical). Others: 22 h *1* (1951Me10, α-decay curve, analysis complicated by the presence of ^{229}Pa activity); 29 h *1* (1964Ge08).

^{228}Pa-Q(α): From 2021Wa16.

^{228}Pa-%α decay: From measured Iα/(Iα+Iε)=0.020 *2* (1994Ah03). Other: Iε/Iα=53 *5* (1951Me10).

1994Ah03: ^{228}Pa produced in ^{232}Th(p,5n) at 45 MeV followed by chemical separation. Measured Eα, Iα, Eγ, Iγ, ce, $\alpha\gamma$-, and α(x ray)-coin, $\alpha\gamma\gamma$-coin, α(ce)-coin using Ge, LEPS and Si(Li) detectors. Deduced levels, J, π, conversion coefficients, multipolarity, α hindrance factors, octupole deformation.

1993Sh07 (also 1991Sh14,2004Sh25,2008Sh18): ^{228}Pa produced in ^{232}Th(p,5n) at 200 MeV followed by chemical separation. Measured Eα, Iα, Eγ, Iγ, ce, $\alpha\gamma$-, and α(ce)-coin using Ge and Si(Li) detectors. Deduced levels, J, π, multipolarity, α hindrance factors, octupole deformation and reflection asymmetry. 2004Sh25 (also 2008Sh18) discuss differences in the level schemes, bands and interpretation presented in 1993Sh07 and those in 1994Ah03.

1958Hi78: ^{228}Pa formed in ^{230}Th(d,4n) reaction; measured Eα, Iα, Eγ. Deduced levels, hindrance factors.

Levels in ^{224}Ac were first proposed in 1958Hi78 from α decay of ^{228}Pa to levels in ^{224}Ac. 1993Sh07 first observed γ rays in singles and coincidence modes, and proposed a level scheme incorporating 34 γ rays out of a total of 45 γ rays observed. The authors interpreted level scheme in terms of parity-doublet (or reflection asymmetric) structures composed of $K^\pi=0^-$, 0^+, 3^+, 3^-, (1^+) and (1^-) bands. 1994Ah03 investigated in detail γ, ce and α spectra in singles and coincidence modes using a much stronger source than in 1993Sh07, and reported 86 γ rays with 73 γ rays incorporated in a level scheme based essentially on coincidence data. For most levels the authors assigned only the parities based on gamma-ray multipolarities, but did not agree with $K^\pi=0^-$ and 0^+ parity-doublet bands proposed by 1993Sh07. Although energies and relative intensities of most γ rays reported in 1993Sh07 agreed with those in 1994Ah03, yet there were several differences in γ-ray placements. 2004Sh25 (also 2008Sh18) have further discussed these differences and proposed revised level schemes and band structures.

In this evaluation, the level scheme is essentially that proposed by 1994Ah03 with some modifications suggested in 2004Sh25. The band structures are taken essentially from 2004Sh25, but considered tentative at this stage. As pointed out in 1994Ah03 and 2004Sh25, the level scheme of ^{224}Ac is very complex and many additional levels are expected. Thus the level scheme presented here is considered as incomplete. Information about confirmed multipolarities, mixing ratios and other spectroscopic details is lacking. Further experiments on the decay of ^{228}Pa and involving nuclear reactions are needed to confirm and elucidate the structure of this nucleus.

^{224}Ac Levels

Levels at 66.0, 89.3, (117.2), 132.9, 184.2, 397.5, (453.2) keV reported by 1993Sh07 have not been included here. The γ rays from these levels have been reassigned to other levels in 1994Ah03 from their detailed $\alpha\gamma$ and $\alpha\gamma\gamma$ coincidence data. Some of the levels are close in energy to the ones given here but transitions from them are different.

Band assignments are proposed in 2004Sh25. For the $K^\pi=0$ and 1 bands, two scenarios are presented in their figures 4 and 5. See detailed discussion by the authors. Assignments given here are arbitrarily taken from figure 4 in 2004Sh25. $K^\pi=3^+$ and 3^- parity-doublet bands are also supported by 1994Ah03 with minor differences in level assignments at high energy. 2004Sh25 suggest 5 other bands, not listed here, for which only one or two levels each are known.

E(level)[†]	J^π[‡]	$T_{1/2}$	Comments
0.0[@]	0^-	2.78 h *16*	$T_{1/2}$: from Adopted Levels.
17.60[@] *15*	(1^-)		
23.40 *11*	(2^-)		
29.83[&] *9*	(1^+)		

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

^{224}Ac Levels (continued)

E(level)[†]	Jπ[‡]	Comments
34.2? *8*		
37.17[@] *9*	(2⁻)	
44.2? *3*		
45.8? *4*	(⁻)	
47.4? *4*		
49.08 *13*	(3⁻)	
52.20[&] *11*	(2⁺)	
64.47 *14*	(3⁺)	Jπ: no parity assigned in 1994Ah03.
65.2? *6*		E(level): a level at 66.0 was suggested by 1993Sh07 with 28.8, 49 and 66.0 deexciting γ rays. These γ rays were placed elsewhere by 1994Ah03.
75.9? *6*		
78.51[@] *12*	(3⁻)	
80.49[&] *10*	(3⁺)	
84.1? *4*		
90.56 *13*	(⁺)	Jπ: parity assigned in 1994Ah03.
92.6? *4*		
100.44? *23*		
103.31 *13*	(4⁺)	
105.1? *6*		
109.33 *17*	(4⁻)	Jπ: no parity assigned in 1994Ah03.
110.53 *15*	(⁺)	Jπ: parity from 1994Ah03.
116.46[@] *13*	(4⁻)	
130.30[&] *11*	(4⁺)	
133.4? *4*		
142.5 *3*	(5⁺)	Jπ: no parity assigned in 1994Ah03.
146.6[#] *4*		E(level): this level may be the same as 142.4 level, but the energy matching is poor.
159.3[#] *4*		
169[#] *2*		
176.72[&] *14*	(5⁺)	
183.40[@] *13*	(5⁻)	
212[#] *2*		
219.7 *4*		
236.5[@] *4*	(6⁻)	
252.68[&] *17*	(6⁺)	
283.48 *13*	(3⁻)	
300[#] *2*		
317.2 *5*		
333.04 *12*	(3⁺)	
353.89[a] *11*	(3⁻)	
360.25[b] *11*	(3⁺)	
380.80 *16*	(⁺)	
395.84[a] *19*	(4⁻)	
402.92[b] *16*	(4⁺)	
448.08[a] *20*	(5⁻)	
452.1[b] *4*	(5⁺)	

[†] From least squares fit to Eγ data, unless otherwise noted.

[‡] J^π and band assignments are generally from 2004Sh25 (also 1993Sh07), $K^\pi=3^+$ and 3^- bands are supported also by 1994Ah03. For low-lying levels (below 254 keV), 1994Ah03 assign only parities based on γ-ray multipolarities. See also Adopted Levels.

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

^{224}Ac Levels (continued)

[#] From Eα.
[@] Band(A): Band based on 0^-. Mixture of $K^\pi=0^-$ and $K^\pi=1^-$ bands from $\pi3/2\otimes\nu3/2$ and $\pi5/2\otimes\nu3/2$ configurations (2004Sh25).
[&] Band(B): Band based on 1^+. Mixture of $K^\pi=0^+$ and $K^\pi=1^+$ bands from $\pi3/2\otimes\nu3/2$ and $\pi5/2\otimes\nu3/2$ configurations (2004Sh25).
[a] Band(C): Band based on (3^-). Mixture of $K^\pi=2^-$ and $K^\pi=3^-$ bands from $\pi5/2\otimes\nu1/2$ configuration (2004Sh25).
[b] Band(D): Band based on (3^+). Mixture of $K^\pi=2^+$ and $K^\pi=3^+$ bands from $\pi5/2\otimes\nu1/2$ configuration (2004Sh25).

