Adopted Levels, Gammas

History

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

Q(β^-)=45.8 *7*; S(n)=6308.6 *23*; S(p)=8033 *13*; Q(α)=4072 *10* 2012Wa38

Calculations, compilations, systematics:
α-decay, Geiger-Nuttall plot: 1991Bu05, 2009De32, 2010Wa31.
Bound state β^- decay of highly ionized atoms: 1987Ta16.
Binding energies, deformation role: 1986Ch23, 2010Ro08.
Clustering in nuclei: 1986Da03, 2000Bu02.
E1 transition, octupole deformation: 1989De11, 2008Bi03, 2001Ch02, 2000Ku42.
Equilibrium deformation energy, shapes: 1995Ru10, 1988So08, 1984Na22.
Ground state rotational band, excited bands: 2001Sa54, 1993Am07, 1988Ab07.
Selection rule, β^- decay: 1992So06.
Intrinsic structures and associated rotational bands: 1992So10.
Levels, B(λ): 1995De13, 1988Ri07, 1986Go07, 2007Bo46.
Levels, octupole deformed nuclei: 1991Eg01, 2008Ro11, 2006Le09, 2001Za09, 2001Za04, 2010Bo12.
Octupole deformation, octupole vibration: 2005Bo18.
Fission barrier: 2004Mo06.
Quadruple, octupole moment: 2002Ts01.
Quasi-bands in even-even nuclei: 1984Sa37.
Super- and hyper-deformed configurations: 1995We02.
Alpha-decay half life: 2005Sh42, 2006Me15.
Relativistic mean field interaction: 2005La04.
$T_{1/2}$: 2010Sa09.

^{228}Ra Levels

Cross Reference (XREF) Flags

A	^{228}Fr β^- decay
B	^{232}Th α decay
C	^{232}Th(d,^{6}Li)
D	^{232}Th(^{136}Xe,Xγ)

E(level)[†]	J^π[#]	$T_{1/2}$[‡]	XREF	Comments
0[&]	0^+[@]	5.75 y *3*	ABCD	%β^-=100 $T_{1/2}$: from 1962Ma58. Others: 6.7 y (1931Cu01), 5.7 y *2* (1960Du11). Isotope shift: Δ<r^2>=+1.46 *15* relative to ^{214}Ra (1988Ah02). Calculated $T_{1/2}$(^{12}C emission)=4.4×10^{19} y (1986De32).
63.823[&] *20*	2^+[@]	550 ps *20*	ABCD	J^π: E2 γ to 0^+; member of g.s. band. $T_{1/2}$: From ^{228}Fr β^- decay using $\beta\gamma\gamma$(t) method. Others: 550 ps *20* (shape de-convolution in ^{228}Fr β^- decay); 0.55 ns *4* (^{232}Th α-decay).
204.702[&] *22*	4^+[@]	181 ps *3*	ABCD	J^π: E2 γ to 2^+; no γ to 0^+; member of g.s. band. $T_{1/2}$: From ^{228}Fr β^- decay using $\beta\gamma\gamma$(t) method.
411.69[&] *5*	(6^+)		A CD	J^π: γ only to 4^+, probable member of g.s. band.
474.18[a] *4*	1^-[@]	≤7 ps	A CD	J^π: E1 γ to 2^+; γ to 0^+. Probable head of K^π=0^- octupole vibrational band from systematics. $T_{1/2}$: Represents average of four independent measurements in ^{228}Fr β^- decay. 2σ limit.

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Adopted Levels, Gammas (continued)

^{228}Ra Levels (continued)

E(level)[†]	J^π[#]	$T_{1/2}$[‡]	XREF	Comments
537.50[a] *4*	3^-	≤6 ps	A CD	J^π: E1 γ to 4^+; γ to 2^+; probable member of K=0 octupole band. $T_{1/2}$: Represents average of ten time-delayed measurements in ^{228}Fr β^- decay. 2 σ limit.
655.98[a] *5*	(5^-)[@]		A CD	J^π: γ's to 4^+ and (6^+). Probable member of K=0 octupole band.
674.29[&] *11*	(8^+)[@]		D	J^π: (E2) γ to 6^+; member of g.s. band.
721.19[b] *8*	0^+		A C	J^π: L(d,^{6}Li)=0 for even-even nucleus. Bandhead of second $K^\pi=0^+$ band; E0 γ-ray to 0^+.
770.71[b] *4*	2^+		A C	J^π: Strong E0 component of E0+M1+E2 γ-ray to 2^+ state of the g.s. band.
830.1[a] *5*	(7^-)[@]		D	J^π: (E1) γ to (6^+).
846.15[c] *9*	2^+		A C	J^π: E0 γ-ray from 2^+; possible head of $K^\pi=2^+$ band.
880.31[b] *6*	4^+		A C	J^π: Strong E0 component of E0+M1+E2 γ-ray to 4^+ level of the g.s. band.
898.86[c] *8*	(3^+)		A	J^π: γ's to 2^+ and 4^+. Probable member of $K^\pi=2^+$ band.
967.11 *20*	$(2^+,4^+)$		A C	J^π: L=(2,4) in (d,^{6}Li); γ to 4^+; γ's from 2^+.
983.29[&] *15*	(10^+)[@]		D	J^π: (E2) γ to (8^+).
1013.24[d] *14*	2^+		A C	J^π: E0 γ-ray to 2^+. Possible head of second $K^\pi=2^+$ band.
1042.01 *11*	$(0^+,1,2,3^-)$		A	J^π: γ to 1^-. log *ft*=8.4 (log $f^{1u}t$=9.8) from 2^- ^{228}Fr. Suggested as head of third $K^\pi=0^+$ band (1982Ru04), in which case the 1050 (d,^{6}Li) peak, which is not consistent with L=0, must correspond to the 1052.78 level.
1052.79 *13*	$(2^+,3,4^+)$		A C	XREF: C(1050). J^π: γ's to 2^+ and (4^+); L(d,^{6}Li)=(2,4) for E=1050.
1055.0[a] *5*	(9^-)[@]		D	J^π: γ's to 8^+ and 7^-; member of a rotational band.
1070.24[d] *7*	(3^+)		A C	J^π: probable E0 component in γ to (3^+). γ's to 2^+ and 4^+. Possible member of second $K^\pi=2^+$ band.
1087.29 *7*	$(1^-,2,3^-)$		A	J^π: γ's to (1^-) and (3^-). Suggested by 1982Ru04 as a member of the third $K^\pi=0^+$ band.
1109.12 *19*	$(2^+,3)$		A	J^π: γ to 4^+. log *ft*=7.91 (log $f^{1u}t$=9.35) from 2^-.
1140	(4^+)		C	J^π: L(d,^{6}Li)=(4). Possibly same level as 1157.
1157.61 *21*	$(2^+,3,4^+)$		A	J^π: γ's to 2^+ and 4^+.
1182.28 *8*	(3^-)		A	J^π: γ's to (3^-) and (5^-). log *ft*=7.89 (log $f^{1u}t$=9.3) from 2^- ^{228}Fr.
1200	(2^+)		C	J^π: L(d,^{6}Li)=(2). Possibly same level as 1220.
1219.98 *13*	(2^+)		A	J^π: γ's to 0^+ and 4^+.
1238.5 *3*	$(1,2,3^-)$		A	J^π: γ's to (1^-) and 2^+. log *ft*=7.44 (log $f^{1u}t$=8.8) from 2^- ^{228}Fr.
1327.0[a] *4*	(11^-)[@]		D	J^π: (E2) γ to (9^-).
1331.1[&] *4*	(12^+)[@]		D	J^π: (E2) γ to (10^+).
1349.5 *4*	(4^+)		A	J^π: γ's to 4^+ and (6^+). log *ft*=7.9 (log $f^{1u}t$=9.3) from 2^- ^{228}Fr.
1420			C	J^π: L(d,^{6}Li)=(2,4).
1471.75 *12*	$(1^-,2,3,4^+)$		A	J^π: γ's to 2^+ and (3^-). log *ft*=7.7 (log $f^{1u}t$=9.0) from 2^- ^{228}Fr.
1495.35 *13*	$(1^+,2,3,4^+)$		A	J^π: γ's to (3^+) and 2^+.
1507.14 *17*	$(2^+,3^-)$		A	J^π: γ's to (1^-) and 4^+.
1518.88? *21*	$(0^+,1,2,3^-)$		A	J^π: γ's to 2^+ and (1^-).
1579.8 *3*	$(1^-,2,3^-)$		A	J^π: γ's to (1^-) and (3^-).
1639.3[a] *5*	(13^-)[@]		D	J^π: (E2) γ to (11^-).
1710.0[&] *5*	(14^+)[@]		D	J^π: (E2) γ to (12^+).
1911.82 *16*	$1^+,2^+$		A	J^π: γ to 721 0^+ level.
1974.62 *24*	$1,2^+$		A	J^π: γ to 0^+ g.s.
1987.7[a] *6*	(15^-)[@]		D	J^π: (E2) γ to (13^-).
2041.1 *3*	(2^+)		A	J^π: γ's to 721-keV 0^+ and (4^+).
2107.93 *19*	$(2^+,3)$		A	J^π: γ's to 2^+, 4^+. (log $f^{1u}t$=8.2 from 2^- ^{228}Fr).
2110.8 *4*	$(2,3^-)$		A	γ's to (1^-), (3^+), (3^-); log *ft*=6.36 from 2^- ^{228}Fr.
2113.6[&] *7*	(16^+)[@]		D	J^π: (E2) γ to (16^+).
2138.3 *6*	(2^+)		A	J^π: γ's to 0^+ and 4^+.

