Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh et al. ,	NDS 175, 1 (2021)	19-May-2021

Q(β^-)=−2180 *50*; S(n)=5323 *12*; S(p)=4955 *8*; Q(α)=8138 *3* 2021Wa16
S(2n)=12638 *10*, S(2p)=8843 *8* (2021Wa16).
Additional information 1.
Theoretical calculations: 34 primary references in the NSR database (www.nndc.bnl.gov/nsr), 12 related to structure calculations, and 22 to radioactivity.
1952Me13: ^{219}Ra identified in α decay chain: ^{227}U→^{223}Th→^{219}Rn at the 184-inch Berkeley cyclotron, where ^{227}U was produced in bombardment of thorium nitrate with helium beam. Short half-life was deduced for the decay of ^{219}Rn from α measurements. Later measurements at Berkeley by 1970Va13 measured the half-life more precisely.

^{219}Ra Levels

The high-spin level scheme was first proposed by 1987Co36 with the discovery of a ground-state band up to 51/2, later modified and extended by 1992Wi02, 1992Li09, 2000Ri12 and 2017He15. See also 1993Sh43 and 2001Sh14 for analysis of spectroscopic data from in-beam γ-ray and α-decay experiments. The ground state band and two side bands have been proposed, with all the three bands containing states of both parities connected by E1 γ transitions. The ground-state band has been interpreted in terms of weak coupling of a $g_{9/2}$ neutron to a soft quadrupole core of ^{218}Ra. It has K=1/2 and an expected large decoupling constant, which gives rise to J^π=7/2$^+$ ground state. The interpretation of the level scheme with three alternating parity bands having different K values is consistent with average B(E1)/B(E2) branching ratios deduced by 1992Wi02 and 1987Co36.

Cross Reference (XREF) Flags

A	^{223}Th α decay (0.60 s)
B	^{208}Pb(^{14}C,3nγ) E=67 MeV
C	^{208}Pb(^{14}C,3nγ) E=65 MeV
D	^{208}Pb(^{14}C,3nγ) E=68 MeV

E(level)†	J$^\pi$‡	T$_{1/2}$	XREF	Comments
0.0	(7/2$^+$)	9 ms *2*	ABCD	%α=100 T$_{1/2}$: from weighted average of 10 ms *3* for 7980 *10* α and 8 ms *2* for 7660 *20* α (2018Sa45). Others: 10 ms *3* (1970Va13, probably for composite α lines from the decay of the g.s. and 16.6-keV isomer); short half-life (1952Me13). J$^\pi$: analogy with (7/2$^+$) g.s. in isotonic ^{221}Th. 2000Ri12 provide detailed discussion for assignment of 7/2 in preference to 11/2, based on their conversion electron measurements and implied multipolarities of transitions in (^{14}C,3nγ) study, results of α(316γ)(θ) experiment in ^{219}Ra to ^{215}Rn decay (1989Ha26), and consideration of four different scenarios for the structure of the g.s. of ^{219}Ra, and probable inferred J^π values of these structures, concluding that ground state of ^{219}Ra is statically octupole deformed, consistent with spectrum of low-lying levels predicted by 1993Sh43 (also 2001Sh14), pointing out that in the ground state the odd neutron populated a K=1/2 state having a very large decoupling parameter, resulting in a J^π=7/2$^+$ ground state, and 11/2$^+$ first excited state at 16 keV. Other: 1989Ha26 measured 7/2 or 11/2, rejecting 9/2 for the 316 level in ^{215}Rn (α)(316γ)(θ) in ^{219}Ra α decay, and assigning favored α decay (HF=4.7 *15*) of ^{219}Ra g.s. α decay to the 316 level in ^{215}Rn, (7/2,11/2) was assigned for ^{219}Ra g.s., with further preference for 7/2$^+$ for ^{219}Ra g.s. from systematics arguments. Note, however, that the 316 level in ^{215}Rn has since been assigned (11/2)$^+$ in ^{215}Rn Adopted Levels in the ENSDF database (Sept 2013 update), which negates the argument made by 1989Ha26 about favored α decay. In addition, from data in 2018Sa45 for ^{219}Ra decay, HF=7 *3* (deduced by evaluators) for decay to the 316 level in ^{215}Rn may not be a favored decay.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{219}Ra Levels (continued)