α radiations

Eα[†]	E(level)	Iα[‡ b]	HF[#]	Comments
5711[a] *2*	452.1	*a*		
5711[a] *2*	448.08	1.00[a] *12*	48 *8*	Eα=5711, Iα=1.0 (1958Hi78).
5758 *2*	402.92	3.00 *22*	27 *4*	Eα=5756, Iα=2.5, and Eα=5760, Iα=1.4 (1958Hi78).
5765 *2*	395.84	2.6 *2*	34 *5*	Eα=5765, Iα=2.0 (1958Hi78).
5780 *2*	380.80	1.30 *14*	82 *13*	Eα=5779, Iα=1.4 (1958Hi78).
5800 *2*	360.25	10.7 *6*	13 *2*	Eα=5799, Iα=11.3 (1958Hi78).
5806 *2*	353.89	6.9 *4*	21 *3*	Eα=5805, Iα=7.3 (1958Hi78).
5827 *2*	333.04	5.8 *7*	32 *5*	
5844 *2*	317.2	≈0.4	≈5.5×10^2	Eα=5843, Iα=0.4 (1958Hi78).
5859 *2*	300	≈0.3	≈8.9×10^2	Eα=5858, Iα=0.3 (1958Hi78).
5875 *2*	283.48	1.30 *11*	2.5×10^2 *3*	Eα=5974, Iα=1.4 (1958Hi78).
5905 *2*	252.68	1.0 *1*	4.6×10^2 *7*	Eα= 5907, Iα=1.1 (1958Hi78).
5921 *2*	236.5	0.8 *1*	7×10^2 *1*	Eα=5922, Iα=0.8 (1958Hi78).
5940 *2*	219.7	0.5 *1*	1.3×10^3 *3*	Eα=5941, Iα=0.5 (1958Hi78).
5946 *2*	212	0.6 *1*	1.2×10^3 *3*	Eα= 5947, Iα=0.6 (1958Hi78).
5974 *2*	183.40	2.5 *2*	4.0×10^2 *5*	Eα=5975, Iα=2.7 (1958Hi78).
5981 *2*	176.72	2.6 *2*	4.1×10^2 *5*	Eα=5982, Iα=2.8 (1958Hi78).
5988 *2*	169	1.0 *1*	1.2×10^3 *2*	Eα=5989, Iα=1.1 (1958Hi78).
5997 *2*	159.3	≈0.3	≈4.3×10^3	Eα=5998, Iα=0.3 (1958Hi78).
6010 *2*	146.6	0.8 *1*	1.9×10^3 *3*	Eα=6011, Iα=0.8 (1958Hi78).
6027 *2*	130.30	8.5 *4*	2.1×10^2 *3*	Eα=6028, Iα=9.0 (1958Hi78).
6040 *2*	116.46	2.2 *3*	9.3×10^2 *16*	Eα=6041, Iα=2.3 (1958Hi78).
6047[&] *3*	110.53	≈0.3[&]	≈7.3×10^3	
6047[&] *3*	109.33	[&]		
6052 *3*	103.31	≈0.7	≈3.4×10^3	
6065 *2*	90.56	1.0 *2*	2.7×10^3 *6*	Eα=6066, Iα=1.0 (1958Hi78).
6076[@] *2*	80.49	19.5[@] *7*	1.6×10^2 *2*	
6076[@] *2*	78.51	[@]		Eα=6078, Iα=20.7 (1958Hi78).
6089 *2*	64.47	2.2 *3*	1.6×10^3 *3*	Eα=6091, Iα=2.3 (1958Hi78).
6104 *2*	52.20	11.3 *6*	3.6×10^2 *4*	Eα=6105, Iα=12.0 (1958Hi78).
6117 *2*	37.17	9.9 *5*	4.8×10^2 *6*	Eα=6118, Iα=10.5 (1958Hi78).
6126 *3*	29.83	≈1.0	≈5.2×10^3	

[†] From 1994Ah03. Values from 1993Sh07 and 1958Hi78 are given under comments. Uncertainties in 1958Hi78 are stated by 1994Ah03 as 0.5 keV, but systematic uncertainties are 3-4 keV. A 6142α group in 1958Hi78 was later assigned by 1964Mc21 to ^{224}Ac α decay.
[‡] From 1994Ah03, renormalized intensities in α-spectrum of 1958Hi78.
[#] The nuclear radius parameter $r_0(^{224}Ac)=1.5318$ *16* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides from 2020Si16 evaluation.
[@] Doublet feeding 78 and 80 levels; total Iα=19.5 *7*.
[&] Doublet feeding 109 and 110 levels; total Iα≈0.3.

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

α radiations (continued)

[a] Doublet feeding 448 and 451 levels; total Iα=1.00 *12*.
[b] For absolute intensity per 100 decays, multiply by 0.020 *2*.

γ(^{224}Ac)

Iγ normalization: 1994Ah03 and 1993Sh07 give photon intensities per 100 α decays.
Measured I(Kα_1 x ray)=6.7 *7*, I(Kα_2 x ray)=4.0 *4*, I(K x ray)=13.6 *15* (1994Ah03).
Measured I(K x ray)=12.5 *11*, I(L x ray)=55 *10* (1993Sh07).
Experimental K-conversion coefficients are from 1994Ah03.

E_γ[†]	I_γ[†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[d]	Comments
(22)		52.20	(2$^+$)	29.83	(1$^+$)	[M1]	291	α(L)=220 *3*; α(M)=53.4 *8* α(N)=14.16 *20*; α(O)=3.29 *5*; α(P)=0.609 *9*; α(Q)=0.0543 *8* E_γ: γ required by the αγ results of 1993Sh07; γ not in 1994Ah03.
x23.3‡ *2*	0.12‡ *5*							Placed from an 89.3 level, and mult=(E1) (1993Sh07).
x24.9‡ *2*	0.10‡ *5*							
26.3 *1*	0.36 *5*	78.51	(3$^-$)	52.20	(2$^+$)	E1[a]	3.93 *7*	α(L)=2.95 *5*; α(M)=0.751 *13* α(N)=0.193 *4*; α(O)=0.0400 *7*; α(P)=0.00566 *10*; α(Q)=0.000185 *3* Eγ=26.3 *1*, Iγ=0.33 *6* (1993Sh07).
28.3 *1*	≈0.1	80.49	(3$^+$)	52.20	(2$^+$)	[M1]	138.9 *25*	α(L)=105.1 *19*; α(M)=25.3 *5* α(N)=6.71 *12*; α(O)=1.56 *3*; α(P)=0.289 *5*; α(Q)=0.0257 *5* Part of the 28.8 doublet in 1993Sh07.
28.8 *1*	0.76 *12*	52.20	(2$^+$)	23.40	(2$^-$)	E1[a]	3.10 *6*	α(L)=2.33 *4*; α(M)=0.588 *10* α(N)=0.151 *3*; α(O)=0.0316 *6*; α(P)=0.00455 *8*; α(Q)=0.0001549 *25* E_γ: 1993Sh07 placed 28.8γ from a 66.0 and 80.5 levels. 1994Ah03 reported two γ rays at 28.3 and 28.8, former from 80.4 level, and the latter from 52.1 level based on coincidence data. Eγ=28.8 *1*, Iγ=1.33 *20* (1993Sh07).
29.8 *1*	2.8 *3*	29.83	(1$^+$)	0.0	0$^-$	E1[a]	2.83 *5*	α(L)=2.13 *4*; α(M)=0.536 *9* α(N)=0.1381 *23*; α(O)=0.0289 *5*; α(P)=0.00419 *7*; α(Q)=0.0001448 *23* Eγ=29.8 *1*, Iγ=3.10 *30* (1993Sh07).
34.6 *1*	1.8 *2*	52.20	(2$^+$)	17.60	(1$^-$)	E1[a]	1.91	α(L)=1.437 *23*; α(M)=0.359 *6* α(N)=0.0926 *15*; α(O)=0.0196 *4*; α(P)=0.00292 *5*; α(Q)=0.0001074 *17* Eγ=34.6 *1*, Iγ=1.55 *20* (1993Sh07).
36.0 *1*	0.52 *8*	116.46	(4$^-$)	80.49	(3$^+$)	(E1)	1.72 *3*	α(L)=1.294 *21*; α(M)=0.322 *6* α(N)=0.0833 *14*; α(O)=0.0177 *3*; α(P)=0.00265 *5*; α(Q)=9.91×10^{-5} *15* Eγ=36.1 *1*, Iγ=0.22 *5* (1993Sh07).
37.2[f] *1*	≈0.2	37.17	(2$^-$)	0.0	0$^-$	[E2]	1200 *24*	α(L)=881 *17*; α(M)=239 *5* α(N)=63.5 *13*; α(O)=13.8 *3*; α(P)=2.13 *5*; α(Q)=0.00463 *9* Eγ=37.2 *2*, Iγ=0.13 *5* (1993Sh07). γ placed from 37.2 and 89.3 levels (1993Sh07).
41.1 *1*	0.54 *9*	64.47	(3$^+$)	23.40	(2$^-$)	[E1]	1.211 *19*	α(L)=0.912 *14*; α(M)=0.226 *4*

