Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	T. D. Johnson, Balraj Singh	NDS 142, 1 (2017)	15-Apr-2017

Q(β^-)=−6772 *16*; S(n)=10350 *30*; S(p)=1703 *15*; Q(α)=4817 *9* 2017Wa10
S(2n)=18314 *12*, S(2p)=6166 *24*, Q(εp)=466 *9* (2017Wa10).
Identification and production of ^{189}Tl isotope by 1972Va12 in Pb(p,X) reaction; measured half-life and γ-ray energies and intensities. In 1976Ha25 (also 1974Ha10), the isotope was produced in ^{181}Ta(^{16}O,xn) reaction; measured half-life and γ-radiation characteristics.
1987Bo44 (also 1987Bi08, 1986BoZY thesis, 1985Bo46): measured Hyperfine structure, isotope-shift and moments.
Mass measurements: 2000Ra23 (also 1997Ra14, 1999Sc46).
Nuclear structure calculations:
SD bands (theory): 2009Al12, 2009Ch62, 1991Sa12, 1991Ch36.
Normal-deformed levels (theory): 1989Be34, 1988Ar12, 1977Go09, 1976Di14.

^{189}Tl Levels

The high-spin level scheme is primarily adopted here from 1996RiZZ with the exception of sequence 5 in authors′ figure 1, since the lower members of this sequence and connecting transitions to the (9/2$^-$) isomer were not corroborated by the $\gamma\gamma$ coin data in ε decay study by 2009Sa09.

Cross Reference (XREF) Flags

A	^{189}Pb ε decay (39 s)	E	^{156}Gd(^{37}Cl,4nγ)
B	^{189}Pb ε decay (50 s)	F	^{156}Gd(^{37}Cl,4nγ):SD
C	^{193}Bi α decay (3.2 s)	G	^{165}Ho(^{28}Si,4nγ)
D	^{193}Bi α decay (63.6 s)	H	^{169}Tm(^{24}Mg,4nγ)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	XREF	Comments
0.0[j]	(1/2$^+$)	2.3 min *2*	A CD	%ε+%β^+=100 J$^\pi$: suggested by model calculations, expected configuration=π1/2[400] (prolate) (2009Sa09); favored α decay from ^{193}Bi α decay (3.2 s) with parent J^π=(1/2$^+$). T$_{1/2}$: from 1976Ha25 (also 1974Ha10).
281[&] *7*	(9/2$^-$)	1.4 min *1*	B DE GH	%ε+%β^+=98 *2*; %IT<4 μ=3.756 *22* (2012Ba32,2014StZZ) Q=−2.29 *4* (1987Bo44,2016St14) Additional information 1. RMS charge radius (<r^2>)$^{1/2}$=5.424 fm *6* (2004An14,evaluation). The evaluators assume that this value corresponds to the isomer in ^{189}Tl and not the g.s. No value is listed in the recent evaluation by 2013An02. μ: hyperfine structure with HFA correction (2012Ba32). Other value: +3.878 *6* (1987Bo44, collinear fast atomic beam laser spectroscopy). Q: collinear fast atomic beam laser spectroscopy (1987Bo44, also 1987Bi08, 1986BoZY thesis, 1985Bo46). Other: 1992ScZU. E(level): from ^{193}Bi α-decay (1985Co06). Value of 258 keV proposed in 1996RiZZ on the basis of interconnecting γ rays between the high-spin and low-spin structure is proven incorrect by 2009Sa09 in their $\gamma\gamma$ coin data from ^{182}Pb ε decay, where several γ rays were observed similar to the ones in the in-beam study of 1996RiZZ. J$^\pi$: suggested by model calculations, expected configuration=π9/2[505] (oblate) (2009Sa09); favored α decay from ^{193}Bi α decay (63.6 s) with parent J^π=(9/2$^-$). %IT: from B(M4)(W.u.)<10 (RUL). T$_{1/2}$: from 1976Ha25 (also 1974Ha10). Other: 1.4 min *4* (1972Va12).

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Adopted Levels, Gammas (continued)

^{189}Tl Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	T$_{1/2}$[#]	XREF	Comments
318.80?[j] *20*	(3/2$^+$)		A	J$^{\pi}$: γ to (1/2$^+$); model calculation, expected configuration=π1/2[400] (prolate) (2009Sa09). E(level): a level of this energy was also seen by 1996RiZZ. However the γ transition establishing this level and subsequent band appears to have been based on coincidences not confirmed in β decay study (2009Sa09). The placement of the deexciting γ is also not confirmed in 2009Sa09 due to lack of evidence from $\gamma\gamma$ coincidence data.
463.57? *19*	(3/2$^+$)		A	J$^{\pi}$: γ to (1/2$^+$); model calculation, expected configuration=π3/2[402] (prolate) (2009Sa09).
599.79[i] *16*	(9/2$^-$)		B	J$^{\pi}$: γ to (9/2$^-$); possible band assignment.
667.30[a] *10*	(11/2$^-$)	37.8 ps *35*	B E GH	J$^{\pi}$: M1+E2 γ to (9/2$^-$); band member.
667.53? *19*	(3/2$^-$)		A	J$^{\pi}$: γ to (1/2$^+$); model calculation, expected configuration=π3/2[532] (prolate) (2009Sa09).
744.70[g] *16*	(7/2$^-$)		B	J$^{\pi}$: γ to (9/2$^-$); possible band assignment.
885.54? *24*			A	E(level): possible gammas to (3/2$^-$) and (3/2$^+$) suggest 1/2,3/2,5/2.
981.37[&] *9*	(13/2$^-$)	1.9 ps *6*	B E G	J$^{\pi}$: M1 γ to (11/2$^-$); E2 γ to (9/2$^-$); band member.
1028.12[i] *16*	(13/2$^-$)		B	J$^{\pi}$: γ to (9/2$^-$); band member.
1032.6? *5*			A	J$^{\pi}$: γ to (3/2$^-$) suggests 1/2 to 7/2$^-$.
1062.50[g] *15*	(9/2$^-$)		B	J$^{\pi}$: gammas to (7/2$^-$) and (9/2$^-$); band member.
1105.43[h] *18*	(11/2$^-$)		B	J$^{\pi}$: gammas to (7/2$^-$) and (11/2$^-$); model calculation, expected configuration=π11/2[505] (prolate) (2009Sa09).
1147.51[f] *14*	(13/2$^+$)	209 ps *12*	B E GH	J$^{\pi}$: E1 γ to (11/2$^-$); γ to (13/2$^-$); model calculation, expected configuration=π13/2[606] (oblate) (2009Sa09).
1227.79 *25*	(11/2$^-$)		B	J$^{\pi}$: log *ft*=6.5 from (13/2$^+$) parent; γ to (7/2$^-$).
1325.00 *14*	(13/2$^-$)		B GH	J$^{\pi}$: M1 γ to (11/2$^-$); γ to (9/2$^-$).
1332.27[g] *20*	(11/2$^-$)		B	J$^{\pi}$: gammas to (7/2$^-$) and (9/2$^-$); band member.
1368.9? *5*			A	J$^{\pi}$: γ to (3/2$^+$) suggests (1/2 to 7/2$^+$).
1388.78 *23*	(11/2$^-$)		B	J$^{\pi}$: log *ft*=6.5 from (13/2$^+$) parent; γ to (7/2$^-$).
1408.76[a] *15*	(15/2$^-$)		B E GH	J$^{\pi}$: M1 γ to (13/2$^-$); (E2) γ to (11/2$^-$); band member.
1420.94 *22*			B	J$^{\pi}$: γ to (9/2$^-$) suggests (5/2$^-$ to 13/2$^-$).
1461.0[h] *5*	(13/2$^-$)		B	J$^{\pi}$: γ to (11/2$^-$); band member.
1464.30 *22*	(13/2$^-$)		B	J$^{\pi}$: log *ft*=6.5 from (13/2$^+$) parent; γ to (9/2$^-$); γ from (17/2$^-$).
1489.8? *11*			A	J$^{\pi}$: γ to (3/2$^+$) suggests (1/2 to 7/2$^+$).
1492.51 *25*	(11/2$^-$)		B	J$^{\pi}$: log *ft*=6.5 from (13/2$^+$) parent; γ to (9/2$^-$); weak γ to (7/2$^-$).
1532.9 *3*	(11/2,13/2,15/2$^-$)		B	J$^{\pi}$: log *ft* ≈6.5 from (13/2$^+$) parent; γ to (11/2$^-$). Possible γ to (7/2$^-$) favors (11/2$^-$).
1546.38[f] *17*	(15/2$^+$)		B E	J$^{\pi}$: M1+E2 γ to (13/2$^+$); band member.
1553.2 *3*	(11/2,13/2$^-$)		B	J$^{\pi}$: log *ft*=6.8 from (13/2$^+$) parent; γ to (9/2$^-$).
1614.9 *5*	(11/2,13/2$^-$)		B	J$^{\pi}$: log *ft*=6.6 from (13/2$^+$) parent; γ to (9/2$^-$).
1645.66[&] *20*	(17/2$^-$)	1.80 ps *42*	B E GH	Q$_t$=2.7 *3* (2007Ch41). J$^{\pi}$: E2 γ to (13/2$^-$); γ to (15/2$^-$); band member.
1716.7? *5*			A	J$^{\pi}$: γ to (3/2$^+$) suggests (1/2 to 7/2$^+$).
1745.7 *4*			GH	XREF: H(?). J$^{\pi}$: gammas to (15/2$^-$) and (15/2$^+$) suggest (13/2,15/2,17/2).
1752.6 *4*	(11/2,13/2$^-$)		B	J$^{\pi}$: log *ft*=6.8 from (13/2$^+$) parent; γ to (9/2$^-$).
1756.81[i] *21*	(17/2$^-$)		B	J$^{\pi}$: γ to (13/2$^-$); possible band member.
1761.2 *3*	(11/2,13/2,15/2$^-$)		B	J$^{\pi}$: log *ft*=6.7 from (13/2$^+$) parent; γ to (11/2$^-$).
1783.2[g] *5*	(13/2$^-$)		B	J$^{\pi}$: log *ft*=7.0 from (13/2$^+$) parent; band member.
1812.6 *3*	(11/2,13/2,15/2)		B	J$^{\pi}$: log *ft*=6.6 from (13/2$^+$) parent.
1829.73[f] *25*	(17/2$^+$)	9.0 ps *11*	B E GH	Q$_t$=1.1 *1* (2007Ch41). J$^{\pi}$: E2 γ to (13/2$^+$); (M1) γ to (15/2$^+$); band member. Note that log *ft*=6.79 from (13/2$^+$) parent is too low for a ΔJ=2, $\Delta\pi$=no