E(level)[†]	J^{π}[‡]	$T_{1/2}$	XREF	Comments
16.6[#] *2*	(11/2⁺)	10 ms *3*	ABCD	%α≈100 (2018Sa45); %IT=? $T_{1/2}$: estimated half-life from Monte Carlo analysis of α decay data from ^{219}Ra decay (2018Sa45). J^{π}: from prediction of theoretical calculations in 2001Sh14, based on reflection-asymmetric strong coupling model, as shown in authors′ Fig. 5., and comparison of experimental low-lying $(11/2^+)$ levels in isotonic ^{217}Rn (first excited state) and ^{215}Po (second excited state), and in isotope ^{217}Ra (second excited state). Also, almost 100% α decay from this isomer to 316, $(11/2)^+$ state in ^{215}Rn, proposed in 2018Sa45, with HF=3.5 *11* (deduced by evaluators), which may be considered as a favored decay, supporting $(11/2^+)$ for the 16.6 level.
52.1 *3*	(3/2⁺)		A	J^{π}: 88γ from $(5/2^+)$; systematics (2001Sh14).
113.7[&] *1*	(9/2⁺)		ABCD	J^{π}: 97γ M1 to $(11/2^+)$; band member.
140.0 *1*	(5/2⁺)		A	J^{π}: favored α decay (HF=2.7) from ^{223}Th g.s. with $J^{\pi}=(5/2^+)$, where J^{π} can be assigned on the basis of analogy with $5/2^+$ g.s. of isotonic ^{221}Ra, and prediction from theoretical calculations by 1987Sh24.
152.0 *1*	(7/2⁺)		A	J^{π}: 152γ M1+E2 to $(7/2^+)$; 38γ (M1+E2) to $(9/2^+)$.
251.1[#] *2*	(15/2⁺)		BCD	J^{π}: E2 γ to $(11/2^+)$.
271.6? *8*			A	J^{π}: $(5/2^+$ to $11/2^+)$ from possible 158γ to $(9/2)^+$ and 119γ to $(7/2)^+$.
320.6 *4*	(3/2⁺,5/2,7/2⁺)		A	J^{π}: 320γ to $(7/2^+)$; 268γ to $(3/2^+)$. 2001Sh14 suggested $(5/2^-)$ from systematics.
328.3 *5*	(1/2⁺ to 7/2⁺)		A	J^{π}: 276γ to $(3/2^+)$; 188γ to $(5/2^+)$.
404.7 *2*	(3/2⁺,5/2,7/2⁺)		A	J^{π}: 353γ to $(3/2^+)$; 253γ to $(7/2^+)$. 2001Sh14 suggested $(5/2^-)$ from systematics.
421.7 *12*			A	J^{π}: 421γ to $(7/2^+)$.
445.0 *3*	(5/2⁺,7/2,9/2⁺)		A	J^{π}: 331γ to $(9/2^+)$; 305γ to $(5/2^+)$. 2001Sh14 suggested $(7/2^-)$ from systematics.
470.7 *5*	(5/2⁺ to 11/2⁺)		A	J^{π}: 357γ to $(9/2^+)$; 319γ to $(7/2^+)$. 2001Sh14 suggested $(9/2^-)$ from systematics.
475.2[&] *2*	(13/2⁺)		BCD	J^{π}: 361γ E2 to $(9/2^+)$; 459γ M1 to $(11/2^+)$; band member.
512.4[@] *2*	(17/2⁻)		BCD	J^{π}: 261γ E1 to $(15/2^+)$; band member.
515.4 *10*			A	J^{π}: $(5/2^+$ to $13/2^+)$ from 401γ to $(9/2^+)$.
546.1[#] *2*	(19/2⁺)		BCD	
556.0[b] *3*	(13/2⁺)		CD	
604.1[a] *2*	(15/2⁻)		BCD	
751.3[@] *2*	(21/2⁻)		BCD	
779.8[c] *4*	(15/2⁻)		CD	
853.5[&] *3*	(17/2⁺)		BCD	
876.5[b] *3*	(17/2⁺)		BCD	
893.2[#] *3*	(23/2⁺)		BCD	
937.6[a] *2*	(19/2⁻)		BCD	
1053.3[@] *3*	(25/2⁻)		BCD	
1131.2[c] *4*	(19/2⁻)		CD	
1245.7[&] *3*	(21/2⁺)		BCD	
1257.3[b] *3*	(21/2⁺)		CD	
1288.4[#] *3*	(27/2⁺)		BCD	
1324.9[a] *3*	(23/2⁻)		BCD	
1411.4[@] *3*	(29/2⁻)		BCD	
1426.4? *5*			C	
1504.4[c] *4*	(23/2⁻)		CD	
1638.1[&] *4*	(25/2⁺)		BCD	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{219}Ra Levels (continued)

E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF
1671.6[b] 5	(25/2+)	CD	2460.1[&] 4	(33/2+)	BCD	3451.2[a] 7	(43/2−)	D
1701.6[#] 3	(31/2)+	BCD	2567.9[a] 4	(35/2−)	CD	3522.5[#] 5	(47/2+)	B D
1738.2[a] 3	(27/2−)	BCD	2580.4[#] 4	(39/2+)	BCD	3775.6[&] 9	(45/2+)	D
1833.2[@] 3	(33/2−)	BCD	2767.8[@] 4	(41/2−)	BCD	3793.2[@] 5	(49/2−)	B D
1933.1?[c] 9	(27/2−)	D	2888.0[&] 6	(37/2+)	D	3913.8[a] 14	(47/2−)	D
2038.6[&] 4	(29/2+)	BCD	3003.0[a] 5	(39/2−)	CD	4024.7[#] 7	(51/2+)	B D
2130.2[#] 3	(35/2+)	BCD	3045.7[#] 4	(43/2+)	BCD	4324.7?[@] 9	(53/2−)	D
2152.9[a] 4	(31/2−)	BCD	3272.7[@] 4	(45/2−)	B D			
2289.7[@] 4	(37/2−)	BCD	3320.4[&] 7	(41/2+)	D			

† Deduced by evaluators from a least-squares fit to Eγ data.

‡ Spin and parity assignments to levels from ^{208}Pb(^{14}C,3nγ) are based on band structure, γ-ray multipolarities inferred from conversion electron data (2000Ri12,1987Co36), DCO ratios (1992Wi02,2017He15), and γ(θ) data in 1987Co36.

\# Band(A): Band based on (11/2+). Alternating parity band, indicating reflection asymmetric structure.

@ Band(a): Band based on (17/2−). Alternating parity band, indicating reflection asymmetric structure.

