Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, [1] and Jun Chen[2]	NDS 169, 1 (2020)	15-Oct-2020

Q(β^-)=−3955 *15*; S(n)=7827 *12*; S(p)=2030 *30*; Q(α)=4918 *22* 2017Wa10
S(2n)=18180 *30*, S(2n)=6579 *8* (2017Wa10).
Hyperfine structure and isotope-shift measurements using laser spectroscopy for g.s. and isomer: 2013Ba41 (in-source laser spectroscopy at the Investigation of Radioactive Isotopes on Synchrocyclotron facility of Petersburg Nuclear Physics Institute); 1990Di09; and 1987Bo44 (also 1987Bi08,1986BoZY).
Mass measurements: 2014Bo26 and 2013St25 (using Penning-trap ISOLTRAP a ISOLDE/CERN), 2000Ra23, 1999Sc46.
Theory references: consult the NSR database (www.nndc.bnl.gov/nsr/) for about 25 primary references dealing with nuclear structure and other calculations.
Additional information 1.

^{190}Tl Levels

Cross Reference (XREF) Flags

A	^{190}Pb ε decay (71 s)	D	^{160}Gd(^{35}Cl,5nγ)
B	^{194}Bi α decay (95 s)	E	^{168}Er(^{27}Al,5nγ)
C	^{194}Bi α decay (115 s)		

E(level)†	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0	2$^-$	2.6 min *3*	AB	%ε+%β^+=100 μ=+0.253 *2* (1992Me07,2019StZV) Q=−0.329 *9* (1992Me07,2016St14) J$^\pi$: spin from laser spectroscopy (1992Me07), parity from E1 γ from 1$^+$. Possible configuration=$\pi s_{1/2}\otimes\nu p_{3/2}$. μ,Q: Collinear fast-beam laser spectroscopy (1992Me07). T$_{1/2}$: from 1976Bi09 (also 1974Ha10). Other: 2.9 min *2* (1970Va27). %$\varepsilon\approx$60, %$\beta^+\approx$40 (from decay scheme). Evaluated rms charge radius=5.4121 fm *56* (2013An02). Evaluated δ<r^2>(^{205}Tl,^{190}Tl)=−0.6693 fm^2 *3* (2013An02). δ<r^2>(^{205}Tl−^{190}Tl)=−0.7063 fm^2 *4 490*(syst) (2013Ba41); first uncertainty is from isotope shift, the second uncertainty is systematic from the scaling uncertainty of the specific mass shift. δ<r^2>(^{205}Tl−^{190}Tl)=−0.68 fm^2 *8* (1990Di09). Isotope shift: $\Delta\nu$(^{205}Tl-^{190}Tl)=−7040 MHz *240* (2013Ba41).
83 *10*	7$^+$	3.6 min *3*	C E	%ε+%β^+=100 μ=+0.493 *4* (1992Me07,2019StZV) Q=+0.285 *14* (1992Me07,2016St14) Additional information 2. E(level): from measured mass excess=−24289.3 *64* for the 7$^+$ isomer (2013St25,2014Bo26) and mass excess=−24372 *8* for the g.s. (2017Wa10), as also given in 2017Au03. Others: 89 *12* (2013St25), 63 *10* (2019Gh11, deduced from known α-decay energies from previous work in 1991Va04). J$^\pi$: spin from laser spectroscopy (1992Me07), parity from agreement of measured magnetic moment with semiempirical estimated value of 0.471 (1992Me07) for $\pi s_{1/2}\otimes\nu i_{13/2}$ configuration. Also systematic occurrence of the 7$^+$ isomer in odd-odd thallium isotopes. T$_{1/2}$: weighted average of 3.6 min *3* (2013St25); 3.7 min *3* (1976Bi09, also 1974Ha10); 3.4 min *2* (1975Va20, 3.9 min *3* in 1970Va27, also 1970FeZY). In the averaging procedure, uncertainty increased to 0.3 min in 1975Va20. μ,Q: Collinear fast-beam laser spectroscopy (CFBLS) (1992Me07). Other: μ=+0.495 *4* (1987Bo44, CFBLS method). %$\varepsilon\approx$65, %$\beta^+\approx$35 (from decay scheme).