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Adopted Levels, Gammas (continued)

^{189}Tl Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	XREF	Comments
				β transition.
1845.0 *5*	(17/2$^-$)		B E H	XREF: H(?). Jπ: ΔJ=0, dipole γ to (17/2$^-$); γ to (13/2$^-$).
1861.4 *3*	(11/2,13/2,15/2)		B	Jπ: log *ft*=6.7 from (13/2$^+$) parent.
1865.0 *5*	(11/2,13/2,15/2$^-$)		B	Jπ: log *ft*=7.0 from (13/2$^+$) parent; γ to (11/2$^-$).
1878.0 *3*	(11/2,13/2,15/2$^-$)		B	Jπ: log *ft*=6.5 from (13/2$^+$) parent; γ to (11/2$^-$).
1893.9 *11*	(11/2,13/2,15/2)		B	Jπ: log *ft*=6.9 from (13/2$^+$) parent.
1959.6 *4*	(11/2,13/2,15/2)		B	Jπ: log *ft*=6.7 from (13/2$^+$) parent.
1962.2 *5*	(11/2,13/2,15/2)		B	Jπ: log *ft*=7.0 from (13/2$^+$) parent.
1995.3[e] *3*	(17/2$^+$)		B E GH	Jπ: ΔJ=1, (M1) γ to (15/2$^+$); γ to (13/2$^+$); band member. Note that log *ft*=6.98 from (13/2$^+$) parent is too low for a ΔJ=2, Δπ=no β transition.
2006.3 *4*	(13/2$^-$,15/2)		B	Jπ: log *ft*=6.9 from (13/2$^+$) parent; γ to (17/2$^-$).
2025.3 *5*	(11/2,13/2,15/2$^-$)		B	Jπ: log *ft*=7.0 from (13/2$^+$) parent; γ to (11/2$^-$).
2062.0 *7*			G	
2147.6[d] *3*	(19/2$^-$)	7.1 ps *14*	E GH	Jπ: ΔJ=1, (M1) γ to (17/2$^-$). *J*π was proposed as (21/2$^-$) in 1991Po15 (also in 2007Ch41), based on ΔJ=2, Q assignment in 1991Po15. But in 1995Re18, the 502 transition is proposed as a stretched dipole based on DCO ratios for the cascading 303 and 199 transitions, parallel to the 502 transition.
2163.4[a] *4*	(19/2$^-$)		E H	Jπ: gammas to (15/2$^-$) and (17/2$^-$); band member.
2174.5 *4*	(11/2,13/2,15/2$^-$)		B	Jπ: log *ft*=6.7 from (13/2$^+$) parent; γ to (11/2$^-$).
2185.0 *3*	(13/2$^-$,15/2)		B	Jπ: log *ft*=6.3 from (13/2$^+$) parent; γ to (17/2$^-$).
2213.4 *5*	(11/2,13/2,15/2$^-$)		B	Jπ: log *ft*=7.1 from (13/2$^+$) parent; γ to (11/2$^-$).
2237.1[e] *3*	(21/2$^+$)	8.6 ps *12*	E GH	Q_t=3.8 *3* (2007Ch41). Jπ: ΔJ=2, E2 γ to (17/2$^+$); band member.
2237.2 *6*			G	Jπ: γ to (15/2$^+$) in in-beam γ suggests (15/2,17/2,19/2$^+$).
2308.1? *4*			GH	Jπ: γ to (17/2$^-$) suggests (17/2,19/2,21/2$^-$).
2308.2[f] *5*	(19/2$^+$)		G	Jπ: gammas to (15/2$^+$) and (17/2$^+$); band member.
2420.3 *5*	(11/2,13/2,15/2)		B	Jπ: log *ft*=7.0 from (13/2$^+$) parent.
2500.7[&] *5*	(21/2$^-$)		E	Jπ: gammas to (17/2$^-$) and (19/2$^-$); band member.
2632.5[e] *5*	(25/2$^+$)	2.08 ps *28*	E GH	Q_t=7.8 *5* (2007Ch41). Jπ: ΔJ=2, E2 γ to (21/2$^+$); band member.
2649.6[c] *4*	(23/2$^-$)	<6.1 ps	E GH	Q_t>2.8 (2007Ch41). Jπ: ΔJ=2, E2 γ to (19/2$^-$); band member.
2668.6[d] *11*	(23/2$^-$)		E	Jπ: γ to (19/2$^-$); band member.
2698.0[a] *8*	(23/2$^-$)		E	Jπ: gammas to (19/2$^-$) and (21/2$^-$); band member.
2788.4[b] *6*	(25/2$^-$)		E GH	Jπ: ΔJ=1, dipole (most likely M1) γ to (23/2$^-$); γ to (21/2$^-$); band member.
3025.3[c] *6*	(27/2$^-$)		E GH	Jπ: ΔJ=1, dipole γ to (25/2$^-$); γ to (23/2$^-$); band member.
3094.9[e] *6*	(29/2$^+$)	0.90 ps *14*	E GH	Q_t=8.6 *8* (2007Ch41). Jπ: ΔJ=2, E2 γ to (25/2$^+$); band member.
3253.6[d] *15*	(27/2$^-$)		E	Jπ: γ to (23/2$^-$); band member.
3277.5[b] *6*	(29/2$^-$)		E GH	Jπ: ΔJ=1, dipole γ to (27/2$^-$); γ to (25/2$^-$); band member.
3442.9 *8*			G	Jπ: γ to (29/2$^+$) suggests (29/2,31/2,33/2$^+$).
3627.0[c] *8*	(31/2$^-$)		E G	Jπ: gammas to (27/2$^-$) and (29/2$^-$); band member.
3629.0[e] *6*	(33/2$^+$)	<0.7 ps	E GH	Q_t>8.8 (2007Ch41). Jπ: ΔJ=2, E2 γ to (29/2$^+$); band member.
3901.6[d] *18*	(31/2$^-$)		E	Jπ: γ to (27/2$^-$); band member.
3957.8[b] *9*	(33/2$^-$)		E	Jπ: gammas to (29/2$^-$) and (31/2$^-$); band member.
4232.1[e] *8*	(37/2$^+$)		E G	Jπ: γ to (33/2$^+$); band member.
4359.9?[c] *10*	(35/2$^-$)		E	Jπ: gammas to (31/2$^-$) and (33/2$^-$); band member.

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Adopted Levels, Gammas (continued)

^{189}Tl Levels (continued)

E(level)[†]	Jπ[‡]	XREF	Comments
4605.6[d] *21*	(35/2⁻)	E	Jπ: γ to (31/2⁻); band member.
4728.8?[b] *12*	(37/2⁻)	E	Jπ: gammas to (33/2⁻) and (35/2⁻); band member.
4896.1[e] *13*	(41/2⁺)	E G	Jπ: γ to (37/2⁺); band member.
5361.6[d] *23*	(39/2⁻)	E	Jπ: γ to (35/2⁻); band member.
5606.1[e] *17*	(45/2⁺)	E	Jπ: γ to (41/2⁺); band member.
6333.1[e] *19*	(49/2⁺)	E	Jπ: γ to (45/2⁺); band member.
x[k]	J1≈(27/2)[@]	F	Additional information 2.
326.3+x[k] *10*	J1+2	F	
694.2+x[k] *12*	J1+4	F	
1102.7+x[k] *12*	J1+6	F	
1551.3+x[k] *13*	J1+8	F	
2039.6+x[k] *13*	J1+10	F	
2566.4+x[k] *14*	J1+12	F	
3131.1+x[k] *14*	J1+14	F	
3732.6+x[k] *15*	J1+16	F	
4369.4+x[k] *16*	J1+18	F	
5040.3+x?[k] *19*	J1+20	F	
y[l]	J2≈(25/2)[@]	F	Additional information 3.
304.5+y?[l] *10*	J2+2	F	
649.3+y[l] *12*	J2+4	F	
1034.3+y[l] *16*	J2+6	F	
1461.3+y[l] *19*	J2+8	F	
1927.5+y[l] *19*	J2+10	F	
2432.3+y[l] *19*	J2+12	F	
2973.7+y[l] *19*	J2+14	F	
3552.8+y[l] *20*	J2+16	F	
4167.0+y[l] *21*	J2+18	F	
4815.4+y?[l] *24*	J2+20	F	

[†] From least-squares fit to Eγ data, assuming 1 keV uncertainty when not given. Reduced χ^2=0.91.