& Band(B): Band based on (9/2+). Alternating parity band, indicating reflection asymmetric structure.

a Band(b): Band based on (15/2−). Alternating parity band, indicating reflection asymmetric structure.

b Band(C): Band based on (13/2+). Alternating parity band, indicating reflection asymmetric structure.

c Band(c): Band based on (15/2−). Alternating parity band, indicating reflection asymmetric structure.

Adopted Levels, Gammas (continued)

γ(^{219}Ra)

E$_i$(level)	J$^\pi_i$	E$_\gamma$†	I$_\gamma$†	E$_f$	J$^\pi_f$	Mult.†	δ	α#	Comments
52.1	(3/2$^+$)	52.0‡ *3*	100‡	0.0	(7/2$^+$)	[E2]		216 *7*	
113.7	(9/2$^+$)	97.14‡ *17*	56‡ *7*	16.6	(11/2$^+$)	M1‡		3.39	
		113.74‡ *11*	100‡ *13*	0.0	(7/2$^+$)	M1‡		10.83	
140.0	(5/2$^+$)	88.0‡ *5*	9‡ *7*	52.1	(3/2$^+$)	[M1+E2]		11 *7*	
		140.01‡ *9*	100‡ *11*	0.0	(7/2$^+$)	M1‡		5.99	
152.0	(7/2$^+$)	38.2‡ *3*	1.9‡ *9*	113.7	(9/2$^+$)	(M1+E2)‡	0.31‡ *15*	132 *62*	
		151.99‡ *10*	100‡ *11*	0.0	(7/2$^+$)	M1+E2‡	0.95‡ *+90−50*	3.3 *10*	
251.1	(15/2$^+$)	234.5 *1*	100	16.6	(11/2$^+$)	E2		0.336	
271.6?		119.6‡@		152.0	(7/2$^+$)				
		157.8‡@		113.7	(9/2$^+$)				
320.6	(3/2$^+$,5/2,7/2$^+$)	168.8‡ *5*	100‡ *50*	152.0	(7/2$^+$)				
		268.0‡ *10*	≈167‡	52.1	(3/2$^+$)				
		320.6‡ *8*	≈33‡	0.0	(7/2$^+$)				
328.3	(1/2$^+$ to 7/2$^+$)	188.4‡ *7*	≈50‡	140.0	(5/2$^+$)				
		276.1‡ *6*	100‡ *50*	52.1	(3/2$^+$)				
404.7	(3/2$^+$,5/2,7/2$^+$)	252.8‡ *2*	43‡ *13*	152.0	(7/2$^+$)				
		264.7‡ *2*	100‡ *30*	140.0	(5/2$^+$)				
		353.0‡@	≈2.9‡	52.1	(3/2$^+$)				
421.7		421.7‡ *12*	100‡	0.0	(7/2$^+$)				
445.0	(5/2$^+$,7/2,9/2$^+$)	124.4‡@		320.6	(3/2$^+$,5/2,7/2$^+$)				
		293.0‡ *5*	100‡ *25*	152.0	(7/2$^+$)				
		305.0‡ *5*	100‡ *50*	140.0	(5/2$^+$)				
		331.3‡ *5*	100‡ *50*	113.7	(9/2$^+$)				
470.7	(5/2$^+$ to 11/2$^+$)	318.8‡ *7*	60‡ *30*	152.0	(7/2$^+$)				
		356.9‡ *7*	100‡ *60*	113.7	(9/2$^+$)				
475.2	(13/2$^+$)	361.5 *2*	100 *5*	113.7	(9/2$^+$)	E2		0.0887	
		458.6 *2*	68 *4*	16.6	(11/2$^+$)	M1		0.224	
512.4	(17/2$^-$)	261.2 *1*	100	251.1	(15/2$^+$)	E1		0.048	
515.4		401.7‡ *10*	100‡	113.7	(9/2$^+$)				
546.1	(19/2$^+$)	295.0 *1*	100	251.1	(15/2$^+$)	(E2)		0.160	
556.0	(13/2$^+$)	539.1 *4*	100	16.6	(11/2$^+$)	D			
604.1	(15/2$^-$)	(48.1)		556.0	(13/2$^+$)				E$_\gamma$: unobserved transition with Eγ=48.4 in E=65 MeV (1992Wi02) only. Here Eγ is from level-energy difference.
		128.9 *2*	100 *6*	475.2	(13/2$^+$)	E1		0.260	
		353.0 *3*	30 *3*	251.1	(15/2$^+$)				I$_\gamma$: from E=68 MeV (2017He15). Other: 11 *2* (E=65 MeV, 1992Wi02).

$^{219}_{88}Ra_{131}$-4

$\gamma(^{219}Ra)$ (continued)