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Adopted Levels, Gammas (continued)

^{190}Tl Levels (continued)

E(level)†	Jπ	$T_{1/2}$	XREF	Comments
				Δ<r²>(^{205}Tl−^{190m}Tl)=−0.7223 fm² *5 510*(syst) (2013Ba41); first uncertainty is from isotope shift, the second uncertainty is systematic from the scaling uncertainty of the specific mass shift.
				Δ<r²>(^{205}Tl−^{190}Tl)=−0.69 fm² *8* (1990Di09).
				Isotope shift: Δν(^{205}Tl-^{190m}Tl)=−7380 MHz *180* (2013Ba41).
151.3 *3*	1⁺,2⁺,3⁺	>34 ns	B	$T_{1/2}$: from αγ(t) (1991Va04).
				Jπ: E1 γ to 2⁻.
				E(level): this level may be the same as 151.31 populated in ^{190}Pb ε decay, but opposite parities are suggested from the mult(151.3γ)=E1 in ^{194}Bi α decay (1991Va04) and mult(151.19γ)=(M1,E2) in ^{190}Pb ε decay (1981El03).
151.31 *8*	(1⁻)		A	Jπ: (M1,E2) γ to 2⁻; (E1) γ from 1⁺.
158.15 *15*	(0 to 3)(−)		A	Jπ: (M1,E2) γ to 2⁻; γ from (0,1).
195 *10*	(6⁺,7⁺)	<0.25 ns	C	Jπ: (M1) γ to 7(+); no transition from (9⁻).
210.55 *13*	(1⁻,2⁻,3⁻)		A	Jπ: (M1) γ to 2⁻.
245? *10*	(8⁻)		E	Jπ: possible (E1+M2) γ to 7(+).
245+x?		0.75 ms *4*	E	$T_{1/2}$: from γ(t) (1981Kr20).
				E(level): proposed by the evaluators, where x is likely to be low energy.
				1991Va04 (from study of ^{194}Bi α decay) suggest that the placement of 161.9γ from this isomer is incorrect for the following reasons: no (10⁻) to (8⁻) α transition observed, no coincidences observed between 5598α and 5660α with a possible (9⁻) to (8⁻) M1 γ transition, and E1 hindrance factor of 161.9γ is high by three to four orders of magnitude, as compared to those for neighboring Tl nuclides.
274.17 *8*	(1⁻,2⁻,3⁻)		A	Jπ: (M1) γ to 2⁻.
325.2 *5*	(9⁻)	>1 μs	CD	%IT=100
				Additional information 3.
				$T_{1/2}$: estimated by 1991Va04 in ^{194}Bi α decay from lack of αγ-coin, and non-observation of gamma de-excitation from this level to lower levels, although a gamma ray with <10 keV cannot be excluded.
372.75? *24*	(0 to 4)(−)		A	Jπ: (M1) γ to (1⁻,2⁻,3⁻).
376.26 *8*	(1⁻,2⁻)		A	Jπ: (M1) γ to 2⁻; γ from 1⁺.
389.0# *5*	(10⁻)‡	<0.25 ns	CD	$T_{1/2}$: αγ(t) (1991Va04).
416.68 *22*	(0,1,2⁻)		A	Jπ: γ to (1⁻); weak β feeding (log *ft*=6.7) from 0⁺.
495.07 *21*	(0⁻,1⁻,2⁻)		A	Jπ: (M1,E2) γ to (1⁻,2⁻); possible β⁺+ε feeding from 0⁺.
539.81 *21*	(0,1,2⁻)		A	Jπ: possible β⁺+ε feeding from 0⁺.
598.33 *17*	(1⁻,2⁻,3⁻)		A	Jπ: (M1) γ to 2⁻.
661.3# *5*	(11⁻)‡		CDE	
738.99 *16*	(0⁻ to 4⁻)		A	Jπ: γ to (1⁻,2⁻).
890.72 *17*	(1⁺)		A	Jπ: probable log *ft*≈5.7 from 0⁺.
941.8# *5*	(12⁻)‡		DE	
942.21 *9*	1⁺		A	Jπ: log *ft*≈4.7 from 0⁺, strong (≈44%) β⁺+ε feeding suggests allowed transition.
1235.50 *15*	(1⁺)		A	Jπ: probable log *ft*=5.2 *2* from 0⁺.
1243.6@ *5*	(11)		D	
1324.2# *5*	(13⁻)‡		DE	
1494.5@ *7*	(12)		D	
1651.3# *5*	14⁻‡		D	
1824.0@ *8*	(13)		D	
1854.5 *3*	(1⁺)		A	Jπ: probable log *ft*=5.2 *1* from 0⁺.
2081.7# *5*	15⁻‡		D	B(M1)/B(E2)=1.5 *6* (2005Xi06).
2153.5@ *8*	(14)		D	