[‡] The high-spin states (J>4) are based on 9/2⁻ isomer at 281 keV supported by γ(θ), γγ(θ) and γ(lin pol) data for selected transitions and extensive shell-model calculations by 2009Sa09. Ascending spins with excitation energy are assumed in in-beam γ-ray data which follows from yrast type population of states in such studies. In some cases specific arguments are given.

[#] From DSAM in ^{165}Ho(^{28}Si,4nγ) (2007Ch41) for levels above 300 keV.

[@] Proposed in 1998Re20 based on fitting of measured dynamic moment of inertia as a function of $\hbar\omega$ using a Harris parameterization. These assignments are consistent with the observation that the SD bands feed the normal-deformed states at and below spin 25/2.

[&] Band(A): π9/2[505],α=+1/2. Interpreted as oblate (β_2≈0.15) band from $h_{9/2}$ proton orbital. This band is crossed by a strongly coupled band due to a pair of $i_{13/2}$ neutrons.

[a] Band(a): π9/2[505],α=−1/2. See comment for α=+1/2 signature partner.

[b] Band(B): π9/2[505]⊗$\nu i^2_{13/2}$,α=+1/2. The π9/2[505] band is crossed by $\nu i^2_{13/2}$ band, thus producing a sharp backbend.

[c] Band(b): π9/2[505]⊗$\nu i^2_{13/2}$,α=−1/2. See comment for α=+1/2 signature partner.

[d] Band(C): Possible π1/2[550] band. Interpreted as oblate hole band.

[e] Band(D): π1/2[660],α=+1/2. Interpreted as decoupled prolate (β_2≈0.27) intruder band from $\pi i_{13/2}$ orbital.

[f] Band(E): π1/2[660]. Interpreted as oblate intruder band from $\pi i_{13/2}$ orbital (2007Ch41, 1991Po15). 2009Sa09 propose

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Adopted Levels, Gammas (continued)

^{189}Tl Levels (continued)

π13/2[606], oblate band. But in 1996RiZZ the character of the $13/2^+$ state as oblate was not confirmed.

[g] Band(F): π7/2[514] (oblate).

[h] Band(G): π11/2[505] (prolate).

[i] Band(H): π1/2[541] (prolate).

[j] Band(I): π1/2[400] band (prolate).

[k] Band(J): SD-1 band. Percent population=0.1-0.2. SD-1 and SD-2 bands are interpreted (by 1998Re20) as signature partners associated with $\pi i_{13/2}$ (Ω=5/2) configuration.

[l] Band(j): SD-2 band. Percent population=0.1-0.2. See comment for SD-2 band.

Adopted Levels, Gammas (continued)

γ(^{189}Tl)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[#]	α[@]	Comments
318.80?	(3/2$^+$)	318.8[&a] *2*	100	0.0	(1/2$^+$)			
463.57?	(3/2$^+$)	463.7[&a] *2*	100	0.0	(1/2$^+$)			
599.79	(9/2$^-$)	318.8[&] *2*	100	281	(9/2$^-$)	[M1]	0.332	α(K)=0.272 *4*; α(L)=0.0459 *7*; α(M)=0.01071 *16* α(N)=0.00270 *4*; α(O)=0.000525 *8*; α(P)=4.97×10^{-5} *7*
667.30	(11/2$^-$)	386.1 *2*	100	281	(9/2$^-$)	M1+E2	0.17 *3*	α(K)=0.14 *3*; α(L)=0.025 *3*; α(M)=0.0058 *6* α(N)=0.00146 *15*; α(O)=0.00028 *3*; α(P)=2.6×10^{-5} *4* E_γ: 386.7 *1* from (^{24}Mg,4nγ) (1988Kr16) not used. Weighted average of all three values is 386.5 *2* with reduced χ^2=6.5.
667.53?	(3/2$^-$)	667.4[a] *2*	100	0.0	(1/2$^+$)			
744.70	(7/2$^-$)	463.7[&] *2*	100	281	(9/2$^-$)	[M1+E2]		
885.54?		217.5[a] *4*	34 *6*	667.53?	(3/2$^-$)			
		422.1[a] *2*	100 *16*	463.57?	(3/2$^+$)			
981.37	(13/2$^-$)	314.0 *1*	57 *9*	667.30	(11/2$^-$)	M1	0.346	B(M1)(W.u.)=0.10 *+5−2* α(K)=0.284 *4*; α(L)=0.0479 *7*; α(M)=0.01117 *16* α(N)=0.00282 *4*; α(O)=0.000548 *8*; α(P)=5.18×10^{-5} *8* I_γ: from ε decay, 109 *12* in (^{24}Mg,4nγ) (1988Kr16) is in disagreement.
		700.2 *2*	100 *13*	281	(9/2$^-$)	E2	0.01310	B(E2)(W.u.)=17 *+8−4* α(K)=0.01006 *14*; α(L)=0.00231 *4*; α(M)=0.000559 *8* α(N)=0.0001407 *20*; α(O)=2.63×10^{-5} *4*; α(P)=2.03×10^{-6} *3*
1028.12	(13/2$^-$)	428.3 *2*	≈112	599.79	(9/2$^-$)	[E2]	0.0413	α(K)=0.0282 *4*; α(L)=0.00993 *14*; α(M)=0.00248 *4* α(N)=0.000623 *9*; α(O)=0.0001133 *16*; α(P)=7.11×10^{-6} *10*
		747.1 *2*	100 *15*	281	(9/2$^-$)			
1032.6?		365.1[a] *4*	100	667.53?	(3/2$^-$)			
1062.50	(9/2$^-$)	317.7 *2*	100 *18*	744.70	(7/2$^-$)	[M1+E2]		
		781.6 *2*	69 *10*	281	(9/2$^-$)			
1105.43	(11/2$^-$)	361[&] *1*	≈5.7	744.70	(7/2$^-$)	[E2]	0.0652 *11*	α(K)=0.0415 *7*; α(L)=0.0178 *3*; α(M)=0.00450 *8* α(N)=0.001130 *20*; α(O)=0.000203 *4*; α(P)=1.166×10^{-5} *19*
		437.8 *4*	8.7 *13*	667.30	(11/2$^-$)	[M1+E2]		
		824.5 *2*	100 *17*	281	(9/2$^-$)	[M1+E2]		
1147.51	(13/2$^+$)	166.0 *3*	8.0 *16*	981.37	(13/2$^-$)	[E1]	0.1208	B(E1)(W.u.)=1.6×10^{-5} *4* α(K)=0.0979 *15*; α(L)=0.0175 *3*; α(M)=0.00410 *6* α(N)=0.001022 *16*; α(O)=0.000190 *3*; α(P)=1.424×10^{-5} *21*
		480.2 *1*	100 *3*	667.30	(11/2$^-$)	E1	0.01004	B(E1)(W.u.)=8.1×10^{-6} *6* α(K)=0.00832 *12*; α(L)=0.001328 *19*; α(M)=0.000307 *5* α(N)=7.71×10^{-5} *11*; α(O)=1.473×10^{-5} *21*; α(P)=1.275×10^{-6} *18*
1227.79	(11/2$^-$)	165 *1*	≈19	1062.50	(9/2$^-$)			
		483.1 *2*	100 *15*	744.70	(7/2$^-$)			
		560.3[a] *4*	42 *6*	667.30	(11/2$^-$)			
1325.00	(13/2$^-$)	657.4 *2*	100 *20*	667.30	(11/2$^-$)	M1	0.0485	α(K)=0.0399 *6*; α(L)=0.00659 *10*; α(M)=0.001535 *22* α(N)=0.000387 *6*; α(O)=7.53×10^{-5} *11*; α(P)=7.15×10^{-6} *10*

$^{189}_{81}Tl_{108}$-6

Adopted Levels, Gammas (continued)

γ(^{189}Tl) (continued)