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Adopted Levels, Gammas (continued)

^{228}Ra Levels (continued)

E(level)[†]	J$^{\pi}$[#]	XREF	Comments
2161.3 *5*	(2$^+$)	A	J$^{\pi}$: γ's to 0$^+$ and 4$^+$.
2168.2 *7*	(2$^+$,3)	A	J$^{\pi}$: γ's to 2$^+$ and 4$^+$. log *ft*=7.10 (log $f^{1u}t$=8.2 *2*) from 2$^-$ ^{228}Fr.
2368.0[a] *7*	(17$^-$)[@]	D	J$^{\pi}$: γ to (15$^-$).
2536.0[&] *8*	(18$^+$)[@]	D	J$^{\pi}$: γ to (16$^+$).
2776.6[a] *9*	(19$^-$)[@]	D	J$^{\pi}$: γ to (17$^-$).
2972.1[&] *10*	(20$^+$)[@]	D	J$^{\pi}$: γ to (18$^+$).
3418.9[&] *11*	(22$^+$)[@]	D	J$^{\pi}$: γ to (20$^+$).

[†] From a least-squares fit to Eγ.

[‡] From 1998Gu09 using $\beta\gamma\gamma$(t) method, except otherwise noted.

[#] Based on multipolarity extracted in β^- decay from conversion electron intensities and fast timing data (1998Gu09). The agreement between the theoretical predictions and the measured CC confirm the previously tentatively assigned spins in 1982Ru04. 1982Ru04: show a comparison of experimental branching ratios with those expected from the Alaga rule as modified to account for Coriolis interaction between the K^{π}=0$^-$ and the (unobserved) K^{π}=1$^-$ bands. These calculated branching ratios for the E1 transitions between the K^{π}=0$^-$ and K^{π}=0$^+$, K^{π}=2$^+$ bands are in good agreement with experiment.

[@] Band structure and band parameters; member of a rotational band in particle transfer reaction.

[&] Band(A): K$^{\pi}$=0$^+$ g.s. band. α=6.80 keV *23*.

[a] Band(B): K$^{\pi}$=0$^-$ octupole-vibrational band. α=6.15 keV *7*.

[b] Band(C): second K$^{\pi}$=0$^+$ band.

[c] Band(D): K$^{\pi}$=2$^+$ band,γ-vibrational.

[d] Band(E): K$^{\pi}$=second 2$^+$ band.