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Adopted Levels, Gammas (continued)

^{190}Tl Levels (continued)

E(level)[†]	J^{π}	XREF
2412.6[#] *5*	16^{-}[‡]	D
2508.6[@] *10*	(15)	D
2752.5[#] *6*	17^{-}[‡]	D
2990.8?[#] *8*	(18^{-})[‡]	D

[†] From least-squares fit to γ-ray energies, assuming 0.5 keV uncertain for energy, when not stated.
[‡] Probable member of band based on 8^{-}, configuration=$\pi h_{9/2}\otimes\nu i_{13/2}$.
[#] Band(A): $\pi h_{9/2}\otimes\nu i_{13/2}$ band.
[@] Band(B): Band based on (11).

Adopted Levels, Gammas (continued)

$\gamma(^{190}Tl)$

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	δ	α[‡]	Comments
151.3	$1^+,2^+,3^+$	151.3 *3*	100	0.0	2^-	E1		0.1523 *23*	
151.31	(1^-)	151.19 *10*	100	0.0	2^-	(M1+E2)		1.88 *76*	
158.15	(0 to 3)$^{(-)}$	158.15 *15*	100	0.0	2^-	(M1,E2)		1.64 *69*	
195	$(6^+,7^+)$	112.2	100	83	7^+	(M1)		6.18	
210.55	$(1^-,2^-,3^-)$	59.4[@]		151.31	(1^-)				
		210.55 *13*	100 *25*	0.0	2^-	(M1)		1.042	
245?	(8^-)	161.9[@] *2*	100	83	7^+	(E1+M2)	0.50 *5*	2.6 *4*	1991Va04 suggest that the placement of 161.9γ from a 0.75 ms isomer proposed by 1981Kr20 is incorrect. See comment for 245+x level. Mult.,δ: from α(K)exp determined from K x ray (1981Kr20), considered as uncertain by evaluators. If 245 level is an isomer of 0.75 ms half-life as suggested in 1981Kr20, B(E1)(W.u.)=1.43×10^{-11} *19*, B(M2)(W.u.)=6.3×10^{-4} *13*, giving unrealistically low B(E1)(W.u.) value by two orders of magnitude.
245+x?		x[@]		245?	(8^-)				Possibly highly converted transition.
274.17	$(1^-,2^-,3^-)$	122.25 *20*	22 *3*	151.31	(1^-)	(M1+E2)		3.7 *12*	
		274.21 *10*	100 *18*	0.0	2^-	(M1)		0.502	
372.75?	(0 to 4)$^{(-)}$	162.2 *2*	100	210.55	$(1^-,2^-,3^-)$	(M1(+E2))		2.17	α: for M1.
376.26	$(1^-,2^-)$	101.8 *2*	9.2 *13*	274.17	$(1^-,2^-,3^-)$	[M1,E2]		6.8 *14*	
		376.35 *10*	100 *13*	0.0	2^-	(M1)		0.212	
389.0	(10^-)	63.9	100	325.2	(9^-)	(M1)		5.81	γ from ^{194}Bi α decay.
416.68	$(0,1,2^-)$	142.2 *3*	≈100	274.17	$(1^-,2^-,3^-)$				
		265.7[@] *3*	≈2	151.31	(1^-)				
495.07	$(0^-,1^-,2^-)$	78.6[@]		416.68	$(0,1,2^-)$				
		118.8 *2*	100 *24*	376.26	$(1^-,2^-)$	(M1+E2)		4.1 *12*	
539.81	$(0,1,2^-)$	381.66 *15*	100	158.15	(0 to 3)$^{(-)}$				
598.33	$(1^-,2^-,3^-)$	598.3 *2*	100	0.0	2^-	(M1(+E2))		0.0621	α: for M1.
661.3	(11^-)	272.3 *1*	100 *5*	389.0	(10^-)	D			
		336.1[@] *5*	≤5.0	325.2	(9^-)				
738.99	$(0^-$ to $4^-)$	140.6 *3*	≈220	598.33	$(1^-,2^-,3^-)$				
		362.74 *15*	100 *14*	376.26	$(1^-,2^-)$				
890.72	(1^+)	739.41 *15*	100	151.31	(1^-)				
941.8	(12^-)	280.5 *1*	100 *5*	661.3	(11^-)	D			
		552.8 *1*	48.7 *24*	389.0	(10^-)	Q			
942.21	1^+	566.0 *2*	13.6 *7*	376.26	$(1^-,2^-)$	(E1)		0.00714	
		790.90 *20*	8.7 *8*	151.31	(1^-)	(E1)		0.00370	
		942.20 *10*	100 *8*	0.0	2^-	(E1)		0.00268	
1235.50	(1^+)	1235.50 *15*	100	0.0	2^-				
1243.6	(11)	582.3 *3*	100 *15*	661.3	(11^-)	D			
		854.5 *3*	98 *15*	389.0	(10^-)	D			Mult.: ΔJ=0, dipole.