E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult.#	α@	Comments
1325.00	(13/2⁻)	1044.3 *2*	50 *8*	281	(9/2⁻)	[E2]	0.00583	α(K)=0.00468 *7*; α(L)=0.000877 *13*; α(M)=0.000207 *3* α(N)=5.22×10^{-5} *8*; α(O)=9.95×10^{-6} *14*; α(P)=8.52×10^{-7} *12* E_γ: γ not reported in in-beam γ-ray studies.
1332.27	(11/2⁻)	269.7 *2*	47 *7*	1062.50	(9/2⁻)	[M1+E2]		
		587.6 *2*	100 *15*	744.70	(7/2⁻)	[E2]	0.0193	α(K)=0.01433 *20*; α(L)=0.00375 *6*; α(M)=0.000916 *13* α(N)=0.000230 *4*; α(O)=4.27×10^{-5} *6*; α(P)=3.09×10^{-6} *5*
1368.9?		1050.1[a] *4*	100	318.80?	(3/2⁺)			
1388.78	(11/2⁻)	283.4[a] *4*	≈8	1105.43	(11/2⁻)			
		326.2 *4*	18 *2*	1062.50	(9/2⁻)			
		644.1 *2*	100 *16*	744.70	(7/2⁻)			
1408.76	(15/2⁻)	427.1 *2*	54 *14*	981.37	(13/2⁻)	M1	0.1512	α(K)=0.1241 *18*; α(L)=0.0208 *3*; α(M)=0.00484 *7* α(N)=0.001221 *18*; α(O)=0.000237 *4*; α(P)=2.25×10^{-5} *4* I_γ: 25% uncertainty is assumed by the evaluators. E_γ,I_γ: 428.0 *2* with Iγ=157 *8* in (^{24}Mg,4nγ) not used in averaging.
		741.7 *2*	100 *15*	667.30	(11/2⁻)	(E2)	0.01160	α(K)=0.00898 *13*; α(L)=0.00199 *3*; α(M)=0.000480 *7* α(N)=0.0001208 *17*; α(O)=2.27×10^{-5} *4*; α(P)=1.783×10^{-6} *25* Mult.: ΔJ=2, Q from γ(θ), ΔJ^π.
1420.94		821.2 *2*	100	599.79	(9/2⁻)			
1461.0	(13/2⁻)	355.6 *4*	100	1105.43	(11/2⁻)	[M1+E2]		
1464.30	(13/2⁻)	864.5 *2*	100	599.79	(9/2⁻)			
1489.8?		1171[a] *1*	100	318.80?	(3/2⁺)			
1492.51	(11/2⁻)	430.0 *2*	100 *15*	1062.50	(9/2⁻)		0.08 *7*	
		748 *1*	≈13	744.70	(7/2⁻)			
1532.9	(11/2,13/2,15/2⁻)	427.5 *2*	≈100	1105.43	(11/2⁻)			
		787[a] *1*	≈10	744.70	(7/2⁻)			
1546.38	(15/2⁺)	398.9 *1*	100	1147.51	(13/2⁺)	M1+E2		
1553.2	(11/2,13/2⁻)	491.0 *4*	26 *4*	1062.50	(9/2⁻)			
		885.5 *4*	100 *13*	667.30	(11/2⁻)			
1614.9	(11/2,13/2⁻)	194.0 *4*	≈100	1420.94				
		1015 *1*	≈100	599.79	(9/2⁻)			
1645.66	(17/2⁻)	236.9[&] *5*		1408.76	(15/2⁻)			E_γ: γ not seen in ε decay. In in-beam γ-ray data this γ is doubly placed with only a small component from 1646 level.
		664.3 *2*	100 *3*	981.37	(13/2⁻)	E2	0.01468	B(E2)(W.u.)=37 *+12−7* α(K)=0.01117 *16*; α(L)=0.00267 *4*; α(M)=0.000646 *9* α(N)=0.0001625 *23*; α(O)=3.03×10^{-5} *5*; α(P)=2.30×10^{-6} *4* For B(E2)(W.u.) value, it is assumed that the 664.3γ is the dominant transition from 1646 level.
1716.7?		1397.9[a] *4*	100	318.80?	(3/2⁺)			
1745.7		199.6 *5*		1546.38	(15/2⁺)			E_γ: γ only from (^{28}Si,4nγ).
		336.7 *5*		1408.76	(15/2⁻)			
1752.6	(11/2,13/2⁻)	420.2 *4*	100 *15*	1332.27	(11/2⁻)			
		690.2 *4*	92 *15*	1062.50	(9/2⁻)			

$^{189}_{81}Tl_{108}$-7

Adopted Levels, Gammas (continued)

$\gamma(^{189}Tl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[#]	α[@]	Comments
1756.81	(17/2$^-$)	292.6 *4*	17 *2*	1464.30	(13/2$^-$)			
		336.3 *4*	19 *4*	1420.94				
		728.6 *2*	100 *15*	1028.12	(13/2$^-$)			
1761.2	(11/2,13/2,15/2$^-$)	429[a] *1*	≈100	1332.27	(11/2$^-$)			
		613.2 *4*	≈170	1147.51	(13/2$^+$)			
		1094.4 *4*	100 *20*	667.30	(11/2$^-$)			
1783.2	(13/2$^-$)	450.9 *4*	100	1332.27	(11/2$^-$)	[M1+E2]		
1812.6	(11/2,13/2,15/2)	348.5 *4*	≈32	1464.30	(13/2$^-$)			
		391.4 *4*	100 *16*	1420.94				
		784.6 *4*	≈68	1028.12	(13/2$^-$)			
1829.73	(17/2$^+$)	283.6 *3*	58 *26*	1546.38	(15/2$^+$)	(M1)	0.457	B(M1)(W.u.)=0.033 *17* α(K)=0.375 *6*; α(L)=0.0633 *9*; α(M)=0.01478 *22* α(N)=0.00373 *6*; α(O)=0.000725 *11*; α(P)=6.86×10^{-5} *10* Mult.: ΔJ=1, dipole from $\gamma(\theta)$, ΔJ^π. I_γ: unweighted average from (^{24}Mg,4nγ) and (^{28}Si,4nγ), assuming 50% uncertainty in the value from the latter reaction.
		682.1 *3*	100 *5*	1147.51	(13/2$^+$)	E2	0.01386	B(E2)(W.u.)=3.6 *9* α(K)=0.01060 *15*; α(L)=0.00248 *4*; α(M)=0.000601 *9* α(N)=0.0001511 *22*; α(O)=2.83×10^{-5} *4*; α(P)=2.16×10^{-6} *3*
1845.0	(17/2$^-$)	199		1645.66	(17/2$^-$)	(D)		E_γ: γ only from (^{37}Cl,4nγ).
		436		1408.76	(15/2$^-$)			E_γ: from (^{37}Cl,4nγ) only.
		863 *1*		981.37	(13/2$^-$)			
1861.4	(11/2,13/2,15/2)	536.4 *4*	100 *15*	1325.00	(13/2$^-$)			
		880.0 *4*	65 *10*	981.37	(13/2$^-$)			
1865.0	(11/2,13/2,15/2$^-$)	1197.7 *4*	100	667.30	(11/2$^-$)			
1878.0	(11/2,13/2,15/2$^-$)	730 *1*	≈45	1147.51	(13/2$^+$)			
		896.0 *4*	85 *15*	981.37	(13/2$^-$)			
		1211.4 *4*	100 *15*	667.30	(11/2$^-$)			
1893.9	(11/2,13/2,15/2)	361[&] *1*	100	1532.9	(11/2,13/2,15/2$^-$)			
1959.6	(11/2,13/2,15/2)	811.9[a] *4*	26 *4*	1147.51	(13/2$^+$)			
		978.2 *4*	≈100	981.37	(13/2$^-$)			
1962.2	(11/2,13/2,15/2)	498[a] *1*	≈36	1464.30	(13/2$^-$)			
		934.1 *4*	100 *18*	1028.12	(13/2$^-$)			
1995.3	(17/2$^+$)	448.8 *3*	100 *9*	1546.38	(15/2$^+$)	(M1)	0.1325	α(K)=0.1088 *16*; α(L)=0.0182 *3*; α(M)=0.00423 *6* α(N)=0.001069 *15*; α(O)=0.000208 *3*; α(P)=1.97×10^{-5} *3*
		848[a]		1147.51	(13/2$^+$)			
2006.3	(13/2$^-$,15/2)	249.7 *4*	66 *11*	1756.81	(17/2$^-$)			
		541.8 *4*	100 *11*	1464.30	(13/2$^-$)			
2025.3	(11/2,13/2,15/2$^-$)	919.9 *4*	100	1105.43	(11/2$^-$)			
2062.0		317.0 *5*		1745.7				
2147.6	(19/2$^-$)	303		1845.0	(17/2$^-$)			

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Adopted Levels, Gammas (continued)

γ(^{189}Tl) (continued)

E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult.#	α@	Comments
2147.6	(19/2⁻)	502.1& *3*	100	1645.66	(17/2⁻)	(M1)	0.0984	B(M1)(W.u.)=0.025 *+6−4* α(K)=0.0808 *12*; α(L)=0.01346 *19*; α(M)=0.00313 *5* α(N)=0.000791 *12*; α(O)=0.0001538 *22*; α(P)=1.458×10^{-5} *21* For B(M1)(W.u.) value, it is assumed that the 502.1γ is the dominant transition from 2148 level. Mult.: suggested as stretched dipole in 1995Re18, but stretched E2 in 1991Po15.
2163.4	(19/2⁻)	319		1845.0	(17/2⁻)			
		518		1645.66	(17/2⁻)			
		754.7 *5*		1408.76	(15/2⁻)			
2174.5	(11/2,13/2,15/2⁻)	1027 *1*	≈50	1147.51	(13/2⁺)			
		1507.2 *4*	100 *17*	667.30	(11/2⁻)			
2185.0	(13/2⁻,15/2)	372.5 *4*	28 *6*	1812.6	(11/2,13/2,15/2)			
		428.1 *4*	≈167	1756.81	(17/2⁻)			
		720 *1*	≈50	1464.30	(13/2⁻)			
		860.0 *4*	100 *17*	1325.00	(13/2⁻)			
2213.4	(11/2,13/2,15/2⁻)	1108.0 *4*	100	1105.43	(11/2⁻)			
2237.1	(21/2⁺)	241.6 *5*		1995.3	(17/2⁺)			
		407.4 *2*	100 *10*	1829.73	(17/2⁺)	E2	0.0471	B(E2)(W.u.)=87 *+14−11* α(K)=0.0315 *5*; α(L)=0.01174 *17*; α(M)=0.00294 *5* α(N)=0.000739 *11*; α(O)=0.0001339 *19*; α(P)=8.19×10^{-6} *12* For B(E2)(W.u.) value, it is assumed that the 407.4γ is the dominant transition from 2237 level.
2237.2		690.7 *5*		1546.38	(15/2⁺)			
2308.1?		562.5 *2*	100 *5*	1745.7		(D)		
		662 *1*		1645.66	(17/2⁻)			
2308.2	(19/2⁺)	479 *1*	100	1829.73	(17/2⁺)			
		761.7 *5*		1546.38	(15/2⁺)			
2420.3	(11/2,13/2,15/2)	956.0 *4*	100	1464.30	(13/2⁻)			
2500.7	(21/2⁻)	336.7 *5*		2163.4	(19/2⁻)			Additional information 4.
		657		1845.0	(17/2⁻)			
		856		1645.66	(17/2⁻)			
2632.5	(25/2⁺)	395.4 *3*	100	2237.1	(21/2⁺)	E2	0.0509	B(E2)(W.u.)=4.2×10^2 *6* α(K)=0.0337 *5*; α(L)=0.01299 *19*; α(M)=0.00326 *5* α(N)=0.000819 *12*; α(O)=0.0001482 *22*; α(P)=8.92×10^{-6} *13*
2649.6	(23/2⁻)	484		2163.4	(19/2⁻)	(E2)	0.0304	α(K)=0.0216 *3*; α(L)=0.00670 *10*; α(M)=0.001660 *24* α(N)=0.000417 *6*; α(O)=7.64×10^{-5} *11*; α(P)=5.09×10^{-6} *8* Mult.: ΔJ=2 from DCO ratio; RUL.
		502.1& *3*	100	2147.6	(19/2⁻)	E2	0.0278	B(E2)(W.u.)>44 α(K)=0.0199 *3*; α(L)=0.00598 *9*; α(M)=0.001477 *21* α(N)=0.000371 *6*; α(O)=6.82×10^{-5} *10*; α(P)=4.62×10^{-6} *7*
2668.6	(23/2⁻)	521		2147.6	(19/2⁻)			
2698.0	(23/2⁻)	197		2500.7	(21/2⁻)			