E_i(level)	J^{π}_i	E_{γ} †	I_{γ} †	E_f	J^{π}_f	Mult. †	α #	Comments
751.3	(21/2⁻)	205.2 *2*	100 *4*	546.1	(19/2⁺)	E1	0.0849	
		238.5 *2*	4.3 *11*	512.4	(17/2⁻)	(E2)	0.316	I_{γ}: unweighted average of 6.36 *23* (E=68 MeV, 2017He15); 3.88 *15* (E=65 MeV, 1992Wi02); 2.80 *15* (E=67 MeV, 1987Co36).
779.8	(15/2⁻)	223.8 *3*	100	556.0	(13/2⁺)			
853.5	(17/2⁺)	249.4 *2*	100 *5*	604.1	(15/2⁻)	D		
		378.3 *3*	35 *4*	475.2	(13/2⁺)			
876.5	(17/2⁺)	96.7 *3*	16 *4*	779.8	(15/2⁻)	[E1]	0.1207	I_{γ}: from E=68 MeV (2017He15). Other: 56 *4* in E=65 MeV (1992Wi02).
		320.5 *3*	16 *4*	556.0	(13/2⁺)	(E2)	0.125	I_{γ}: from E=68 MeV (2017He15). Other: 85 *41* in E=65 MeV (1992Wi02).
		625.7 *3*	100 *11*	251.1	(15/2⁺)	D		
893.2	(23/2⁺)	141.7 *2*	100 *5*	751.3	(21/2⁻)	E1	0.207	
		347.3 *2*	75 *8*	546.1	(19/2⁺)	E2	0.0991	I_{γ}: unweighted average of 67 *2* (E=68 MeV, 2017He15) and 83 *5* (E=65 MeV, 1992Wi02). Other: 123 *6* (E=67 MeV, 1987Co36). Unweighted average of all the three results is 91 *17*.
937.6	(19/2⁻)	(61.1)		876.5	(17/2⁺)			E_{γ}: unobserved transition with Eγ=61.4 in E=65 MeV (1992Wi02) only. Here Eγ is from level-energy difference.
		84.3 *3*	29 *8*	853.5	(17/2⁺)	(E1)	0.174	I_{γ}: from E=65 MeV (1992Wi02). Other: 244 *17* (E=68 MeV, 2017He15).
		333.6 *2*	100 *5*	604.1	(15/2⁻)	(E2)	0.111	
		391.9 *5*		546.1	(19/2⁺)			
		425.4 *3*	28 *4*	512.4	(17/2⁻)			I_{γ}: from E=68 MeV (2017He15). Other: 12 *2* (E=65 MeV, 1992Wi02).
1053.3	(25/2⁻)	160.1 *2*	100 *3*	893.2	(23/2⁺)	E1	0.1545	
		302.0 *2*	26 *4*	751.3	(21/2⁻)	E2	0.1492	I_{γ}: unweighted average of 19.7 *16* (E=68 MeV, 2017He15); 26.1 *13* (E=65 MeV, 1992Wi02); 31.9 *16* (E=67 MeV, 1987Co36).
1131.2	(19/2⁻)	254.8 *3*	100 *8*	876.5	(17/2⁺)	D		
		351.2 *5*	44 *11*	779.8	(15/2⁻)			I_{γ}: available from E=68 MeV (2017He15) only.
		619@ *1*	100 *15*	512.4	(17/2⁻)			E_{γ}: γ from E=65 MeV only (1992Wi02).
1245.7	(21/2⁺)	308.4 *3*	100 *17*	937.6	(19/2⁻)	D		I_{γ}: from E=68 MeV (2017He15).
		390.7 *10*	25 *8*	853.5	(17/2⁺)			E_{γ}: from E=68 MeV (2017He15). Tentative γ with Eγ=392.3 *5* in E=65 MeV (1992Wi02). Not reported in E=67 MeV (1987Co36).
1257.3	(21/2⁺)	126.0 *3*	97 *17*	1131.2	(19/2⁻)	[E1]	0.275	I_{γ}: unweighted average of 80 *10* (E=68 MeV, 2017He15) and 114 *14* (E=65 MeV, 1992Wi02).
		381.0 *3*	100 *10*	876.5	(17/2⁺)			
		711.0 *3*	84 *17*	546.1	(19/2⁺)			I_{γ}: unweighted average of 100 *10* (E=68 MeV, 2017He15) and 67 *7* (E=65 MeV, 1992Wi02).
1288.4	(27/2⁺)	234.9 *2*	100.0 *25*	1053.3	(25/2⁻)			
		395.0 *2*	36 *6*	893.2	(23/2⁺)	(E2)	0.0697	I_{γ}: unweighted average of 26.8 *25* (E=68 MeV, 2017He15); 35.9 *16* (E=65 MeV, 1992Wi02); 46.9 *26* (E=67 MeV, 1987Co36).
1324.9	(23/2⁻)	79.4 *3*	20 *2*	1245.7	(21/2⁺)	[E1]	0.204	I_{γ}: from E=68 MeV (2017He15). Other: 7.1 *24* (E=65 MeV, 1992Wi02).
		387.4 *2*	100 *5*	937.6	(19/2⁻)	(E2)	0.0735	
		573.6 *3*	45 *4*	751.3	(21/2⁻)			I_{γ}: from E=68 MeV (2017He15). Other: 16.5 *24* (E=65 MeV, 1992Wi02).
1411.4	(29/2⁻)	122.8 *2*	83 *12*	1288.4	(27/2⁺)	(E1)	0.292	I_{γ}: unweighted average of 94 *3* (E=68 MeV, 2017He15) and 71 *3* (E=65 MeV, 1992Wi02). Other: 46.9 *26* (E=67 MeV, 1987Co36).
		358.1 *1*	100 *3*	1053.3	(25/2⁻)	E2	0.0911	
1426.4?		295.2@ *3*	100	1131.2	(19/2⁻)			

$^{219}_{88}Ra_{131}$-5

Adopted Levels, Gammas (continued)

γ(^{219}Ra) (continued)