$^{190}_{81}Tl_{109}$-4

Adopted Levels, Gammas (continued)

$\gamma(^{190}Tl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]
1324.2	(13$^-$)	382.4 *1*	100 *5*	941.8	(12$^-$)	D
		662.8 *3*	48 *7*	661.3	(11$^-$)	Q
1494.5	(12)	250.9 *5*	100	1243.6	(11)	D
1651.3	14$^-$	327.1 *3*	86 *13*	1324.2	(13$^-$)	D
		709.5 *1*	100 *5*	941.8	(12$^-$)	Q
1824.0	(13)	329.5[#] *3*	100[#]	1494.5	(12)	(D)
1854.5	(1$^+$)	1854.5 *3*	100	0.0	2$^-$	
2081.7	15$^-$	430.5 *5*	79 *24*	1651.3	14$^-$	D
2081.7	15$^-$	757.5 *3*	100 *15*	1324.2	(13$^-$)	Q
2153.5	(14)	329.5[#] *3*	100[#]	1824.0	(13)	(D)
2412.6	16$^-$	330.9 *5*	39 *12*	2081.7	15$^-$	D
		761.3 *3*	100 *15*	1651.3	14$^-$	Q
2508.6	(15)	355.1 *5*	100	2153.5	(14)	(D)
2752.5	17$^-$	339.9 *5*	100 *30*	2412.6	16$^-$	D
		670.8 *5*	75 *23*	2081.7	15$^-$	Q
2990.8?	(18$^-$)	238.3[@] *5*	100	2752.5	17$^-$	D

[†] From ^{190}Pb ε decay for γ rays from low-spin (J<6) levels, and from ^{160}Gd(^{35}Cl,5nγ) for γ rays from high-spin levels.
[‡] 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.
[#] Multiply placed with undivided intensity.
[@] Placement of transition in the level scheme is uncertain.