$\gamma(^{228}Ra)$

E_i(level)	J_i^π	E_γ‡	I_γ#	E_f	J_f^π	Mult.@	α†	Comments
63.823	2^+	63.83 2	100	0	0^+	E2	80.3 12	B(E2)(W.u.)=142 6 α(L)=59.0 9; α(M)=16.03 23; α(N+..)=5.25 8 α(N)=4.23 6; α(O)=0.897 13; α(P)=0.1289 19; α(Q)=0.000306 5 Mult.: from (L1+L2)/L3/M/(N+...)=100/83.5/60/18.7 in agreement with theoretical prediction (100/82.5/50/15.6) for E2 γ-ray (1998Gu09).
204.702	4^+	140.88 1	100	63.823	2^+	E2	2.26 4	B(E2)(W.u.)=207 4 α(K)=0.283 4; α(L)=1.450 21; α(M)=0.394 6; α(N+..)=0.1295 19 α(N)=0.1041 15; α(O)=0.0222 4; α(P)=0.00324 5; α(Q)=1.90×10^{-5} 3 Mult.: (L1+L2)/L3/M/(N+...)=100/57.4/39.6/13.6; theory:(100/56.9/37.7/15.1), α(K)exp=0.27 5;α(K)theory=0.29 for E2 (1998Gu09).
411.69	(6^+)	206.97 4	100	204.702	4^+	[E2]	0.517	α(K)=0.154; α(L)=0.274; α(M)=0.0737; α(N+..)=0.0264
474.18	1^-	410.40 6	82 4	63.823	2^+	E1	0.0177	B(E1)(W.u.)≥1.5×10^{-4} α(K)=0.0145; α(L)=0.00255; α(M)=0.00060; α(N+..)=0.00021 Mult.: α(K)exp=0.017 3;α(K)theory=0.015 for E1 (1998Gu09).
		474.0 1	100 19	0	0^+	[E1]	0.0133	B(E1)(W.u.)≥1.2×10^{-4} α(K)=0.0108; α(L)=0.00187; α(M)=0.00044; α(N+..)=0.00015
537.50	3^-	332.91 5	25.1 16	204.702	4^+	E1	0.0279	B(E1)(W.u.)≥1.5×10^{-4} α(K)=0.0226; α(L)=0.00409; α(M)=0.00097; α(N+..)=0.00034 Mult.: α(K)exp=0.032 7; α(K)theory=0.023 for E1 (1998Gu09).
		473.7 1	100 11	63.823	2^+	[E1]	0.0133	B(E1)(W.u.)≥2.2×10^{-4} α(K)=0.0108; α(L)=0.00187; α(M)=0.00044; α(N+..)=0.00015
655.98	(5^-)	244.4 1	4.8 11	411.69	(6^+)	[E1]	0.0567	α(K)=0.0454; α(L)=0.00853; α(M)=0.00203; α(N+..)=0.00071
		451.20 6	100 5	204.702	4^+	[E1]	0.0147	α(K)=0.0119; α(L)=0.00207; α(M)=0.00049; α(N+..)=0.00017
674.29	(8^+)	262.6 1	100 13	411.69	(6^+)	(E2)	0.231	α(K)=0.0935 14; α(L)=0.1011 15; α(M)=0.0270 4; α(N+..)=0.00892 13 α(N)=0.00714 10; α(O)=0.001538 22; α(P)=0.000232 4; α(Q)=3.84×10^{-6} 6
721.19	0^+	247.01 8	44 5	474.18	1^-	[E1]	0.0549	α(K)=0.0440 7; α(L)=0.00825 12; α(M)=0.00197 3; α(N+..)=0.000650 10 α(N)=0.000515 8; α(O)=0.0001147 16; α(P)=1.90×10^{-5} 3; α(Q)=1.183×10^{-6} 17
		657.4 2	100 6	63.823	2^+	[E2]	0.0209	α(K)=0.01497 21; α(L)=0.00446 7; α(M)=0.001122 16; α(N+..)=0.000373 6 α(N)=0.000296 5; α(O)=6.56×10^{-5} 10; α(P)=1.071×10^{-5} 15; α(Q)=5.30×10^{-7} 8
		(721.2 5)		0	0^+	E0		E_γ: proposed by 1998Gu09 based on conversion electron spectrum. Mult.: α(K)exp>1.4 (1998Gu09);α(K)theory=0.0.0048 for E1, 0.057 for M1, and 0.013 for E2 (1998Gu09).
770.71	2^+	233.25 4	58 6	537.50	3^-	[E1]	0.0627	α(K)=0.0502 7; α(L)=0.00949 14; α(M)=0.00227 4; α(N+..)=0.000748 11 α(N)=0.000593 9; α(O)=0.0001319 19; α(P)=2.18×10^{-5} 3; α(Q)=1.341×10^{-6} 19
		296.53 5	63 7	474.18	1^-	[E1]	0.0363	α(K)=0.0293; α(L)=0.00536; α(M)=0.00128; α(N+..)=0.00044
		565.8 1	53 8	204.702	4^+	[E2]	0.0293	α(K)=0.0200; α(L)=0.00698
		706.9 1	76 5	63.823	2^+	E0+M1+E2	0.55 8	α(K)=0.037 24; α(L)=0.007 4 Mult.: α(K)exp=0.55 8;α(K)theory=0.0049 for E1, 0.061 for M1, and 0.013 for E2 (1998Gu09).
		770.7 1	100 5	0	0^+	[E2]	0.0152	α(K)=0.0113; α(L)=0.00296

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

E_i(level)	J_i^π	E_γ[‡]	I_γ[#]	E_f	J_f^π	Mult.[@]	α[†]	$I_{(\gamma+ce)}$	Comments
830.1	(7⁻)	418.4 *5*	100 *25*	411.69	(6⁺)	(E1)	0.0170		
846.15	2⁺	782.3 *1*	100 *5*	63.823	2⁺	M1+E2	0.036 *22*		α(K)=0.029 *18*; α(L)=0.006 *3* Mult.: α(K)exp=0.012 *5*;α(K)theory=0.0041 for E1, 0.046 for M1, and 0.010 for E2 (1998Gu09).
		846.2 *2*	72 *5*	0	0⁺	[E2]	0.0126		α(K)=0.0095; α(L)=0.00234
880.31	4⁺	224.35 *8*	48 *6*	655.98	(5⁻)	[E1]	0.0693		α(K)=0.0550 *8*; α(L)=0.01045 *15*; α(M)=0.00250 *4*; α(N+..)=0.000823 *12* α(N)=0.000652 *10*; α(O)=0.0001451 *21*; α(P)=2.39×10^{-5} *4*; α(Q)=1.460×10^{-6} *21*
		342.88 *6*	100 *8*	537.50	3⁻	[E1]	0.0263		α(K)=0.0211 *3*; α(L)=0.00380 *6*; α(M)=0.000903 *13*; α(N+..)=0.000299 *5* α(N)=0.000236 *4*; α(O)=5.30×10^{-5} *8*; α(P)=8.88×10^{-6} *13*; α(Q)=5.89×10^{-7} *9*
		468.4 *1*	1.0 *3*	411.69	(6⁺)	[E2]	0.0459		α(K)=0.01097 *16*; α(L)=0.00190 *3*; α(M)=0.000450 *7*; α(N+..)=0.0001493 *21* α(N)=0.0001179 *17*; α(O)=2.65×10^{-5} *4*; α(P)=4.50×10^{-6} *7*; α(Q)=3.14×10^{-7} *5*
		675.6 *5*	44 *7*	204.702	4⁺	E0+M1+E2	1.3	3	α(K)=0.04 *3*; α(L)=0.008 *4* Mult.: α(K)exp=1.3 *3*;α(K)theory=0.0054 for E1, 0.068 for M1, and 0.014 for E2 (1998Gu09).
898.86	(3⁺)	694.2 *1*	21.1 *11*	204.702	4⁺	[M1,E2]	0.05 *3*		α(K)=0.039 *25*; α(L)=0.008 *4*
		835.0 *2*	100 *6*	63.823	2⁺	[M1,E2]	0.029 *17*		α(K)=0.024 *15*; α(L)=0.0047 *24*
967.11	(2⁺,4⁺)	762.4 *2*	100	204.702	4⁺				
983.29	(10⁺)	309.0 *1*	100	674.29	(8⁺)	(E2)	0.1392		α(K)=0.0667 *10*; α(L)=0.0536 *8*; α(M)=0.01422 *20*; α(N+..)=0.00469 *7* α(N)=0.00376 *6*; α(O)=0.000812 *12*; α(P)=0.0001239 *18*; α(Q)=2.63×10^{-6} *4*
1013.24	2⁺	167.1 *3*		846.15	2⁺	E0		≈7.4	$I_{(\gamma+ce)}$: I(γ+ce)/Iγ(949)≈0.095 from I(K x ray) in γγ.
		949.4 *2*	100 *5*	63.823	2⁺	[M1,E2]	0.021 *13*		α(K)=0.018 *10*; α(L)=0.0034 *16*
		1013.7[&] *10*	2.6[&] *7*	0	0⁺				
1042.01	(0⁺,1,2,3⁻)	567.8 *1*	100 *5*	474.18	1⁻				
1052.79	(2⁺,3,4⁺)	172.4 *2*	1.9 *3*	880.31	4⁺				
		515.2 *2*	10 *3*	537.50	3⁻				
		989.8 *3*	100 *5*	63.823	2⁺				
1055.0	(9⁻)	225.0[a] *5*		830.1	(7⁻)				
		380.8 *5*		674.29	(8⁺)				
1070.24	(3⁺)	171.4 *1*	10.0 *12*	898.86	(3⁺)	E0+M1+E2	16 *7*		Mult.: From α(L1+L2)(exp)=1.0 *3*; theory: 0.017 for E1, 0.41 for E2, and 0.53 for M1. These values reveal strong component of E0 (1998Gu09). α: from α(K)exp (value not given) from I(K x ray) in γγ and α/α(K) (theory, value not given).
		532.68 *8*	11.1 *12*	537.50	3⁻	[E1]	0.0105		α(K)=0.0085; α(L)=0.00146