E_i(level)	J^{π}_i	E_γ†	I_γ†	E_f	J^{π}_f	Mult.†	α#	Comments
1504.4	(23/2⁻)	247.2 *3*	100 *11*	1257.3	(21/2⁺)			
		373.3 *10*	22 *11*	1131.2	(19/2⁻)			E_γ,I_γ: from E=68 MeV (2017He15). Tentative 373.3 *5* γ in E=65 MeV (1992Wi02), with no intensity given.
		753@ *1*		751.3	(21/2⁻)			γ from E=65 MeV (1992Wi02) only, with Iγ=425 *75*. Treated as uncertain by evaluators, since not confirmed in 2017He15.
1638.1	(25/2⁺)	313.1 *3*	100 *10*	1324.9	(23/2⁻)			
		392.4 *9*	43 *5*	1245.7	(21/2⁺)			E_γ,I_γ: from E=68 MeV (2017He15). Tentative 392.6 *5* γ in E=65 MeV (1992Wi02), with no intensity given.
1671.6	(25/2⁺)	167.3 *3*	100 *17*	1504.4	(23/2⁻)	(E1)	0.138	
		414.0 *5*	117 *34*	1257.3	(21/2⁺)			I_γ: given in E=68 MeV (2017He15) only.
		776.8@ *10*	33 *17*	893.2	(23/2⁺)			E_γ,I_γ: tentative γ from E=68 MeV (2017He15) only.
1701.6	(31/2)⁺	290.2 *2*	100 *3*	1411.4	(29/2⁻)	E1	0.0379	
		413.2 *2*	14.3 *10*	1288.4	(27/2⁺)	Q		
1738.2	(27/2⁻)	100.2 *5*	59.1 *23*	1638.1	(25/2⁺)	[E1]	0.110	I_γ: available from E=68 MeV (2017He15) only.
		413.7 *3*	100 *7*	1324.9	(23/2⁻)	Q		
		685.0 *4*	68 *5*	1053.3	(25/2⁻)			I_γ: from E=68 MeV (2017He15). Other: 28.6 *36* (E=65 MeV, 1992Wi02).
1833.2	(33/2⁻)	131.6 *2*	41 *8*	1701.6	(31/2)⁺	(E1)	0.247	I_γ: unweighted average of 56 *4* (E=68 MeV, 2017He15); 36.4 *15* (E=65 MeV, 1992Wi02); 30.7 *16* (E=67 MeV, 1987Co36).
		421.8 *1*	100 *4*	1411.4	(29/2⁻)	E2	0.0588	
1933.1?	(27/2⁻)	261.5 *7*	100 *13*	1671.6	(25/2⁺)			
		428.1@ *10*	13 *6*	1504.4	(23/2⁻)			
2038.6	(29/2⁺)	300.4 *4*	100 *4*	1738.2	(27/2⁻)			
		400.5 *3*	21 *4*	1638.1	(25/2⁺)			I_γ: weighted average of 19.4 *32* (E=68 MeV, 2017He15) and 32 *8* (E=65 MeV, 1992Wi02).
2130.2	(35/2⁺)	297.0 *3*	100 *5*	1833.2	(33/2⁻)	E1	0.0360	
		428.6 *2*	23.6 *20*	1701.6	(31/2)⁺	Q		I_γ: unweighted average of 21.7 *11* (E=68 MeV, 2017He15) and 25.5 *10* (E=65 MeV, 1992Wi02). Other: 11.7 *5* (E=67 MeV, 1987Co36).
2152.9	(31/2⁻)	114.1 *3*	13.4 *15*	2038.6	(29/2⁺)			I_γ: from E=68 MeV (2017He15). Other: 22.4 *9* (E=65 MeV, 1992Wi02).
		414.9 *2*	100 *5*	1738.2	(27/2⁻)	Q		
		741.4 *5*	27 *3*	1411.4	(29/2⁻)			I_γ: weighted average of 28 *3* (E=68 MeV, 2017He15) and 25.9 *35* (E=65 MeV, 1992Wi02). Other: 11.7 *5* (E=67 MeV, 1987Co36).
2289.7	(37/2⁻)	159.5 *3*	46 *12*	2130.2	(35/2⁺)	[E1]	0.155	I_γ: unweighted average of 34 *6* (E=65 MeV, 1992Wi02) and 57 *8* (E=67 MeV, 1987Co36). Other: 13.4 *15* (E=68 MeV, 2017He15). Unweighted average of all three results is 35 *13*.
		456.4 *2*	100 *5*	1833.2	(33/2⁻)	E2	0.0482	
2460.1	(33/2⁺)	307.5 *3*	100 *10*	2152.9	(31/2⁻)			
		421.6 *5*	127 *10*	2038.6	(29/2⁺)			I_γ: from E=68 MeV (2017He15) only. Tentative γ in E=65 MeV (1992Wi02), with no Iγ; γ not reported in 1987Co36.
2567.9	(35/2⁻)	108.1 *3*	45 *5*	2460.1	(33/2⁺)			I_γ: from E=68 MeV (2017He15). Other: 15 *8* (E=65 MeV, 1992Wi02).
		415.1 *3*	173 *9*	2152.9	(31/2⁻)			I_γ: from E=68 MeV (2017He15). Other: 85 *39* (E=65 MeV, 1992Wi02).
		734.4 *4*	100 *9*	1833.2	(33/2⁻)			
2580.4	(39/2⁺)	290.6 *3*	100 *4*	2289.7	(37/2⁻)	D		

$^{219}_{88}Ra_{131}$-6

γ(^{219}Ra) (continued)