$^{190}_{81}Tl_{109}$-5

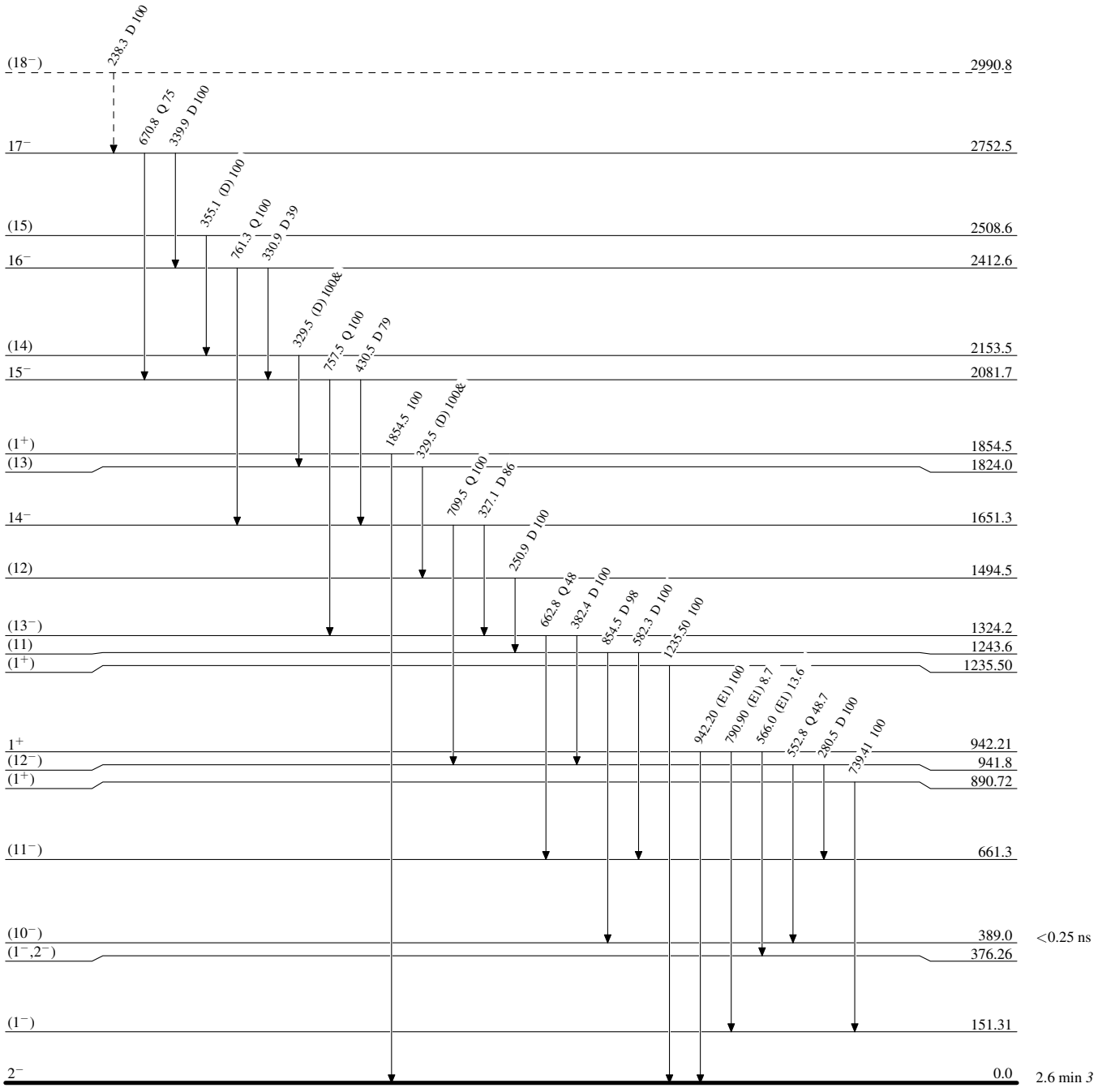
Adopted Levels, Gammas

Legend

Level Scheme

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

- - - - - - ► γ Decay (Uncertain)