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ [†]	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	α [d]	Comments
								α(N)=0.0584 *9*; α(O)=0.01251 *20*; α(P)=0.00191 *3*; α(Q)=7.56×10^{-5} *12* E_γ: 1993Sh07 placed 41.1γ from 78.4 level. Eγ=41.1 *1*, Iγ=0.48 *8* (1993Sh07). Mult.: (M1) in 1993Sh07, but no argument given.
43.3 *1*	2.4 *3*	80.49	(3$^+$)	37.17	(2$^-$)	E1 [a]	1.054 *17*	α(L)=0.794 *13*; α(M)=0.196 *3* α(N)=0.0508 *8*; α(O)=0.01092 *17*; α(P)=0.00168 *3*; α(Q)=6.79×10^{-5} *10* Eγ=43.3 *1*, Iγ=2.40 *20* (1993Sh07).
46.5 *2*	≈0.2	176.72	(5$^+$)	130.30	(4$^+$)	[M1]	32.1 *6*	α(L)=24.3 *5*; α(M)=5.84 *11* α(N)=1.55 *3*; α(O)=0.360 *7*; α(P)=0.0666 *13*; α(Q)=0.00593 *12* Eγ=46.5 *2*, Iγ=0.11 *5* (1993Sh07).
48.6[#f] *1*	0.80 *13*	78.51	(3$^-$)	29.83	(1$^+$)	[M2]	1320 *23*	α(L)=958 *17*; α(M)=269 *5* α(N)=73.5 *13*; α(O)=16.9 *3*; α(P)=2.97 *5*; α(Q)=0.210 *4* 2004Sh25 suggest that this γ may belong to ^{220}Fr from ^{224}Ac α decay, yet αγ coincidence data in figure 3 of 1994Ah03 clearly show this γ ray, and this γ is also listed in αγγ coin data in table 4 of 1994Ah03. Its implied M2 multipolarity is, however, problematic, for J^π=3$^-$ for 78 level and 1$^+$ for 29.8 level.
49.8 *1*	0.27 *5*	130.30	(4$^+$)	80.49	(3$^+$)	[M1]	26.3	α(L)=19.9 *3*; α(M)=4.77 *8* α(N)=1.266 *20*; α(O)=0.294 *5*; α(P)=0.0545 *9*; α(Q)=0.00485 *8* Eγ=49.9 *2*, Iγ=0.36 *10* (1993Sh07).
51.8 *1*	1.35 *15*	130.30	(4$^+$)	78.51	(3$^-$)	(E1)	0.654	α(L)=0.494 *8*; α(M)=0.1211 *18* α(N)=0.0314 *5*; α(O)=0.00682 *11*; α(P)=0.001073 *16*; α(Q)=4.66×10^{-5} *7* Eγ=51.9 *1*, Iγ=2.20 *20* (1993Sh07); 51.8, 52.0, 52.1 γ rays with total Iγ=2.10 *18* in 1994Ah03.
52.0 *2*	0.45 *8*	116.46	(4$^-$)	64.47	(3$^+$)	[E1]	0.647 *12*	α(L)=0.489 *9*; α(M)=0.1199 *21* α(N)=0.0311 *6*; α(O)=0.00675 *12*; α(P)=0.001063 *19*; α(Q)=4.62×10^{-5} *8* Part of 51.9γ in 1993Sh07 from 130 level.
52.1[f] *2*	0.30 *6*	52.20	(2$^+$)	0.0	0$^-$	[M2]	963 *22*	α(L)=699 *16*; α(M)=196 *5* α(N)=53.4 *12*; α(O)=12.3 *3*; α(P)=2.16 *5*; α(Q)=0.154 *4* Part of 51.9γ from 130 level in 1993Sh07. E_γ: 2004Sh25 argue against the placement or existence of this γ ray in 1994Ah03, and suggest that its appearance in αγ coincidence data of 1994Ah03 may be due to α+ce sum line. Its implied M2 multipolarity is also problematic for J^π=2$^+$ for 52 level and 0$^-$ for g.s.
53.1 *1*	0.40 *6*	183.40	(5$^-$)	130.30	(4$^+$)	(E1)	0.612	α(L)=0.462 *7*; α(M)=0.1133 *17* α(N)=0.0294 *5*; α(O)=0.00639 *10*; α(P)=0.001009 *15*; α(Q)=4.42×10^{-5} *7* E_γ: 1993Sh07 placed 53.1γ from a 90.3 levels. Eγ=53.1 *1*, Iγ=0.90 *15*, mult=(E1) (1993Sh07), placed from a 90.3 level.