Adopted Levels, Gammas (continued)

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

E_i(level)	J^π_i	E_γ[‡]	I_γ[#]	E_f	J^π_f	Mult.[@]	α[†]	Comments
1070.24	(3^+)	865.8 2	100 5	204.702	4^+	[M1,E2]	0.028 16	α(K)=0.022 14; α(L)=0.0043 21
		1006.5 5	95 15	63.823	2^+			
1087.29	(1^-,2,3^-)	549.83 7	94 8	537.50	3^-			
		613.06 8	100 5	474.18	1^-			
1109.12	(2^+,3)	904.4 2	100 5	204.702	4^+			
1157.61	(2^+,3,4^+)	952.9 3	38 3	204.702	4^+			
		1092.8 5	100 5	63.823	2^+			
1182.28	(3^-)	526.22 8	30 3	655.98	(5^-)			
		644.9 1	100 6	537.50	3^-			
1219.98	(2^+)	498.8 1	36 4	721.19	0^+			
		1015.7 8	100 22	204.702	4^+			
1238.5	(1,2,3^-)	764.5 3	27.4 17	474.18	1^-			
		1174.2 5	100 5	63.823	2^+			
1327.0	(11^-)	272.0 5	100 38	1055.0	(9^-)	(E2)	0.206 4	α(K)=0.0869 13; α(L)=0.0880 14; α(M)=0.0235 4; α(N+..)=0.00774 13 α(N)=0.00620 10; α(O)=0.001337 22; α(P)=0.000202 4; α(Q)=3.54×10^{-6} 6
		343.6 5	100 46	983.29	(10^+)	(E1)	0.0260	α(K)=0.0210 3; α(L)=0.00378 6; α(M)=0.000898 13; α(N+..)=0.000297 5 α(N)=0.000235 4; α(O)=5.27×10^{-5} 8; α(P)=8.84×10^{-6} 13; α(Q)=5.87×10^{-7} 9
1331.1	(12^+)	347.8 3	100 47	983.29	(10^+)	(E2)	0.0988	α(K)=0.0522 8; α(L)=0.0345 5; α(M)=0.00908 13; α(N+..)=0.00300 5 α(N)=0.00240 4; α(O)=0.000521 8; α(P)=8.02×10^{-5} 12; α(Q)=2.02×10^{-6} 3
1349.5	(4^+)	937.6 5	42 6	411.69	(6^+)			
		1145.0 5	100 9	204.702	4^+			
1471.75	(1^-,2,3,4^+)	625.6 1	52 5	846.15	2^+			
		934.3 2	100 6	537.50	3^-			
		1406.4 15	48 10	63.823	2^+			
1495.35	(1^+,2,3,4^+)	425.1 1	23 5	1070.24	(3^+)			
		1432.9 15	100 17	63.823	2^+			
1507.14	(2^+,3^-)	493.9 1	30 3	1013.24	2^+			
		1033.0 10	100 19	474.18	1^-			
		1303.1 10	47 5	204.702	4^+			
1518.88?	(0^+,1,2,3^-)	551.9[a] 1	9.0 15	967.11	(2^+,4^+)			
		1043.2[a] 8	100 20	474.18	1^-			
		1454.7[a] 10	20 2	63.823	2^+			
1579.8	(1^-,2,3^-)	422.3 2	12.9 19	1157.61	(2^+,3,4^+)			
		1041.6 8	86 18	537.50	3^-			
		1105.6 8	100 6	474.18	1^-			
		1514.9 15	23 3	63.823	2^+			
1639.3	(13^-)	308.3 5	45 35	1331.1	(12^+)			