$^{189}_{81}Tl_{108}$-9

Adopted Levels, Gammas (continued)

γ(^{189}Tl) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[#]	α[@]	$I_{(\gamma+ce)}$	Comments
2698.0	(23/2$^-$)	535		2163.4	(19/2$^-$)				
2788.4	(25/2$^-$)	138.8 *4*	100 *10*	2649.6	(23/2$^-$)	D			Mult.: most likely M1 with α(theory)=3.32.
		288		2500.7	(21/2$^-$)				
3025.3	(27/2$^-$)	236.9[&] *2*	100 *10*	2788.4	(25/2$^-$)	D			
		375.8[a] *3*	35 *4*	2649.6	(23/2$^-$)				
3094.9	(29/2$^+$)	462.4 *3*	100	2632.5	(25/2$^+$)	E2	0.0341		B(E2)(W.u.)=4.5×10^2 *+9−14* α(K)=0.0238 *4*; α(L)=0.00774 *11*; α(M)=0.00192 *3* α(N)=0.000483 *7*; α(O)=8.83×10^{-5} *13*; α(P)=5.75×10^{-6} *9*
3253.6	(27/2$^-$)	585		2668.6	(23/2$^-$)				
3277.5	(29/2$^-$)	252.2 *3*	100 *9*	3025.3	(27/2$^-$)	D			
		489.2 *5*		2788.4	(25/2$^-$)				
3442.9		348.0 *5*		3094.9	(29/2$^+$)				
3627.0	(31/2$^-$)	349.7 *5*		3277.5	(29/2$^-$)				
		601		3025.3	(27/2$^-$)				
3629.0	(33/2$^+$)	534.1 *3*	100	3094.9	(29/2$^+$)	E2	0.0240		B(E2)(W.u.)>2.8×10^2 α(K)=0.01749 *25*; α(L)=0.00496 *7*; α(M)=0.001220 *18* α(N)=0.000307 *5*; α(O)=5.65×10^{-5} *8*; α(P)=3.93×10^{-6} *6*
3901.6	(31/2$^-$)	648		3253.6	(27/2$^-$)				
3957.8	(33/2$^-$)	331		3627.0	(31/2$^-$)				
		680		3277.5	(29/2$^-$)				
4232.1	(37/2$^+$)	603.1 *5*		3629.0	(33/2$^+$)				
4359.9?	(35/2$^-$)	402[a]		3957.8	(33/2$^-$)				
		733[a]		3627.0	(31/2$^-$)				
4605.6	(35/2$^-$)	704		3901.6	(31/2$^-$)				
4728.8?	(37/2$^-$)	369[a]		4359.9?	(35/2$^-$)				
		771[a]		3957.8	(33/2$^-$)				
4896.1	(41/2$^+$)	664 *1*		4232.1	(37/2$^+$)				
5361.6	(39/2$^-$)	756		4605.6	(35/2$^-$)				
5606.1	(45/2$^+$)	710		4896.1	(41/2$^+$)				
6333.1	(49/2$^+$)	727		5606.1	(45/2$^+$)				
326.3+x	J1+2	326.3[a] *10*		x	J1≈(27/2)			0.13[‡] *8*	
694.2+x	J1+4	367.9 *6*		326.3+x	J1+2			0.38[‡] *7*	
1102.7+x	J1+6	408.5 *3*		694.2+x	J1+4			1.09[‡] *8*	
1551.3+x	J1+8	448.6 *3*		1102.7+x	J1+6			1.00[‡] *8*	
2039.6+x	J1+10	488.3 *3*		1551.3+x	J1+8			0.95[‡] *8*	
2566.4+x	J1+12	526.8 *3*		2039.6+x	J1+10			0.94[‡] *7*	
3131.1+x	J1+14	564.7 *3*		2566.4+x	J1+12			0.83[‡] *10*	
3732.6+x	J1+16	601.5 *6*		3131.1+x	J1+14			0.50[‡] *7*	
4369.4+x	J1+18	636.8[a] *6*		3732.6+x	J1+16			0.33[‡] *8*	
5040.3+x?	J1+20	670.9[a] *10*		4369.4+x	J1+18			0.23[‡] *7*	

$^{189}_{81}Tl_{108}$-10

Adopted Levels, Gammas (continued)

$\gamma(^{189}Tl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	E_f	J_f^π	$I_{(\gamma+ce)}$	E_i(level)	J_i^π	E_γ[†]	E_f	J_f^π	$I_{(\gamma+ce)}$
304.5+y?	J2+2	304.5[a] *10*	y	J2≈(25/2)	0.39[‡] *8*	2432.3+y	J2+12	504.8 *3*	1927.5+y	J2+10	0.86[‡] *9*
649.3+y	J2+4	344.8 *6*	304.5+y?	J2+2	0.45[‡] *8*	2973.7+y	J2+14	541.4 *3*	2432.3+y	J2+12	0.82[‡] *8*
1034.3+y	J2+6	385 *1*	649.3+y	J2+4		3552.8+y	J2+16	579.1 *6*	2973.7+y	J2+14	0.54[‡] *8*
1461.3+y	J2+8	427 *1*	1034.3+y	J2+6	0.97[‡] *11*	4167.0+y	J2+18	614.2 *6*	3552.8+y	J2+16	0.47[‡] *9*
1927.5+y	J2+10	466.2 *3*	1461.3+y	J2+8	1.00[‡] *9*	4815.4+y?	J2+20	648.4[a] *10*	4167.0+y	J2+18	0.35[‡] *7*

[†] From weighted averages of all available data from ε decay and in-beam γ-ray data. In $^{156}Gd(^{37}Cl,4n\gamma)$ from 1996RiZZ, the energies are given to nearest keV without uncertainties and no intensity data are available.
[‡] Relative I(γ+ce) within the SD band.
[#] From DCO, $\gamma(\theta)$ and $\gamma(\theta,\text{pol})$ data in $^{165}Ho(^{28}Si,4n\gamma)$ (1991Po15).
[@] From BrIcc code (2008Ki07) with "Frozen Orbitals" approximation.
[&] Multiply placed.
[a] Placement of transition in the level scheme is uncertain.