E_i(level)	J^{π}_i	E_{γ}†	I_{γ}†	E_f	J^{π}_f	Mult.†	α#	Comments
2580.4	(39/2+)	450.2 *3*	30.7 *20*	2130.2	(35/2+)	Q		I_{γ}: weighted average of 33.3 *22* (E=68 MeV, 2017He15) and 29.6 *23* (E=65 MeV, 1992Wi02); 29.4 *20* (E=67 MeV, 1987Co36).
2767.8	(41/2−)	187.5 *3*	38.2 *14*	2580.4	(39/2+)	(E1)	0.105	I_{γ}: weighted average of 38.0 *14* (E=68 MeV, 2017He15) and 42 *6* (E=65 MeV, 1992Wi02). Other: 59.5 *27* (E=67 MeV, 1987Co36). Unweighted average of all the three results is 47 *6*.
		478.1 *3*	100 *3*	2289.7	(37/2−)			
2888.0	(37/2+)	319.9 *9*	100 *7*	2567.9	(35/2−)			
		428.1 *9*	73 *7*	2460.1	(33/2+)			
3003.0	(39/2−)	114.8 *10*	29 *5*	2888.0	(37/2+)	[E1]	0.343 *9*	γ from E=68 MeV (2017He15) only.
		435.4 *3*	100 *10*	2567.9	(35/2−)			
		711.9 *9*	67 *5*	2289.7	(37/2−)			γ from E=68 MeV (2017He15) only.
3045.7	(43/2+)	277.7 *5*	100 *4*	2767.8	(41/2−)	D		
		465.1 *3*	80 *5*	2580.4	(39/2+)	Q		I_{γ}: weighted average of 84 *4* (E=68 MeV, 2017He15) and 73 *5* (E=67 MeV, 1987Co36). In E=65 MeV (1992Wi02), Iγ is available for only the 465γ, thus no branching ratio can be deduced.
3272.7	(45/2−)	226.9 *2*	45 *4*	3045.7	(43/2+)	D		I_{γ}: from E=68 MeV (2017He15). Other: 100 *13* (E=67 MeV, 1987Co36).
		505.0 *2*	100 *7*	2767.8	(41/2−)	Q		
3320.4	(41/2+)	317.6 *9*	100 *14*	3003.0	(39/2−)			
		432.5 *10*	57 *14*	2888.0	(37/2+)			
3451.2	(43/2−)	131.0 *8*	100 *4*	3320.4	(41/2+)			
		448.6 *8*	80 *4*	3003.0	(39/2−)			
		682.3 *10*	16 *4*	2767.8	(41/2−)			
3522.5	(47/2+)	249.4 *5*	100 *5*	3272.7	(45/2−)			
		476.9 *5*	95 *9*	3045.7	(43/2+)	Q		I_{γ}: from E=68 MeV (2017He15). Other: 36 *9* (E=67 MeV, 1987Co36).
3775.6	(45/2+)	324.3 *10*	12 *4*	3451.2	(43/2−)			
		455.3 *8*	100 *8*	3320.4	(41/2+)			
3793.2	(49/2−)	270.7 *3*	100 *10*	3522.5	(47/2+)			
		520.6 *4*	50 *10*	3272.7	(45/2−)	Q		I_{γ}: from E=68 MeV (2017He15). Other: 100 *17* (E=67 MeV, 1987Co36).
3913.8	(47/2−)	138.2 *10*	100 *13*	3775.6	(45/2+)			
		462.5@ *10*	75 *13*	3451.2	(43/2−)			
4024.7	(51/2+)	231.7 *5*	100 *4*	3793.2	(49/2−)			
		501.7 *9*	48 *4*	3522.5	(47/2+)	(Q)		E_{γ},I_{γ}: from E=68 MeV (2017He15). Other: Eγ=503.7 *2*, Iγ=86 *7* (E=67 MeV, 1987Co36).
4324.7?	(53/2−)	300.2@ *9*	100 *6*	4024.7	(51/2+)			
		531.2@ *10*	8 *4*	3793.2	(49/2−)			

† From ^{208}Pb(^{14}C,3nγ) reaction in different studies, for γ rays from high-spin (J≥13/2+) levels. Gamma-ray energies are from weighted averages of available data. Relative gamma-ray branching ratios differ significantly between the three studies (2017He15, 1992Wi02, 1987Co36) at different beam energies. In some cases, weighted or unweighted averages are taken, while in others, values are adopted from 2017He15, with apparently, the most statistics. Multipolarity assignments are from ce and $\gamma(\theta)$ data in E=67 MeV (1987Co36), $\gamma\gamma(\theta)$(DCO) data in E=65 MeV (1992Wi02), and ce and $\gamma\gamma(\theta)$ data in E=68 MeV

$^{219}_{88}$Ra$_{131}$-7

$\gamma(^{219}Ra)$ (continued)

(2017He15, 2000Ri12). Mult=Q is is most likely E2, as the transition is within a band, and no long-lived levels are expected to give M2. Exceptions are noted.

‡ From ^{223}Th α decay.