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

E_i(level)	J^π_i	E_γ‡	I_γ#	E_f	J^π_f	Mult.@	α†	Comments
1639.3	(13⁻)	312.3 5	100 40	1327.0	(11⁻)			
1710.0	(14⁺)	378.9 5	100	1331.1	(12⁺)	(E2)	0.0780	α(K)=0.0438 7; α(L)=0.0253 4; α(M)=0.00664 10; α(N+..)=0.00220 4 α(N)=0.00175 3; α(O)=0.000382 6; α(P)=5.92×10⁻⁵ 9; α(Q)=1.670×10⁻⁶ 24
1911.82	1⁺,2⁺	824.4 5	29.1 24	1087.29	(1⁻,2,3⁻)			
		869.7 2	40 3	1042.01	(0⁺,1,2,3⁻)			
		898.7 2	100 5	1013.24	2⁺			
		1013.7& 10	13& 3	898.86	(3⁺)			
		1190.8 15	27 5	721.19	0⁺			
		1847.5 10	46 7	63.823	2⁺			
		1911.5& 10	≤34&	0	0⁺			
1974.62	1,2⁺	816.5 3	83 7	1157.61	(2⁺,3,4⁺)			
		922.3 3	100 6	1052.79	(2⁺,3,4⁺)			
		1501.6 15	36 4	474.18	1⁻			
		1911.5& 10	≤50&	63.823	2⁺			
		1973.8 10	50 5	0	0⁺			
1987.7	(15⁻)	277.5 5	28 18	1710.0	(14⁺)	(E1)	0.0420	α(K)=0.0338 5; α(L)=0.00623 10; α(M)=0.001486 22; α(N+..)=0.000491 8 α(N)=0.000389 6; α(O)=8.68×10⁻⁵ 13; α(P)=1.443×10⁻⁵ 21; α(Q)=9.21×10⁻⁷ 14
		348.3 5	100 42	1639.3	(13⁻)	(E2)	0.0984	α(K)=0.0521 8; α(L)=0.0343 6; α(M)=0.00903 14; α(N+..)=0.00299 5 α(N)=0.00239 4; α(O)=0.000518 8; α(P)=7.98×10⁻⁵ 12; α(Q)=2.01×10⁻⁶ 3
2041.1	(2⁺)	821.7 5	29.2 23	1219.98	(2⁺)			
		1027.2 5	38 8	1013.24	2⁺			
		1162.0 10	50 6	880.31	4⁺			
		1194.2& 15	25& 5	846.15	2⁺			
		1318.8 10	29 6	721.19	0⁺			
		1566.9 10	100 6	474.18	1⁻			
2107.93	(2⁺,3)	600.8 1	29 2	1507.14	(2⁺,3⁻)			
		1902.8 10	22.3 24	204.702	4⁺			
		2043.5 10	100 10	63.823	2⁺			
2110.8	(2,3⁻)	1001.6 5	8.0 15	1109.12	(2⁺,3)			
		1024.4 10	11.7 27	1087.29	(1⁻,2,3⁻)			
		1096.9 8	36.1 20	1013.24	2⁺			
		1211.5 15	6.1 14	898.86	(3⁺)			
		1340.2 10	12.2 27	770.71	2⁺			
		1572.4 10	62 7	537.50	3⁻			
		1637.7 10	10.7 15	474.18	1⁻			
		2047.8 10	100 10	63.823	2⁺			
2113.6	(16⁺)	403.8 5	100 23	1710.0	(14⁺)	(E2)	0.0659	α(K)=0.0385 6; α(L)=0.0203 3; α(M)=0.00529 8; α(N+..)=0.00175 3 α(N)=0.001398 21; α(O)=0.000305 5; α(P)=4.76×10⁻⁵ 7; α(Q)=1.454×10⁻⁶ 21

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Adopted Levels, Gammas (continued)

γ(^{228}Ra) (continued)

E_i(level)	J^π_i	E_γ[‡]	I_γ[#]	E_f	J^π_f	Mult.[@]	α[†]	Comments
2138.3	(2$^+$)	1171.0 *10*	100 *8*	967.11	(2$^+$,4$^+$)			
		1601.1 *15*	58 *12*	537.50	3$^-$			
		1663.7 *15*	53 *8*	474.18	1$^-$			
		1934.8 *15*	51 *6*	204.702	4$^+$			
		2137.8 *15*	46 *7*	0	0$^+$			
2161.3	(2$^+$)	1052.4 *10*	16.0 *22*	1109.12	(2$^+$,3)			
		1194.2[&] *15*	14[&] *3*	967.11	(2$^+$,4$^+$)			
		1390.8 *10*	17.3 *17*	770.71	2$^+$			
		1955.9 *10*	22.5 *17*	204.702	4$^+$			
		2097.4 *10*	100 *10*	63.823	2$^+$			
		2162.4 *15*	15.2 *22*	0	0$^+$			
2168.2	(2$^+$,3)	1631.0 *15*	28 *5*	537.50	3$^-$			
		1963.0 *10*	50 *7*	204.702	4$^+$			
		2104.7 *10*	100 *10*	63.823	2$^+$			
2368.0	(17$^-$)	254.6 *5*	30 *23*	2113.6	(16$^+$)	(E1)	0.0512	α(K)=0.0411 *6*; α(L)=0.00767 *12*; α(M)=0.00183 *3*; α(N+..)=0.000604 *9* α(N)=0.000478 *7*; α(O)=0.0001067 *16*; α(P)=1.77×10^{-5} *3*; α(Q)=1.108×10^{-6} *17*
		380.1 *5*	100 *40*	1987.7	(15$^-$)	(E2)	0.0773	α(K)=0.0435 *7*; α(L)=0.0251 *4*; α(M)=0.00656 *10*; α(N+..)=0.00217 *4* α(N)=0.00173 *3*; α(O)=0.000377 *6*; α(P)=5.86×10^{-5} *9*; α(Q)=1.659×10^{-6} *24*
2536.0	(18$^+$)	422.4 *5*	100	2113.6	(16$^+$)	(E2)	0.0586	α(K)=0.0352 *5*; α(L)=0.0174 *3*; α(M)=0.00452 *7*; α(N+..)=0.001497 *22* α(N)=0.001194 *18*; α(O)=0.000261 *4*; α(P)=4.09×10^{-5} *6*; α(Q)=1.320×10^{-6} *19*
2776.6	(19$^-$)	408.6 *5*	100	2368.0	(17$^-$)	(E2)	0.0639	α(K)=0.0376 *6*; α(L)=0.0195 *3*; α(M)=0.00508 *8*; α(N+..)=0.001680 *25* α(N)=0.001341 *20*; α(O)=0.000292 *5*; α(P)=4.57×10^{-5} *7*; α(Q)=1.417×10^{-6} *21*
2972.1	(20$^+$)	436.1 *5*	100	2536.0	(18$^+$)	(E2)	0.0540	α(K)=0.0330 *5*; α(L)=0.01563 *23*; α(M)=0.00405 *6*; α(N+..)=0.001342 *20* α(N)=0.001070 *16*; α(O)=0.000234 *4*; α(P)=3.68×10^{-5} *6*; α(Q)=1.233×10^{-6} *18*
3418.9	(22$^+$)	446.8 *5*	100	2972.1	(20$^+$)	(E2)		

† Additional information 1.
‡ Weighted average of available data, unless noted otherwise.
\# Relative photon branching from each level in ^{228}Fr β^- decay.
@ Extracted from the measured conversion electron intensity in ^{228}Fr β^- decay. These are in good agreement with the theoretical predictions (1998Gu09). Also ^{232}Th(^{136}Xe,Xγ) reaction assumes that γ-rays connecting thE in-band states of the g.s. and K$^\pi$=0$^-$ octupole-vibrational bands are E2; and the intraband γ's are E1.
& Multiply placed with undivided intensity.
^{a} Placement of transition in the level scheme is uncertain.