$^{189}_{81}Tl_{108}$-11

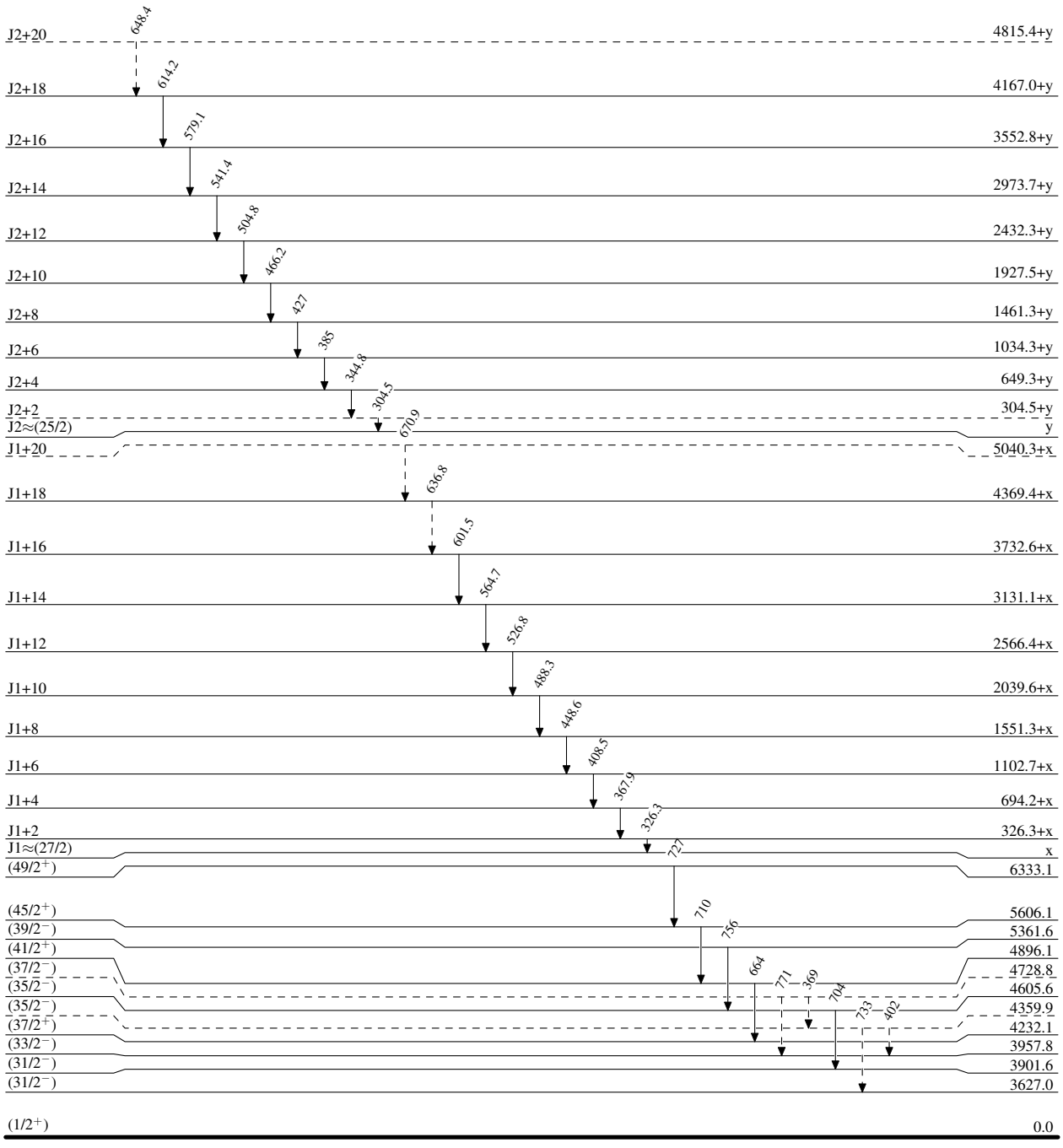
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{189}_{81}Tl_{108}$

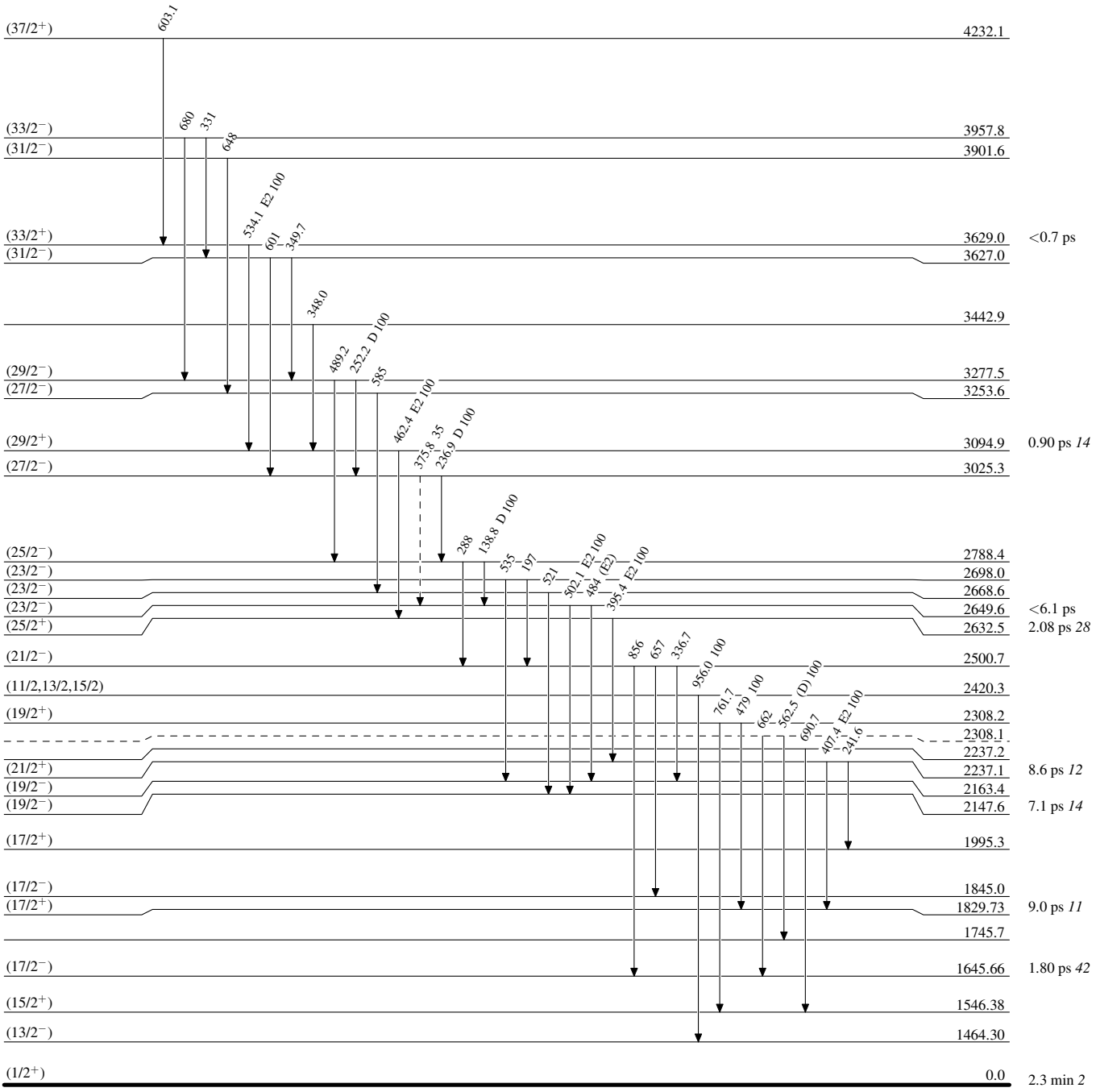
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{189}_{81}Tl_{108}$

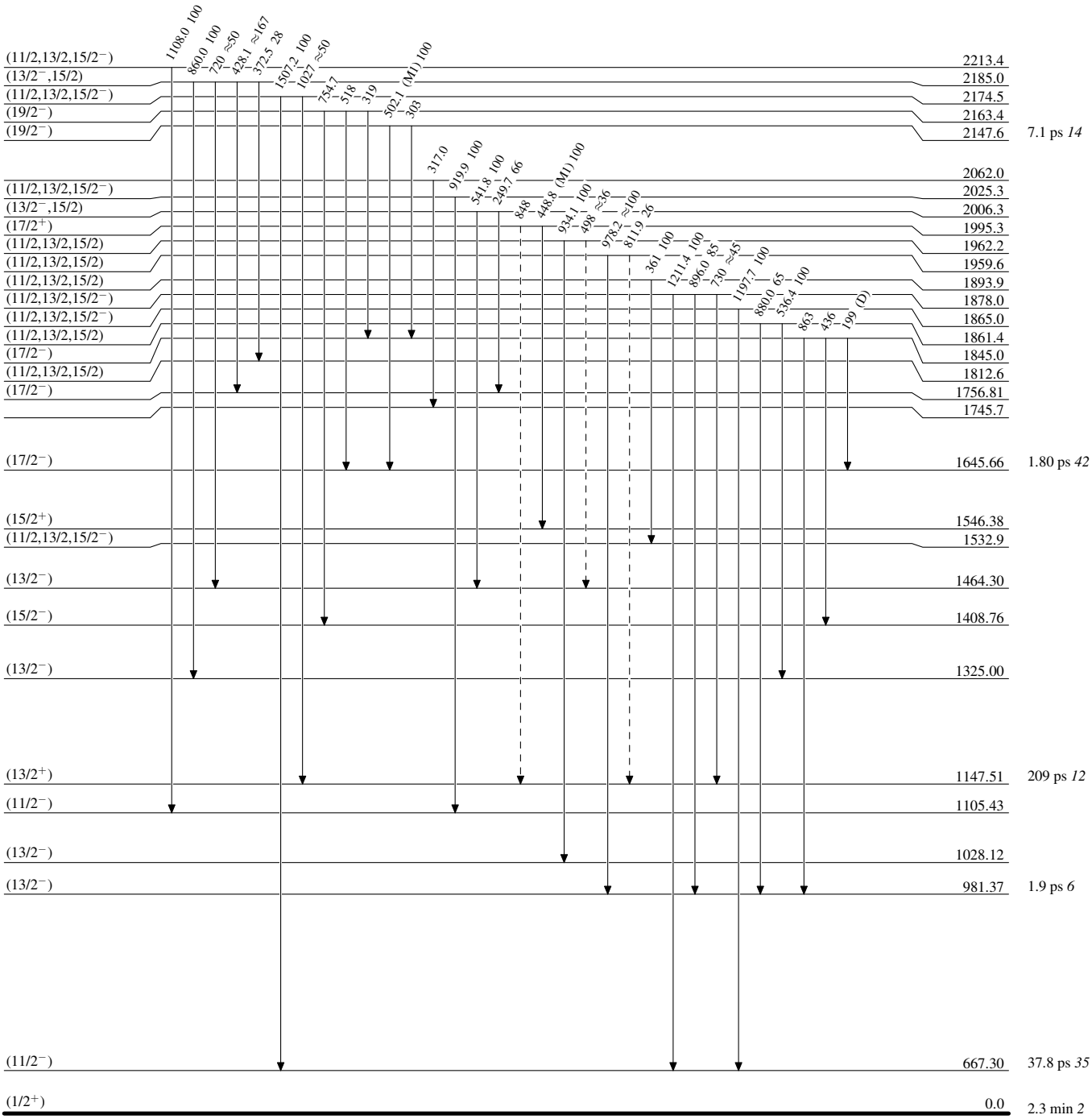
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{189}_{81}Tl_{108}$