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ [†]	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	α [d]	Comments
54.2 *1*	1.2 *2*	103.31	(4$^+$)	49.08	(3$^-$)	(E1)	0.580	α(L)=0.438 *7*; α(M)=0.1073 *16* α(N)=0.0279 *5*; α(O)=0.00606 *9*; α(P)=0.000958 *15*; α(Q)=4.24×10^{-5} *7* Eγ: 1993Sh07 placed 54.2γ from a 184.2 level. Eγ=54.2 *1*, Iγ=1.30 *15* (1993Sh07), placed from a 184.2 level.
59.8 *3*	0.14 *5*	236.5	(6$^-$)	176.72	(5$^+$)	[E1]	0.446 *9*	α(L)=0.337 *7*; α(M)=0.0824 *16* α(N)=0.0214 *5*; α(O)=0.00468 *9*; α(P)=0.000748 *15*; α(Q)=3.43×10^{-5} *6* Part of 60.3γ from 177 level in 1993Sh07.
60.3[eb] *2*	0.84[e] *13*	109.33	(4$^-$)	49.08	(3$^-$)	[M1]	15.0 *3*	α(L)=11.34 *20*; α(M)=2.72 *5* α(N)=0.722 *13*; α(O)=0.168 *3*; α(P)=0.0311 *6*; α(Q)=0.00276 *5* Eγ=60.3 *2*, Iγ=0.55 *7* (1993Sh07), placed from 177.0 and 237.2 levels.
60.3[e] *2*	0.84[e] *13*	176.72	(5$^+$)	116.46	(4$^-$)	(E1)	0.436 *8*	α(L)=0.330 *6*; α(M)=0.0805 *14* α(N)=0.0209 *4*; α(O)=0.00457 *8*; α(P)=0.000733 *12*; α(Q)=3.37×10^{-5} *6* Eγ=60.3 *2*, Iγ=0.55 *7* (1993Sh07).
61.5 *1*	0.30 *5*	110.53	(+)	49.08	(3$^-$)			Eγ: 1993Sh07 placed 61.4γ from 78.4 level. Eγ=61.4 *2*, Iγ=0.33 *6* (1993Sh07).
62.5[f] *1*	0.36 *6*	146.6		84.1?				Eγ=62.5 *2*, Iγ=0.29 *5* (1993Sh07).
66.3[f] *3*	≈0.05	159.3		92.6?				Eγ=66.0 *3*, Iγ=0.16 *4* (1993Sh07); placed from a 66.0 level.
67.2 *1*	1.7 *3*	90.56	(+)	23.40	(2$^-$)	(E1)	0.327	α(L)=0.247 *4*; α(M)=0.0602 *9* α(N)=0.01568 *23*; α(O)=0.00344 *5*; α(P)=0.000557 *8*; α(Q)=2.67×10^{-5} *4* Eγ=67.3 *1*, Iγ=1.50 *20* (1993Sh07); placed from an 89.3 level.
67.4 *2*	0.67 *10*	176.72	(5$^+$)	109.33	(4$^-$)	[E1]	0.324 *6*	α(L)=0.245 *4*; α(M)=0.0597 *10* α(N)=0.0156 *3*; α(O)=0.00341 *6*; α(P)=0.000553 *9*; α(Q)=2.65×10^{-5} *4* Part of 67.3γ from 89.3 level in 1993Sh07.
69.3 *2*	0.35 *6*	252.68	(6$^+$)	183.40	(5$^-$)	(E1)	0.301	α(L)=0.228 *4*; α(M)=0.0555 *9* α(N)=0.01444 *24*; α(O)=0.00317 *5*; α(P)=0.000515 *9*; α(Q)=2.50×10^{-5} *4* Eγ=69.3 *2*, Iγ=0.25 *5* (1993Sh07).
73.4 *2*	0.14 *6*	176.72	(5$^+$)	103.31	(4$^+$)	[M1]	8.43 *14*	α(L)=6.38 *11*; α(M)=1.531 *25* α(N)=0.406 *7*; α(O)=0.0945 *16*; α(P)=0.0175 *3*; α(Q)=0.00155 *3* Eγ: 1993Sh07 placed 73.3γ from a 90.3 level. Eγ=73.3 *3*, Iγ=0.18 *5* (1993Sh07), placed from a 90.3 level.
74.1 *3*	0.15 *4*	183.40	(5$^-$)	109.33	(4$^-$)	[M1]	8.20 *15*	α(L)=6.21 *12*; α(M)=1.49 *3* α(N)=0.395 *8*; α(O)=0.0919 *17*; α(P)=0.0170 *4*; α(Q)=0.00151 *3* Eγ=74.2 *3*, Iγ=0.16 *5* (1993Sh07), unplaced.
75.5[#f] *3*	≈0.10	159.3		84.1?				
76.0[#] *2*	0.15 *4*	252.68	(6$^+$)	176.72	(5$^+$)	[M1]	7.62 *13*	α(L)=5.77 *10*; α(M)=1.384 *23* α(N)=0.367 *6*; α(O)=0.0854 *14*; α(P)=0.0158 *3*; α(Q)=0.001403 *23*
77.2[#] *2*	≈0.3	219.7		142.5	(5$^+$)			
78.6[f] *3*	0.11 *5*	130.30	(4$^+$)	52.20	(2$^+$)	[E2]	32.2 *8*	α(L)=23.6 *6*; α(M)=6.46 *15* α(N)=1.72 *4*; α(O)=0.374 *9*; α(P)=0.0583 *14*;

Continued on next page (footnotes at end of table)

^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ [†]	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	δ	α [d]	Comments
									α(Q)=0.000186 *4* E_γ: γ from 1993Sh07 only.
80.1 *1*	0.34 *6*	183.40	(5⁻)	103.31	(4⁺)	(E1)		0.205	α(L)=0.1550 *23*; α(M)=0.0376 *6* α(N)=0.00982 *15*; α(O)=0.00217 *4*; α(P)=0.000357 *6*; α(Q)=1.82×10⁻⁵ *3* E_γ: 1993Sh07 placed 79.9γ from a tentative 117.2 level.
81.2 *1*	1.2 *2*	130.30	(4⁺)	49.08	(3⁻)	[E1]		0.198	Eγ=79.9 *2*, Iγ=0.37 *7* (1993Sh07). α(L)=0.1495 *22*; α(M)=0.0363 *6* α(N)=0.00947 *14*; α(O)=0.00209 *3*; α(P)=0.000345 *5*; α(Q)=1.77×10⁻⁵ *3* E_γ: 1993Sh07 placed 81.1γ from a 132.9 level. Eγ=81.1 *1*, Iγ=1.50 *20* (1993Sh07).
86.3[#f] *2*	≈0.2	219.7		133.4?					
110.3[#] *4*	0.30 *6*	252.68	(6⁺)	142.5	(5⁺)	[M1]		12.82 *22*	α(K)=10.23 *18*; α(L)=1.96 *4*; α(M)=0.470 *9* α(N)=0.1246 *22*; α(O)=0.0290 *5*; α(P)=0.00536 *10*; α(Q)=0.000476 *9*
122.5[#] *5*	≈0.08	252.68	(6⁺)	130.30	(4⁺)	[E2]		4.34 *10*	α(K)=0.284 *4*; α(L)=2.97 *7*; α(M)=0.812 *20* α(N)=0.216 *5*; α(O)=0.0471 *11*; α(P)=0.00741 *18*; α(Q)=3.91×10⁻⁵ *8*
140.8[#] *4*	0.15 *4*	283.48	(3⁻)	142.5	(5⁺)	[M2]		36.9 *7*	α(K)=23.6 *4*; α(L)=9.83 *18*; α(M)=2.60 *5* α(N)=0.704 *13*; α(O)=0.162 *3*; α(P)=0.0292 *6*; α(Q)=0.00227 *4*
193.0[#] *2*	0.08 *3*	283.48	(3⁻)	90.56	(⁺)				
195.5[#] *2*	0.10 *3*	448.08	(5⁻)	252.68	(6⁺)	[E1]		0.0974	α(K)=0.0773 *11*; α(L)=0.01525 *22*; α(M)=0.00366 *6* α(N)=0.000961 *14*; α(O)=0.000218 *3*; α(P)=3.80×10⁻⁵ *6*; α(Q)=2.50×10⁻⁶ *4*
202.7 *1*	0.56 *8*	333.04	(3⁺)	130.30	(4⁺)	M1(+E2)	<0.6	2.07 *23*	α(K)exp=1.8 *4* α(K)=1.62 *23*; α(L)=0.342 *6*; α(M)=0.0832 *13* α(N)=0.0221 *4*; α(O)=0.00509 *8*; α(P)=0.000925 *23*; α(Q)=7.4×10⁻⁵ *10* Eγ=202.5 *4*, Iγ=0.70 *25* (1993Sh07); unplaced.
212.5[#] *5*	≈0.05	395.84	(4⁻)	183.40	(5⁻)				
222.7[#] *2*	≈0.1	333.04	(3⁺)	110.53	(⁺)				
226.3[#] *2*	≈0.1	402.92	(4⁺)	176.72	(5⁺)	[M1]		1.689	α(K)=1.355 *20*; α(L)=0.253 *4*; α(M)=0.0606 *9* α(N)=0.01608 *23*; α(O)=0.00374 *6*; α(P)=0.000692 *10*; α(Q)=6.13×10⁻⁵ *9*
230.0 *1*	1.8 *3*	360.25	(3⁺)	130.30	(4⁺)	M1(+E2)[&]	<0.7	1.41 *21*	α(K)=1.10 *20*; α(L)=0.233 *10*; α(M)=0.0568 *15* α(N)=0.0151 *4*; α(O)=0.00347 *11*; α(P)=0.00063 *4*; α(Q)=5.0×10⁻⁵ *9* α(K)exp=1.3 *3* Eγ=230.0 *3*, Iγ=2.0 *5* (1993Sh07).