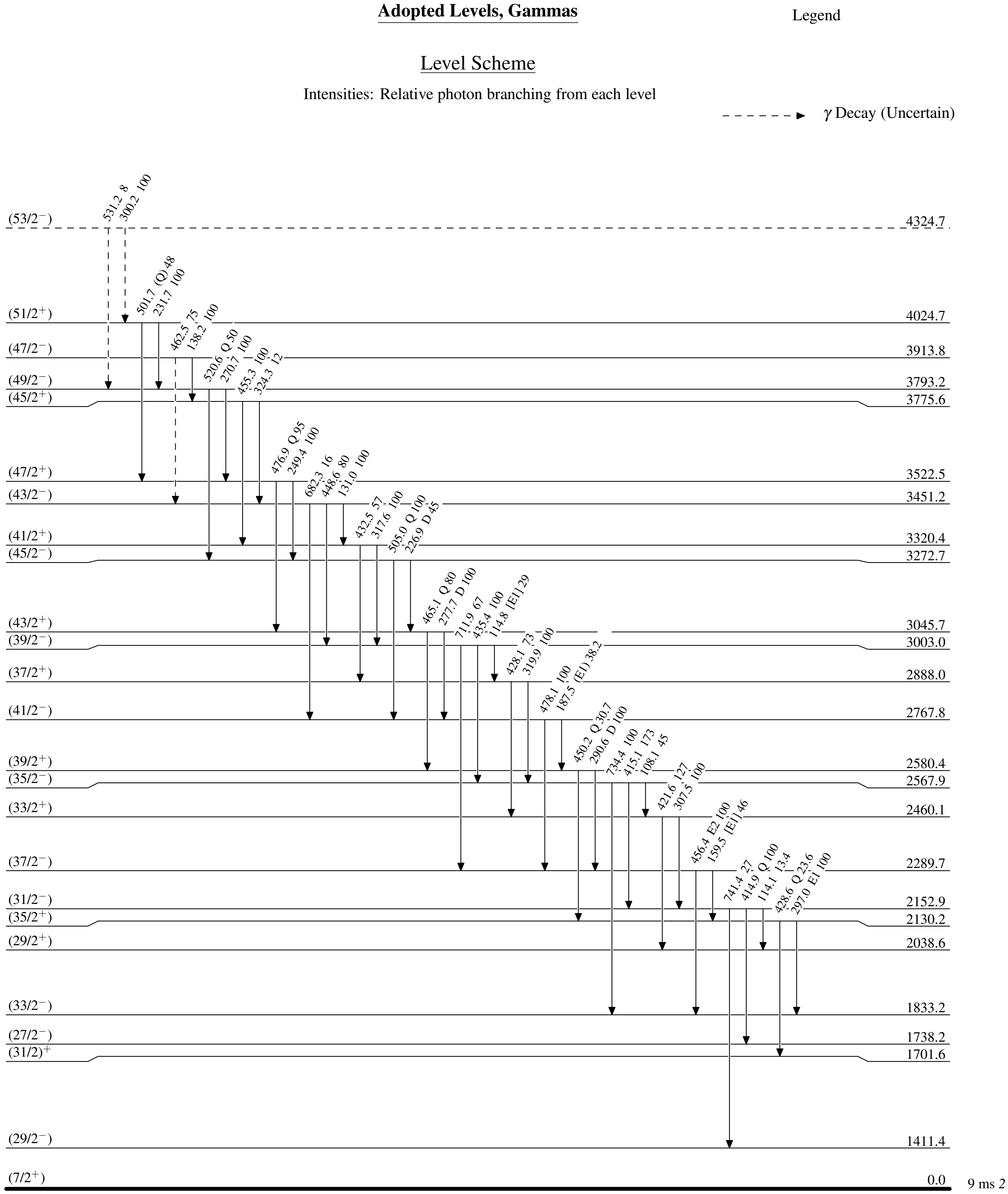
Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

@ Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

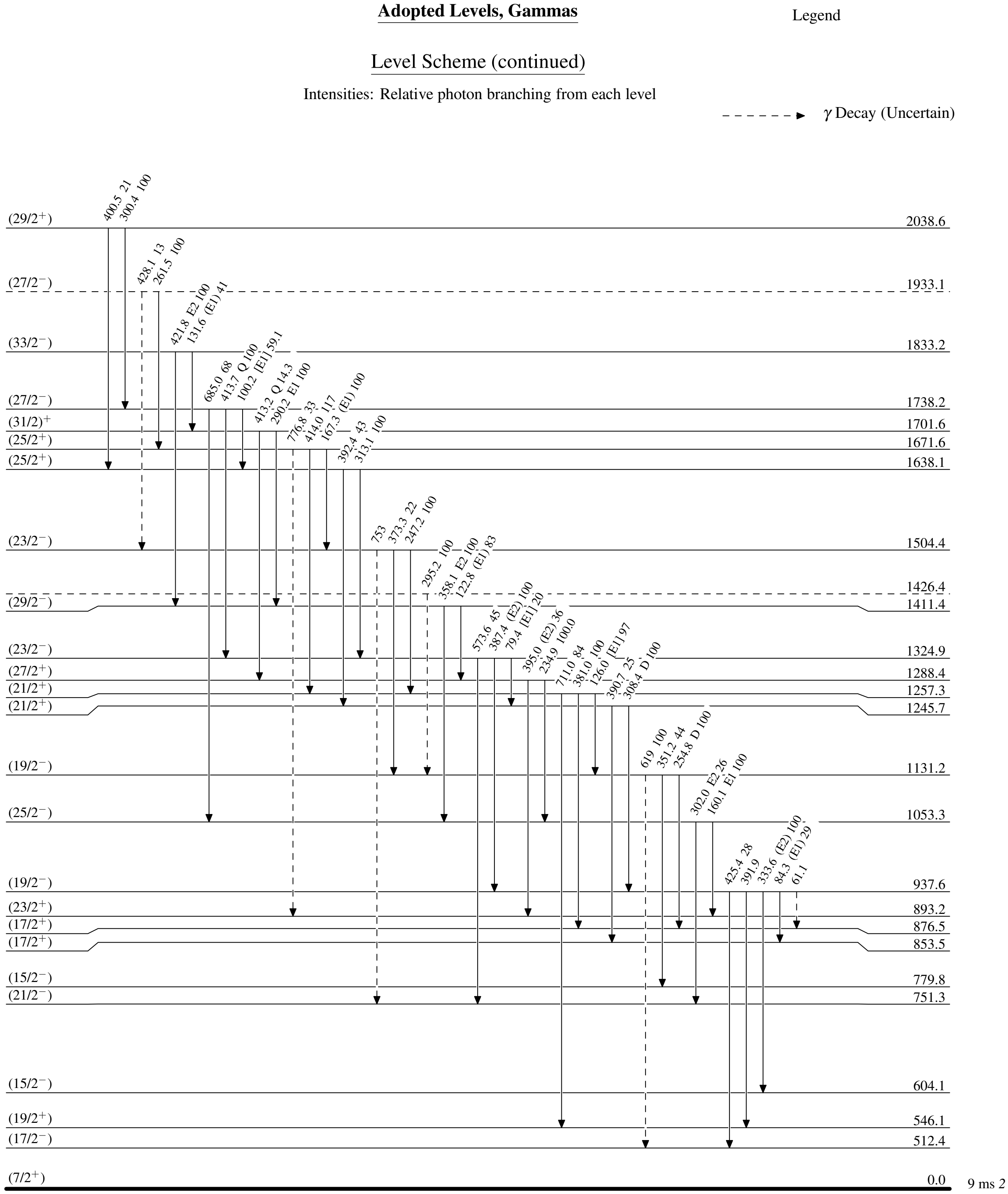


$^{219}_{88}Ra_{131}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level



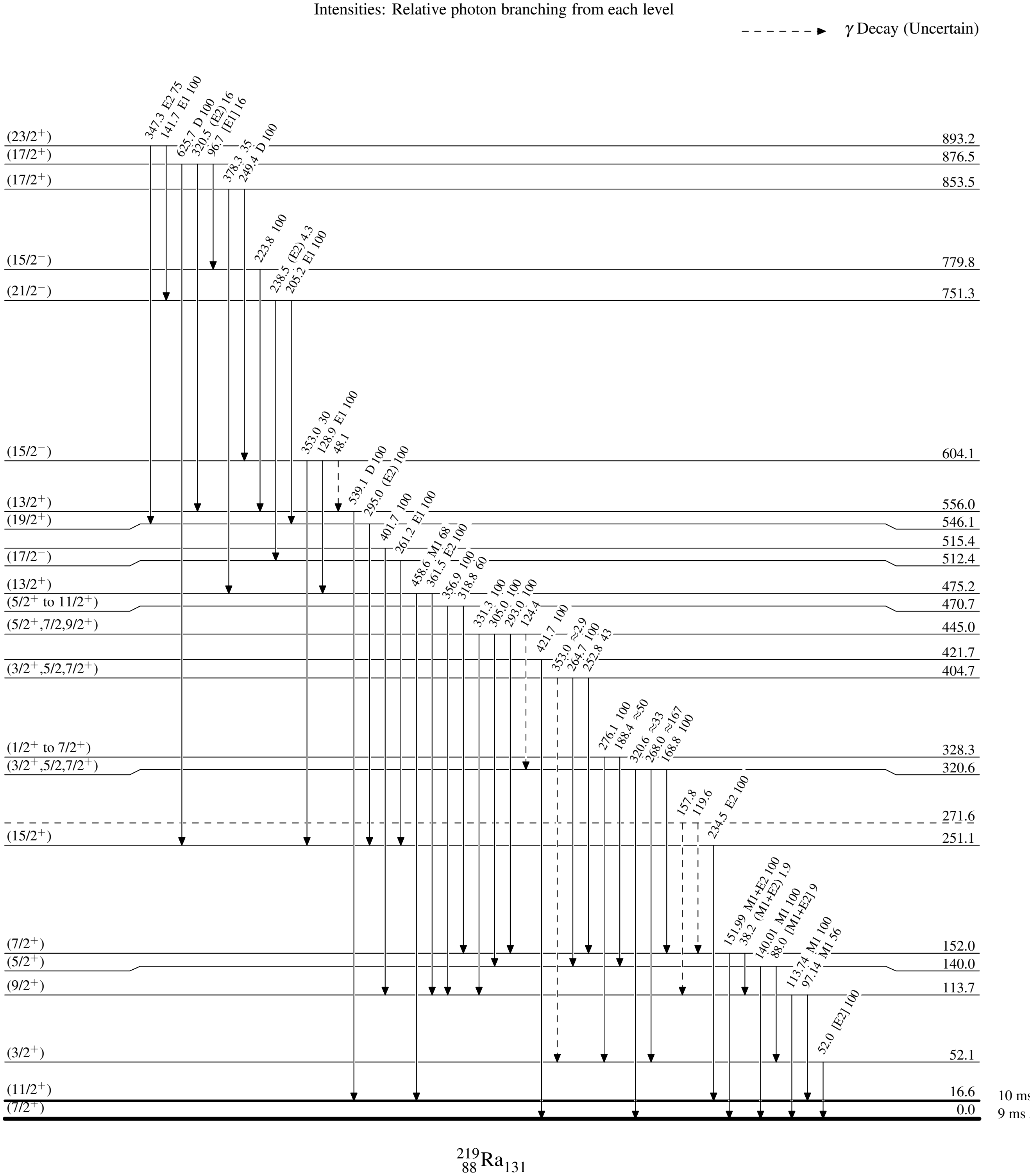
$^{219}_{88}Ra_{131}$

Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level



Adopted Levels, Gammas