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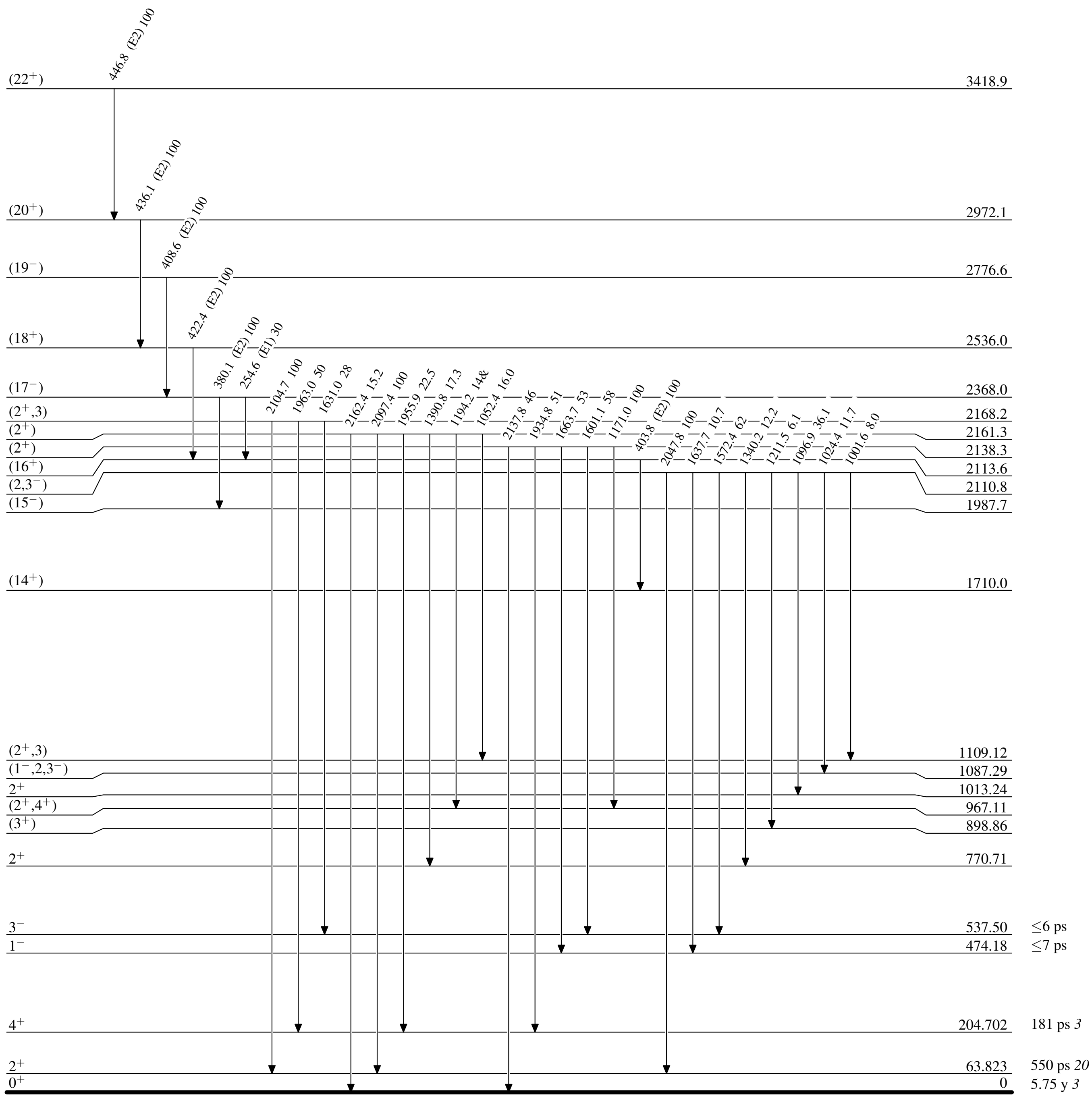
Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given



$^{228}_{88}Ra_{140}$

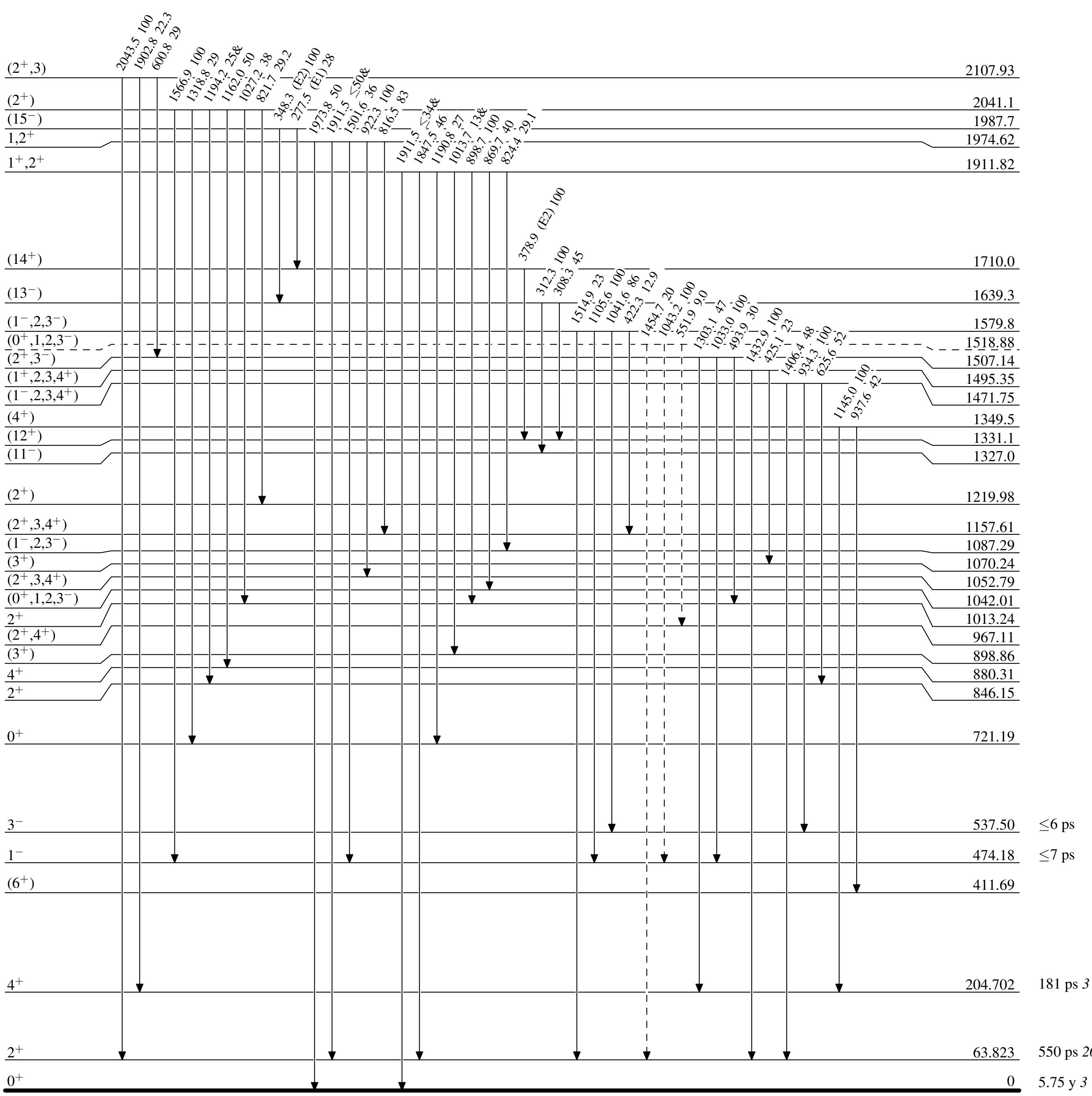
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