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	α[d]	Comments
232.6[f] *2*	0.38 *6*	333.04	(3$^+$)	100.44?				Eγ=233.0 *10*, Iγ=0.50 *30* (1993Sh07).
237.5 *2*	0.40 *5*	353.89	(3$^-$)	116.46	(4$^-$)	(M1)	1.476	α(K)=1.184 *17*; α(L)=0.221 *4*; α(M)=0.0529 *8* α(N)=0.01404 *20*; α(O)=0.00327 *5*; α(P)=0.000604 *9*; α(Q)=5.35×10^{-5} *8* α(K)exp(237.5γ+237.7γ)=1.1 *3* (1994Ah03). Eγ=237.5 *7*, Iγ=0.60 *30* (1993Sh07).
237.7[f] *3*	0.20 *4*	283.48	(3$^-$)	45.8?	(−)	(M1)	1.473	α(K)=1.182 *17*; α(L)=0.221 *4*; α(M)=0.0528 *8* α(N)=0.01401 *21*; α(O)=0.00326 *5*; α(P)=0.000603 *9*; α(Q)=5.34×10^{-5} *8* α(K)exp(237.5γ+237.7γ)=1.1 *3* (1994Ah03). Part of 237.5γ from 354 level in 1993Sh07.
242.6 *2*	0.30 *5*	333.04	(3$^+$)	90.56	(+)	(M1)	1.392	α(K)=1.117 *16*; α(L)=0.208 *3*; α(M)=0.0499 *7* α(N)=0.01323 *19*; α(O)=0.00308 *5*; α(P)=0.000569 *8*; α(Q)=5.04×10^{-5} *8* α(K)exp(242.6γ+244.7γ)=1.2 *4*. Eγ=242.5 *7*, Iγ=0.50 *30* (1993Sh07); unplaced.
244.7 *5*	0.21 *5*	353.89	(3$^-$)	109.33	(4$^-$)	(M1)	1.359	α(K)=1.090 *17*; α(L)=0.203 *3*; α(M)=0.0487 *8* α(N)=0.01292 *20*; α(O)=0.00300 *5*; α(P)=0.000556 *9*; α(Q)=4.92×10^{-5} *8* α(K)exp(242.6γ+244.7γ)=1.2 *3* (1994Ah03). Eγ=245.0 *10*, Iγ=0.40 *20* (1993Sh07); unplaced.
246.2[#] *2*	0.27 *6*	283.48	(3$^-$)	37.17	(2$^-$)	[M1]	1.336	α(K)=1.072 *16*; α(L)=0.200 *3*; α(M)=0.0479 *7* α(N)=0.01270 *18*; α(O)=0.00295 *5*; α(P)=0.000546 *8*; α(Q)=4.84×10^{-5} *7*
248.8[f] *5*	0.17 *6*	353.89	(3$^-$)	105.1?				Eγ=248.6 *6*, Iγ=0.55 *30* (1993Sh07).
250.5 *2*	0.34 *7*	380.80	(+)	130.30	(4$^+$)	(M1)	1.273	α(K)=1.022 *15*; α(L)=0.190 *3*; α(M)=0.0456 *7* α(N)=0.01210 *18*; α(O)=0.00281 *4*; α(P)=0.000520 *8*; α(Q)=4.61×10^{-5} *7* α(K)exp(250.5γ+252.6γ)=0.95 *26* (1994Ah03). Eγ=251.1 *8*, Iγ=0.45 *25* (1993Sh07); unplaced.
252.6 *2*	0.40 *8*	333.04	(3$^+$)	80.49	(3$^+$)	(M1)	1.244	α(K)=0.998 *15*; α(L)=0.186 *3*; α(M)=0.0446 *7* α(N)=0.01182 *17*; α(O)=0.00275 *4*; α(P)=0.000508 *8*; α(Q)=4.50×10^{-5} *7* α(K)exp(250.5γ+252.6γ)=0.95 *26* (1994Ah03). Eγ=252.6 *10*, Iγ=0.35 *20* (1993Sh07); unplaced.
253.4[#] *5*	≈0.08	395.84	(4$^-$)	142.5	(5$^+$)			
260.1 *1*	0.76 *8*	283.48	(3$^-$)	23.40	(2$^-$)	[M1]	1.147	α(K)=0.921 *13*; α(L)=0.1715 *24*; α(M)=0.0411 *6* α(N)=0.01089 *16*; α(O)=0.00253 *4*; α(P)=0.000468 *7*; α(Q)=4.15×10^{-5} *6* Eγ=261.0 *10*, Iγ=0.50 *20* (1993Sh07); unplaced.
267.8[f] *5*	0.21 *7*	333.04	(3$^+$)	65.2?				
268.7[f] *5*	0.36 *8*	360.25	(3$^+$)	90.56	(+)			
269.1[f] *4*	0.29 *7*	353.89	(3$^-$)	84.1?				Eγ=269.0 *10*, Iγ=0.50 *20* (1993Sh07); 267.8, 268.7, 269.1 γ rays with total Iγ=0.86 *13* in 1994Ah03.
278.0[f] *5*	≈0.2	353.89	(3$^-$)	75.9?				
279.5 *4*	0.37 *9*	360.25	(3$^+$)	80.49	(3$^+$)	[M1]	0.940	α(K)=0.754 *11*; α(L)=0.1404 *21*; α(M)=0.0336 *5* α(N)=0.00891 *13*; α(O)=0.00207 *3*; α(P)=0.000383 *6*; α(Q)=3.40×10^{-5} *5* Eγ=279.7 *10*, Iγ=0.40 *20* (1993Sh07).
280.0[b] *5*	≈0.2	317.2		37.17	(2$^-$)			Part of 279.7γ from 360 level in 1993Sh07.
280.8[b] *4*	≈0.2	333.04	(3$^+$)	52.20	(2$^+$)			Eγ=281.0 *10*, Iγ=0.40 *20* (1993Sh07).
283.0[f] *5*	≈0.2	317.2		34.2?				
283.4 *4*	≈0.3	333.04	(3$^+$)	49.08	(3$^-$)			Eγ=283.0 *10*, Iγ=0.40 *20* (1993Sh07); unplaced.

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ[†]	I_γ[†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[d]	Comments
285.8[#f] 5	≈0.1	333.04	(3+)	47.4?					
288.9[#f] 5	≈0.3	333.04	(3+)	44.2?					
290.0 5	≈0.5	353.89	(3−)	64.47	(3+)				Eγ=290.0 7, Iγ=0.60 30 (1993Sh07); unplaced.
295.5[#] 4	≈0.2	333.04	(3+)	37.17	(2−)				
299.5[#] 3	≈0.2	402.92	(4+)	103.31	(4+)	[M1]		0.777	α(K)=0.624 9; α(L)=0.1159 17; α(M)=0.0277 4 α(N)=0.00736 11; α(O)=0.001711 25; α(P)=0.000317 5; α(Q)=2.80×10^{-5} 4
300.3[#] 3	≈0.1	380.80	(+)	80.49	(3+)				
303.2 2	0.64 11	333.04	(3+)	29.83	(1+)	[E2]		0.1550	α(K)=0.0704 10; α(L)=0.0624 9; α(M)=0.01665 24 α(N)=0.00443 7; α(O)=0.000980 14; α(P)=0.0001601 23; α(Q)=3.61×10^{-6} 5 Eγ=303.0 10, Iγ=0.60 30 (1993Sh07); unplaced.
308.0 1	4.0 4	360.25	(3+)	52.20	(2+)	M1(+E2)[&]	<0.4	0.68 4	α(K)=0.54 4; α(L)=0.104 4; α(M)=0.0250 8 α(N)=0.00663 21; α(O)=0.00154 5; α(P)=0.000283 11; α(Q)=2.44×10^{-5} 16 α(K)exp=0.63 12 Eγ=308.1 2, Iγ=4.1 8 (1993Sh07).
309.6[#f] 3	≈0.5	353.89	(3−)	44.2?					
312.3[#] 3	≈0.1	402.92	(4+)	90.56	(+)				
312.8[#f] 4	≈0.2	360.25	(3+)	47.4?					
316.8 1	2.2 3	353.89	(3−)	37.17	(2−)	(M1)[&]		0.666	α(K)=0.535 8; α(L)=0.0992 14; α(M)=0.0238 4 α(N)=0.00630 9; α(O)=0.001465 21; α(P)=0.000271 4; α(Q)=2.40×10^{-5} 4 α(K)exp(316.8γ+317.2γ+317.8γ)=0.50 11 (1994Ah03). Eγ=316.8 2, Iγ=2.6 8 (1993Sh07).
317.2 2	≈0.7	395.84	(4−)	78.51	(3−)	[M1]		0.663	α(K)=0.533 8; α(L)=0.0989 14; α(M)=0.0237 4 α(N)=0.00628 9; α(O)=0.001460 21; α(P)=0.000270 4; α(Q)=2.39×10^{-5} 4 α(K)exp(316.8γ+317.2γ+317.8γ)=0.50 11 (1994Ah03).
317.8[#] 3	≈0.3	448.08	(5−)	130.30	(4+)	[E1]		0.0318	α(K)=0.0256 4; α(L)=0.00471 7; α(M)=0.001124 16 α(N)=0.000296 5; α(O)=6.75×10^{-5} 10; α(P)=1.202×10^{-5} 17; α(Q)=8.80×10^{-7} 13 α(K)exp(316.8γ+317.2γ+317.8γ)=0.50 11 (1994Ah03).
322.4[#] 2	0.60 8	402.92	(4+)	80.49	(3+)	M1(+E2)	<0.7	0.55 9	α(K)exp=0.45 10 α(K)=0.44 8; α(L)=0.087 8; α(M)=0.0211 16 α(N)=0.0056 5; α(O)=0.00129 11; α(P)=0.000237 22; α(Q)=2.0×10^{-5} 4
328.6[#] 2	0.58 8	380.80	(+)	52.20	(2+)				