$^{190}_{81}Tl_{109}$

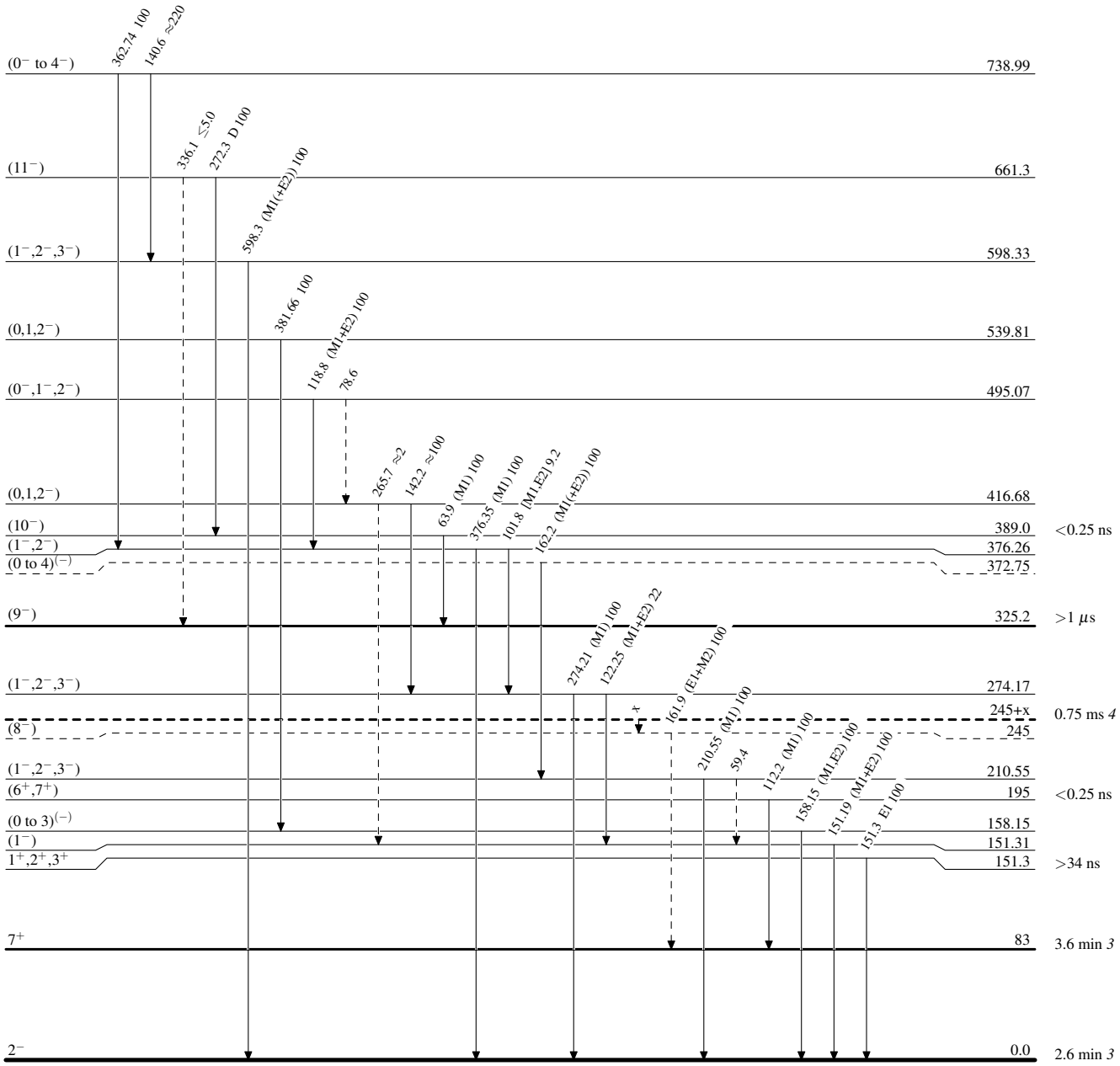
Adopted Levels, Gammas

Legend

Level Scheme (continued)

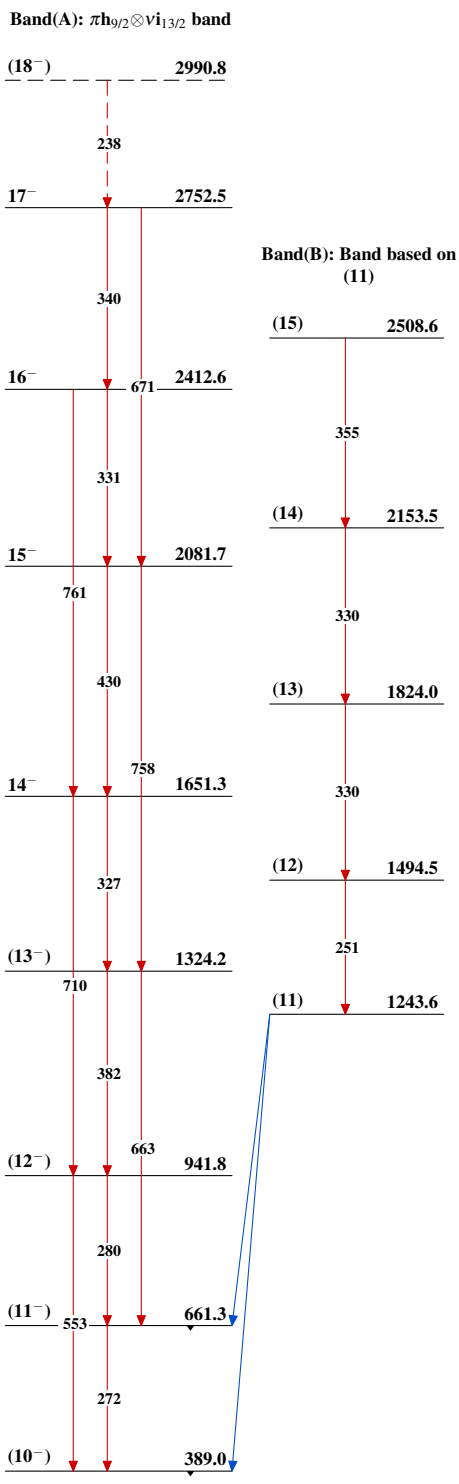
Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

- - - - - - ► γ Decay (Uncertain)



$^{190}_{81}Tl_{109}$

Adopted Levels, Gammas



$^{190}_{81}Tl_{109}$