γ Decay (Uncertain)



$^{228}_{88}Ra_{140}$

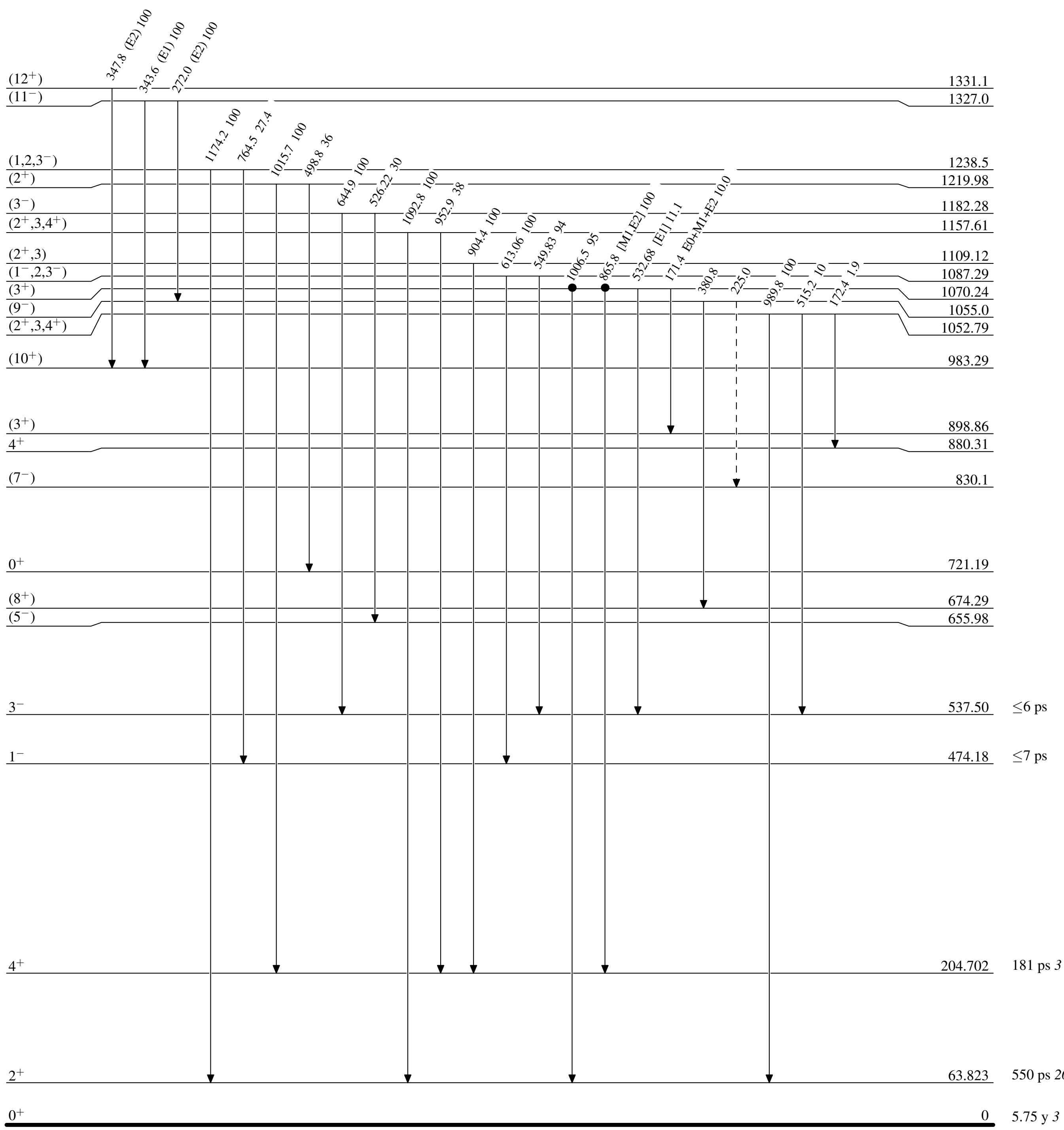
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