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^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78 (continued)

γ(^{224}Ac) (continued)

E_γ [†]	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	α [d]	Comments
330.4 [e] *1*	1.1 [e] *1*	353.89	(3⁻)	23.40	(2⁻)	(M1)	0.593	α(K)=0.476 *7*; α(L)=0.0884 *13*; α(M)=0.0211 *3* α(N)=0.00561 *8*; α(O)=0.001304 *19*; α(P)=0.000241 *4*; α(Q)=2.14×10^{-5} *3* α(K)exp=0.57 *12* E_γ,Mult.: 2004Sh25 suggest placement of 330.4γ from 354 level based on αγ coincidence displayed in top panel of figure 7 in 1994Ah03. This placement is consistent with M1 multipolarity from experimental K-conversion coefficient in 1994Ah03. Evaluators suggest double placement of this γ ray based on αγ coincidence with α groups to both the 354 and 360 levels (see αγ coin figure 7 in 1994Ah03). Eγ=330.2 *3*, Iγ=1.1 *5* (1993Sh07).
330.4 [e] *1*	1.1 [e] *1*	360.25	(3⁺)	29.83	(1⁺)	[E2]	0.1202	α(K)=0.0591 *9*; α(L)=0.0451 *7*; α(M)=0.01198 *17* α(N)=0.00319 *5*; α(O)=0.000706 *10*; α(P)=0.0001161 *17*; α(Q)=2.97×10^{-6} *5*
335.6 [#] *3*	0.16 *4*	452.1	(5⁺)	116.46	(4⁻)	[E1]	0.0282	α(K)=0.0227 *4*; α(L)=0.00415 *6*; α(M)=0.000990 *14* α(N)=0.000261 *4*; α(O)=5.96×10^{-5} *9*; α(P)=1.062×10^{-5} *15*; α(Q)=7.86×10^{-7} *11*
344.3 [#] *4*	≈0.1	448.08	(5⁻)	103.31	(4⁺)	[E1]	0.0267	α(K)=0.0215 *3*; α(L)=0.00391 *6*; α(M)=0.000934 *14* α(N)=0.000246 *4*; α(O)=5.62×10^{-5} *8*; α(P)=1.003×10^{-5} *15*; α(Q)=7.45×10^{-7} *11*
347.0 [#] *3*	0.12 *5*	395.84	(4⁻)	49.08	(3⁻)	[M1]	0.519	α(K)=0.417 *6*; α(L)=0.0772 *11*; α(M)=0.0185 *3* α(N)=0.00490 *7*; α(O)=0.001139 *17*; α(P)=0.000211 *3*; α(Q)=1.87×10^{-5} *3*
351.0 [#] *4*	≈0.1	380.80	(⁺)	29.83	(1⁺)			

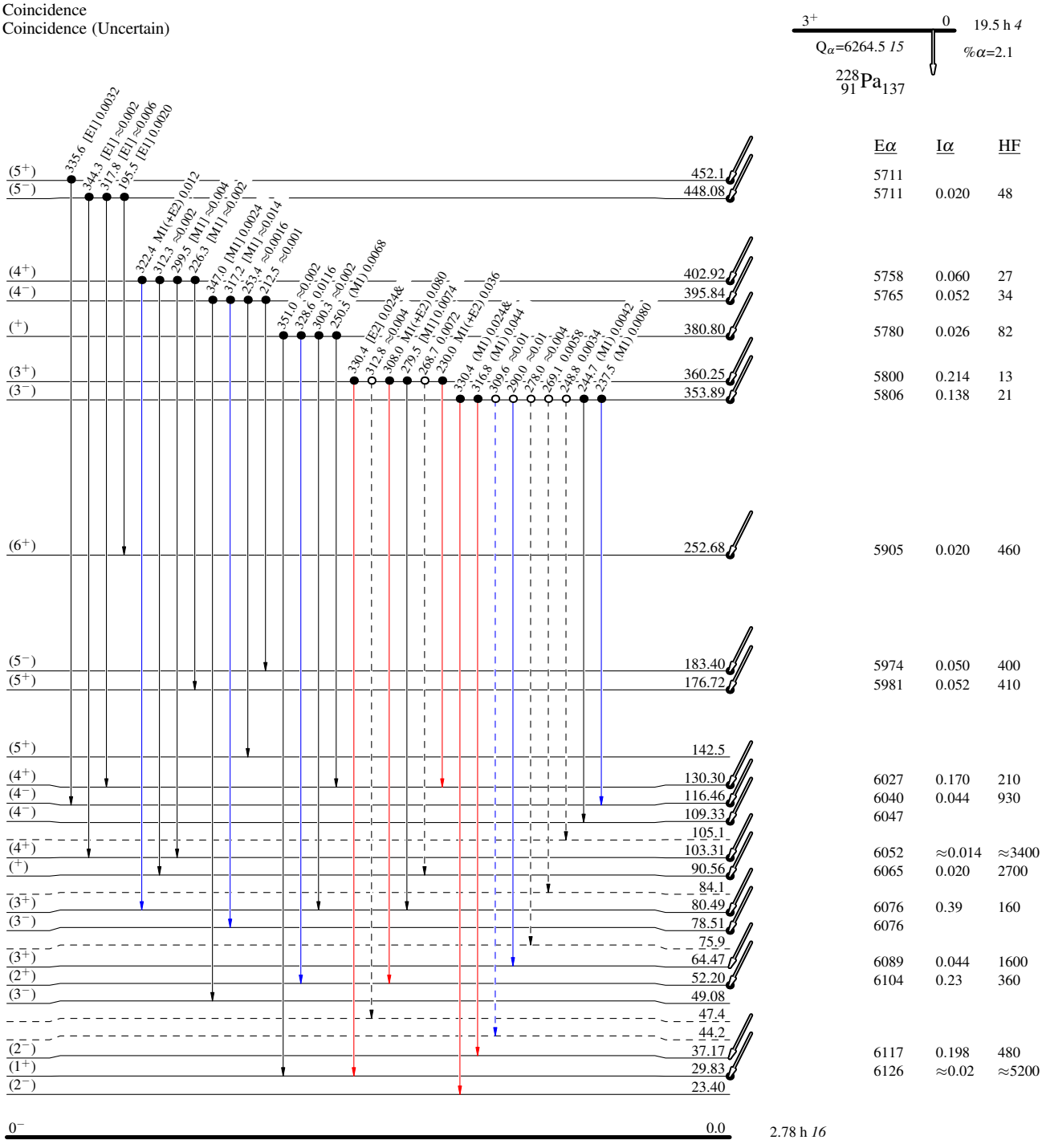
[†] From 1994Ah03, unless otherwise noted. Iγ and I(ce(K)) are given per 100 α decays.
[‡] From 1993Sh07.
[#] γ not reported in 1993Sh07.
[@] The E1 assignments are based on intensity considerations, the M1 assignments are based on experimental results as indicated. In addition, 1994Ah03 have deduced, from a comparison of (L x ray)(α) and (23<Eγ<87)(α) spectra that the major transitions deexciting the 52, 80, 130, 177 and 183 levels have E1 multipolarity.
[&] M1 assignment confirmed by 1993Sh07 from measured I(K x ray)/Iγ ratio.
[a] M1, E2 or higher multipolarities are rejected since these imply unreasonably high transition intensities.
[b] 1993Sh07 placed a 281.0γ from 397.5 level. 1994Ah03 reported two γ rays at 280.0 and 280.8, former from 317 level, and the latter from 333 level based on coincidence data.
[c] For absolute intensity per 100 decays, multiply by 0.020 *2*.
[d] 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.
[e] Multiply placed with undivided intensity.
[f] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78