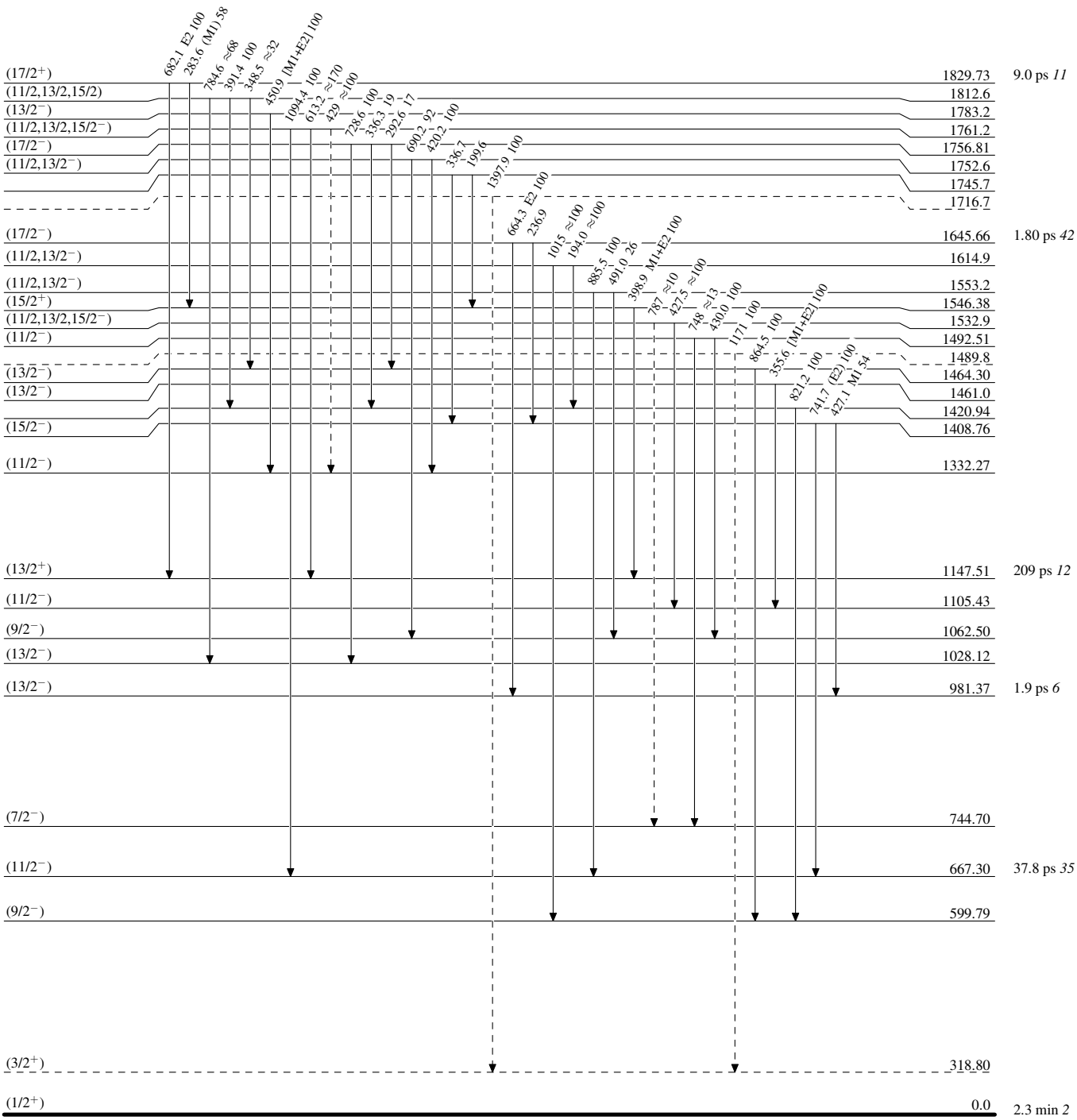
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{189}_{81}Tl_{108}$

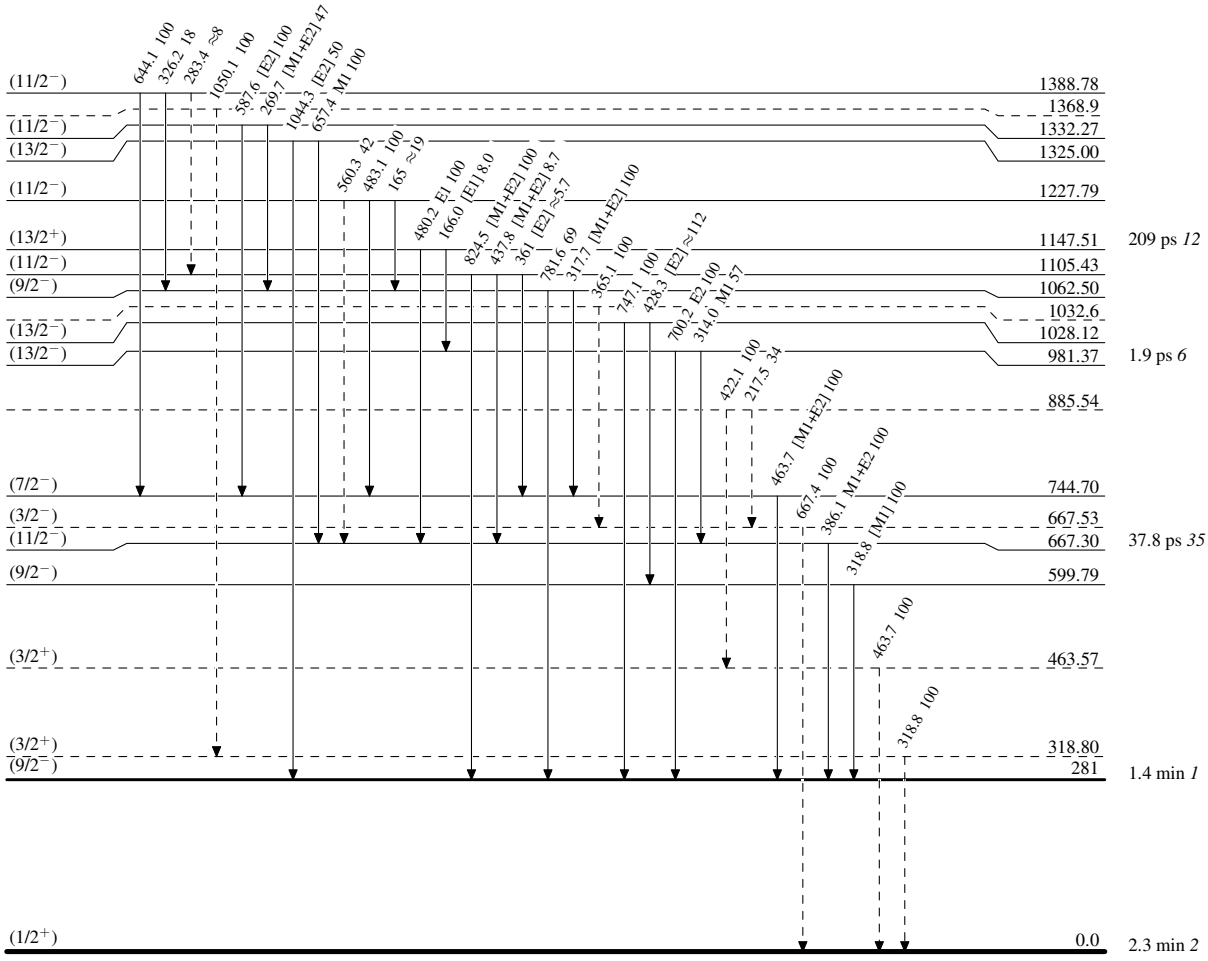
Adopted Levels, Gammas

Legend

Level Scheme (continued)