Legend

γ Decay (Uncertain)
● Coincidence



$^{228}_{88}Ra_{140}$

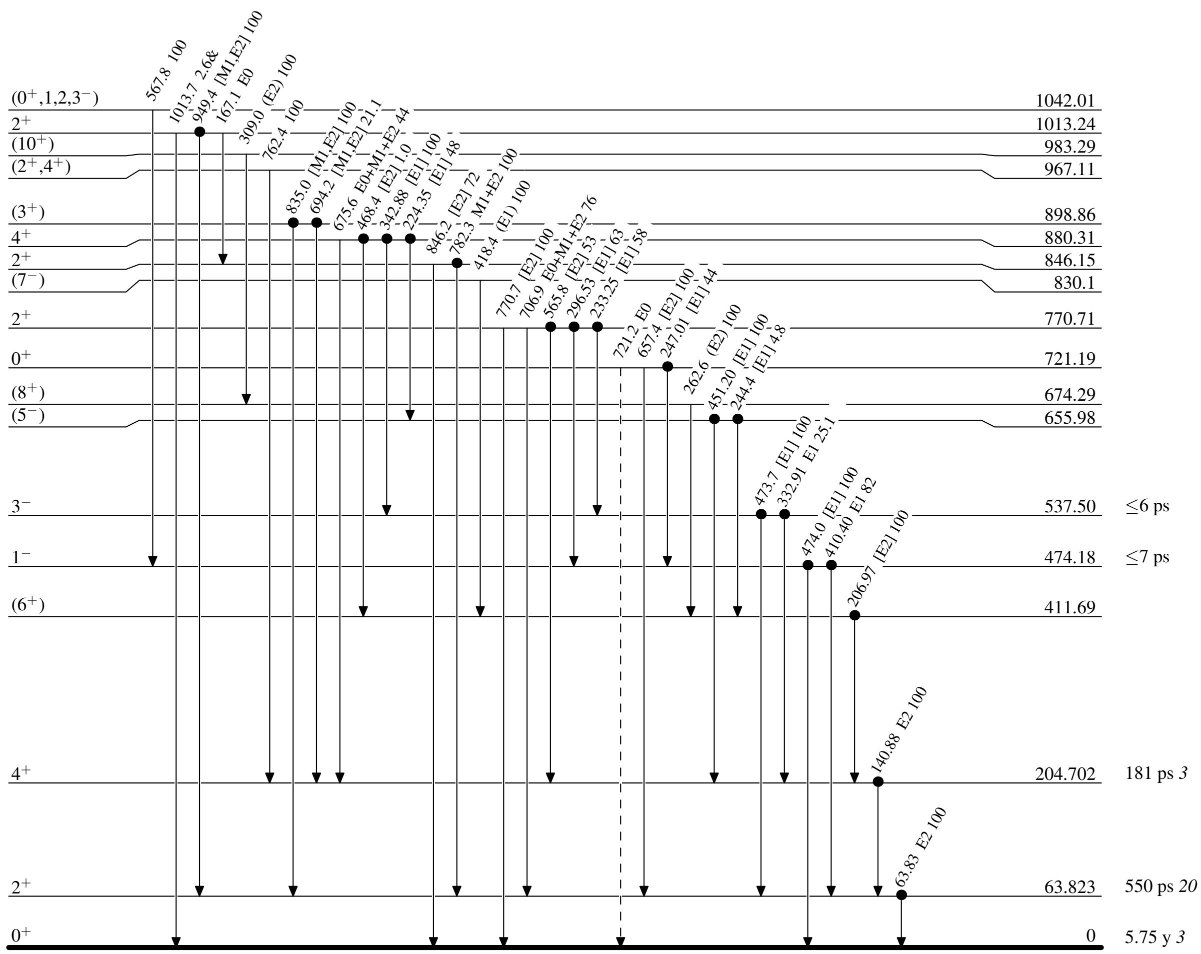
Adopted Levels, Gammas

Legend

Level Scheme (continued)

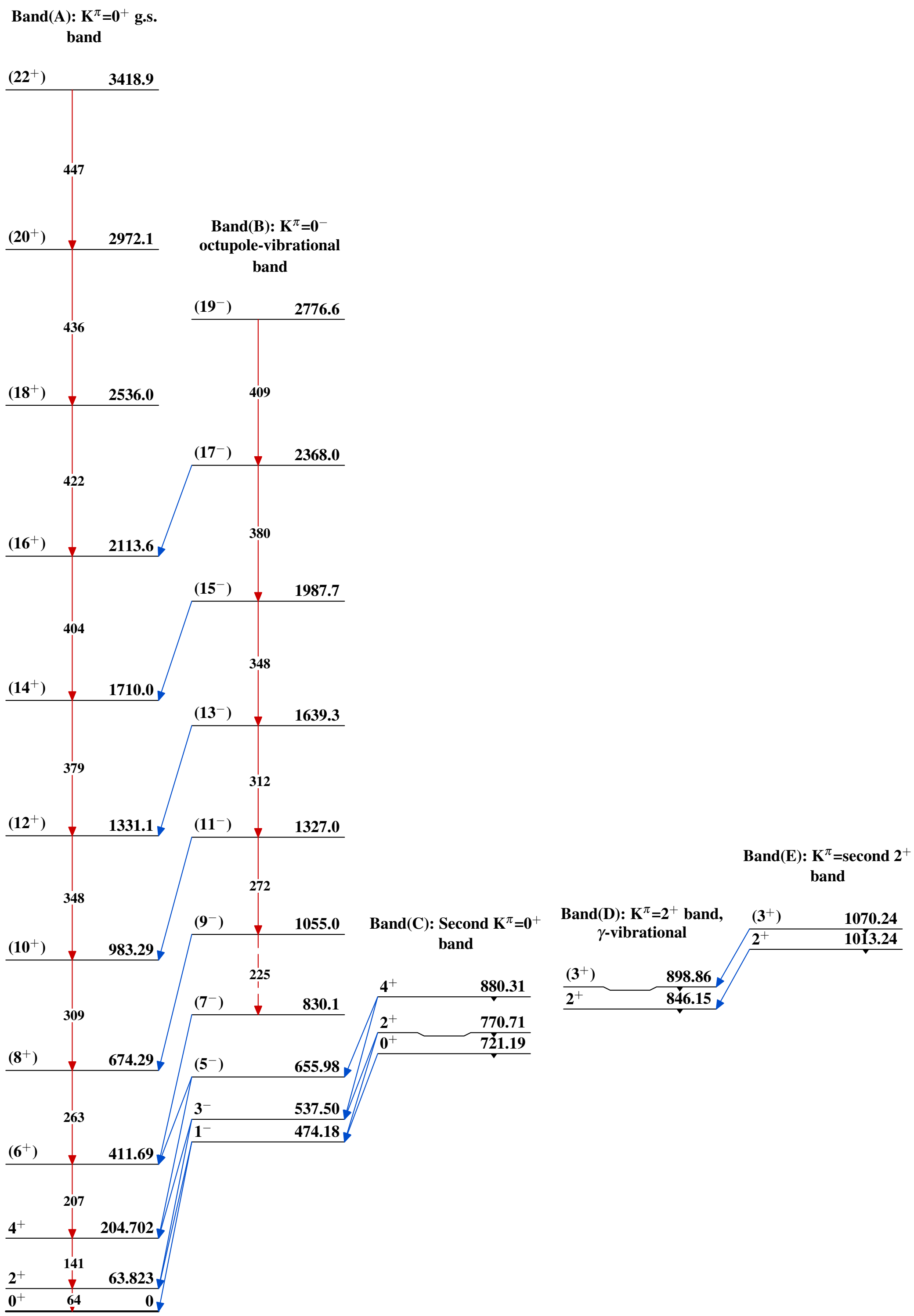
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

γ Decay (Uncertain)
Coincidence



$^{228}_{88}Ra_{140}$

Adopted Levels, Gammas



$^{228}_{88}Ra_{140}$