Decay Scheme

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given

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
- Coincidence (Uncertain)



Eα	Iα	HF
5711		
5711	0.020	48
5758	0.060	27
5765	0.052	34
5780	0.026	82
5800	0.214	13
5806	0.138	21
5905	0.020	460
5974	0.050	400
5981	0.052	410
6027	0.170	210
6040	0.044	930
6047		
6052	≈0.014	≈3400
6065	0.020	2700
6076	0.39	160
6076		
6089	0.044	1600
6104	0.23	360
6117	0.198	480
6126	≈0.02	≈5200

$^{224}_{89}Ac_{135}$

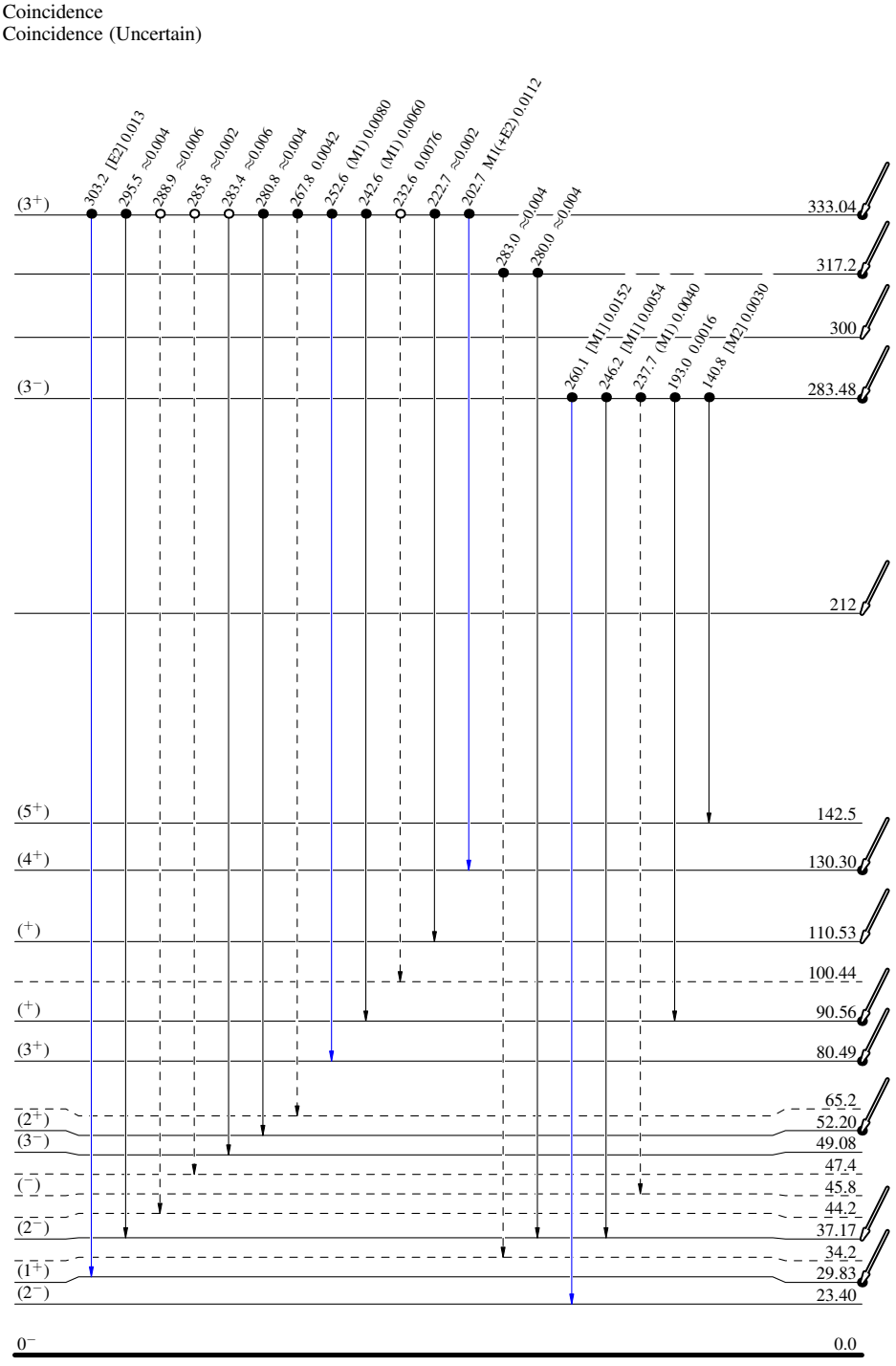
^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78

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
- Coincidence (Uncertain)