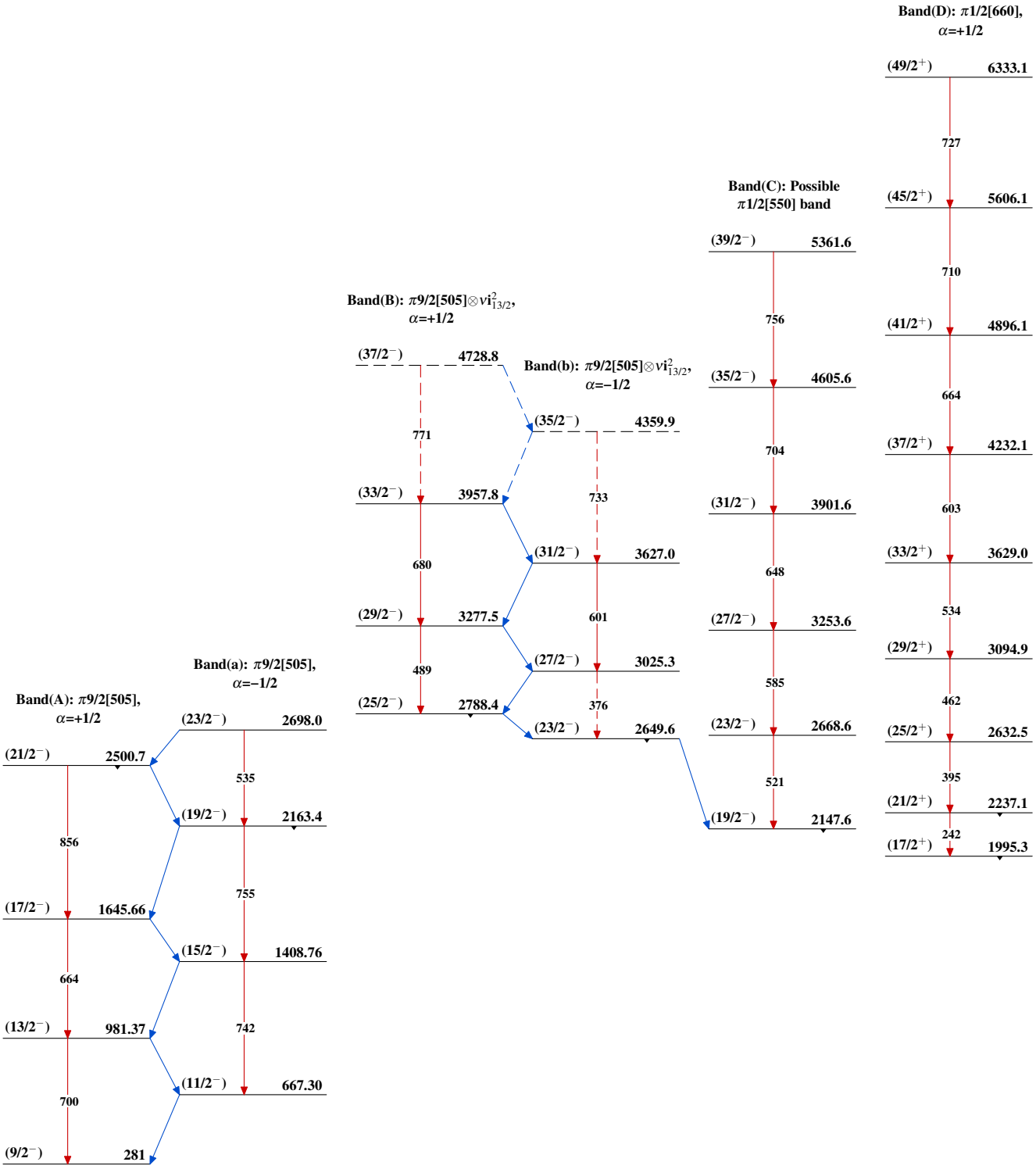
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



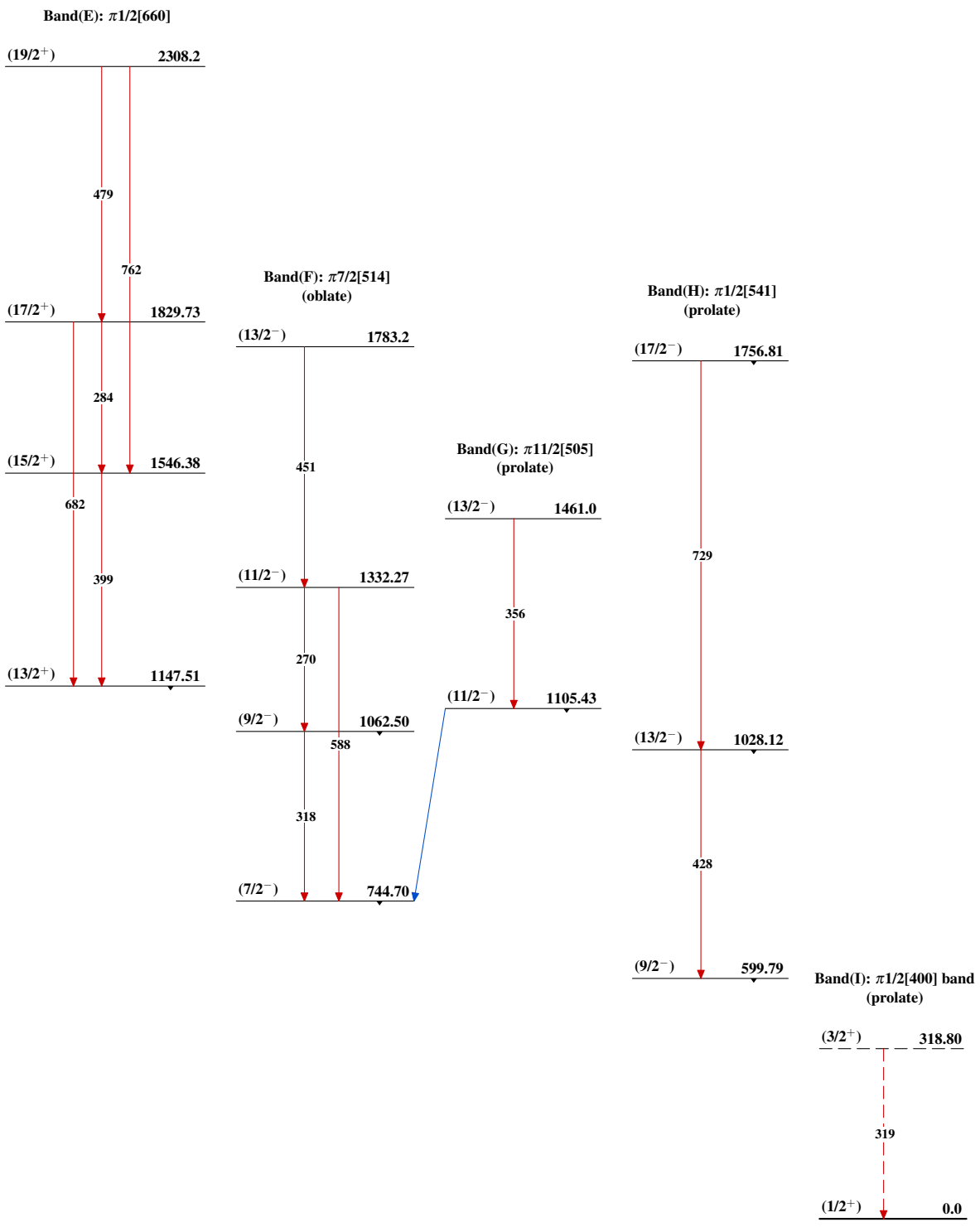
$^{189}_{81}Tl_{108}$

Adopted Levels, Gammas



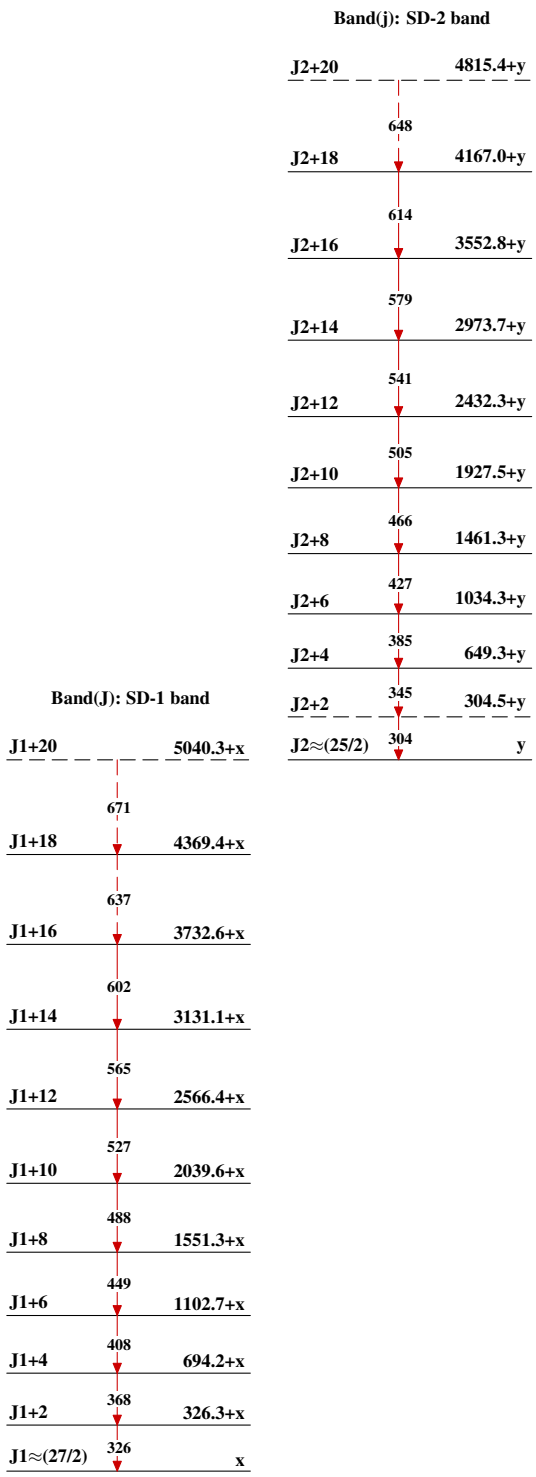
$^{189}_{81}Tl_{108}$

Adopted Levels, Gammas (continued)



$^{189}_{81}Tl_{108}$

Adopted Levels, Gammas (continued)



$^{189}_{81}Tl_{108}$