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given



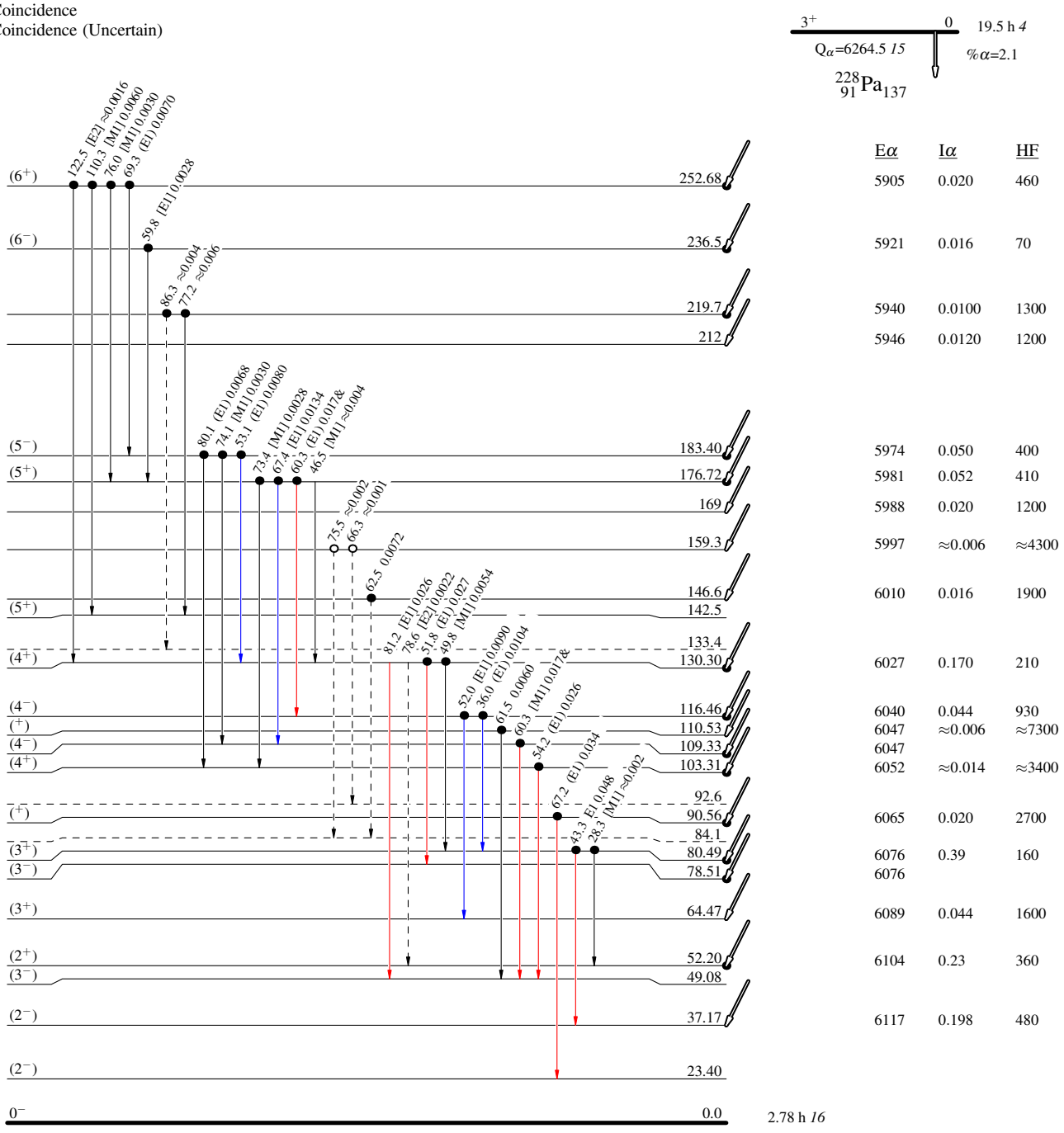
$^{224}_{89}Ac_{135}$

^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given

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
- Coincidence (Uncertain)



$^{224}_{89}Ac_{135}$

^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78

Legend

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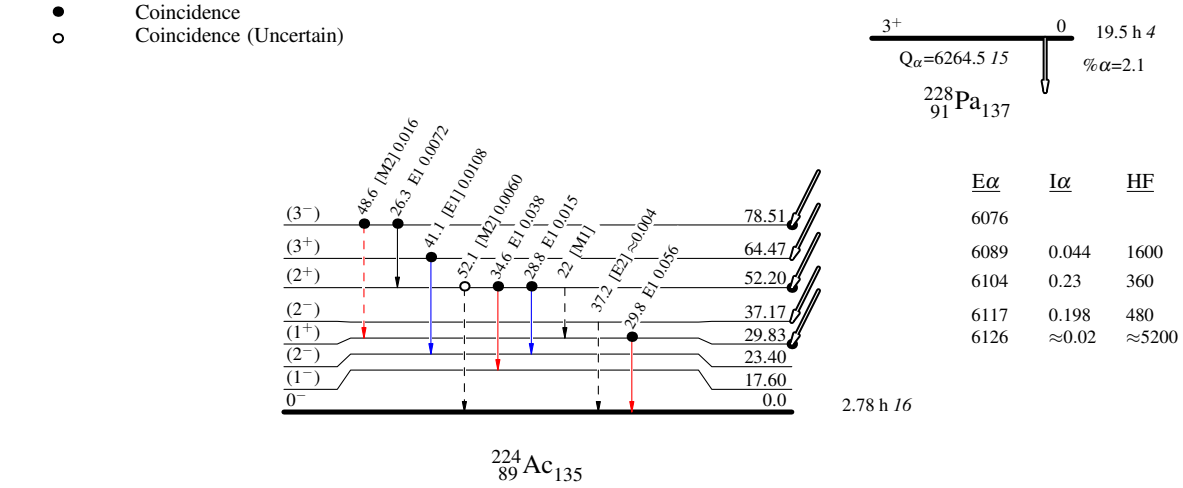
- Coincidence
- Coincidence (Uncertain)

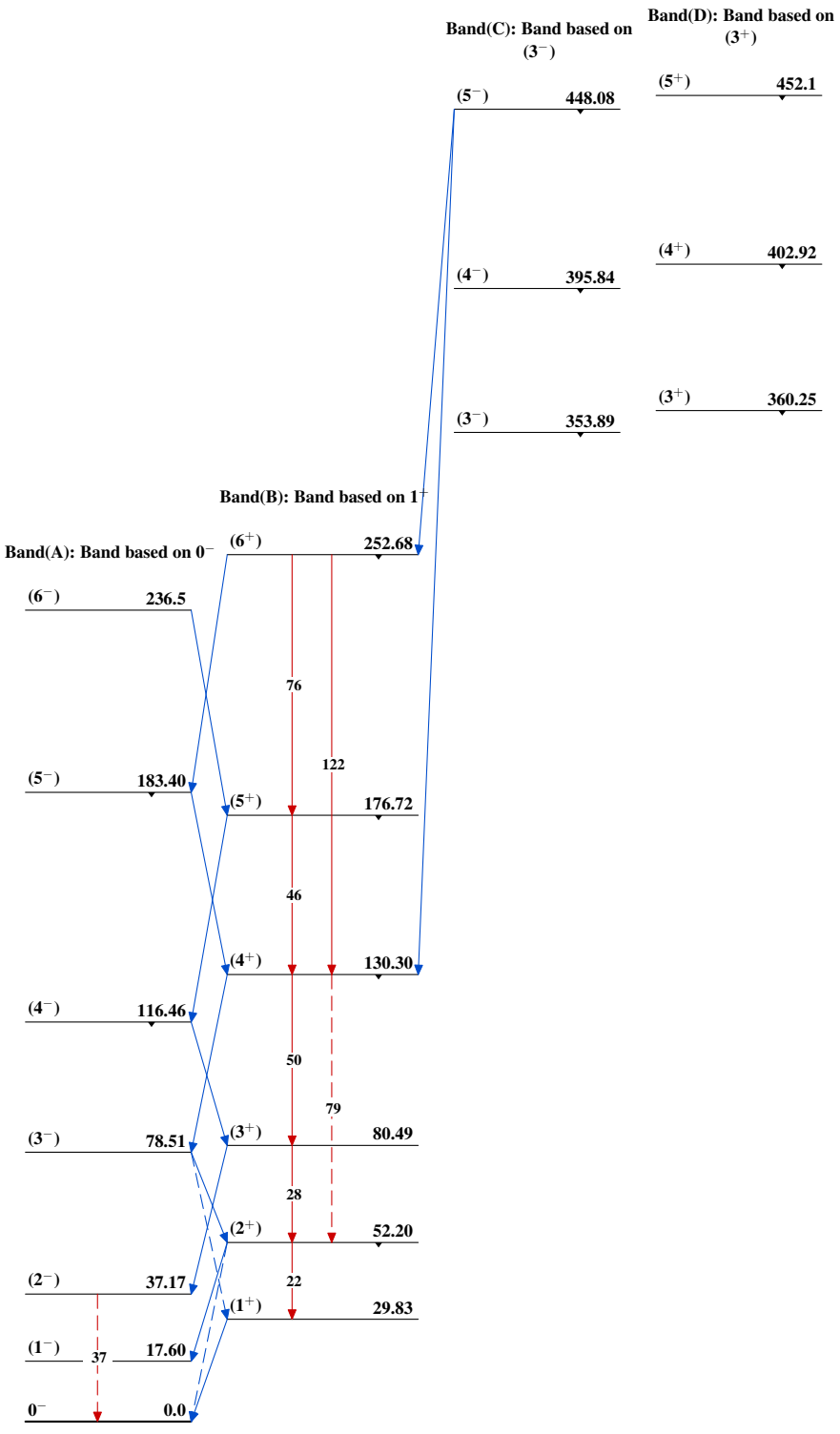
Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given



Eα	Iα	HF
6076		
6089	0.044	1600
6104	0.23	360
6117	0.198	480
6126	≈0.02	≈5200

^{228}Pa α decay (19.5 h) 1994Ah03,1993Sh07,1958Hi78



$^{224}_{89}Ac_{135}$