Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. A. Mccutchan, C. M. Baglin, O. Gorbachenko, N. Todorovic	NDS 114, 661 (2013)	28-Feb-2013

Q(β^-)=574 *5*; S(n)=5138 *5*; S(p)=4419 *5*; Q(α)=6750.3 *5* 2012Wa38
S(2n)=9743 *5*, S(2p)=12798 *10* (2012Wa38).

^{211}Bi evaluated by E.A. McCutchan, c.m. Baglin, O. Gorbachenko, βn. Todorovic.

Theory, calculations, systematics:
α decay widths: 1983Ka15, 1976Fl06
Energy levels, shell model: 1989Ma12, 1981Si08, 1973Ba61, 1971Ra31
Magicities: 1983Ze02
Nuclear moments: 1972Ma10
Quadrupole core vibrations: 1975Ew01
Quadrupole-octupole deformation syst: 1987Sh24

^{211}Bi Levels

Cross Reference (XREF) Flags

A	^{211}Pb β^- decay	E	^{209}Bi(t,p)
B	^{215}At α decay	F	^{209}Bi(t,pγ)
C	^{9}Be(^{238}U,Xγ)	G	^{210}Bi(d,p):J^π=9$^-$ target
D	^{208}Pb(α,p)	H	^{238}U(^{208}Pb,Xγ)

E(level)†	J^π	$T_{1/2}$	XREF	Comments
0.0	9/2$^-$	2.14 min *2*	ABCDEF H	%β^-=0.276 *4*; %α=99.724 *4* μ=(+)3.79 *7* (2007St23,2011StZZ) Configuration=((^{210}Pb 0$^+$)(π h$_{9/2}$)). J^π: L=0 from (t,p) on 9/2$^-$ target. $T_{1/2}$: weighted average of 2.22 min 6 (1970Mu21) and 2.13 min 2 (1965Nu03). %β^-,%α: from measured Iα(^{211}Po)/(Iα(^{211}Bi)+Iα(^{211}Po)); weighted average of 0.274 *4* (1967Da10), 0.274 *10* (1965Nu03), 0.29 *1* (1962Gi04). μ: from 6623α temperature anisotropy (2007St23, original reference D.A. Williams et al., Proc. Conf. on Hyperfine Interactions 1C, p565 (1996), Leuven). Other: 3.5 *3* from static (low-temperature) nuclear orientation (1992Sc26).
404.866 *9*	7/2$^-$	0.317 ns *11*	AB DEF	μ=+4.5 *7* (1965Ag03,2011StZZ); Configuration=((210πB0$^+$)(π f$_{7/2}$)) J^π: from $\gamma\gamma(\theta)$, $\gamma\gamma$(pol) and ce data (^{211}Pb β^- decay). $T_{1/2}$: weighted average of 0.318 ns *14* (1966Go19) and 0.315 ns *20* (1963Va05) (^{211}Pb β^- decay). μ: from $\gamma\gamma(\theta$,H) (^{211}Pb β^- decay).
766.539 *16*	(9/2,11/2)$^-$		A dEFG	J^π: M1 767γ to 9/2$^-$ g.s.; L=(4) from ^{210}Bi(J^π=9$^-$)(d,p) reaction, with 11/2$^-$ favored.
793 *10*	$^-$		dE	J^π: L=2 in (t,p) on 9/2$^-$ target.
828.13 *4*	(13/2)$^-$		CdeFgH	XREF: e(827)g(818). J^π: E2 828γ to 9/2$^-$ g.s.; no γ to 7/2$^-$ level; shell-model calculation.
831.960 *12*	9/2$^-$	<90 ps	A e g	XREF: e(827)g(818). J^π: $\gamma\gamma(\theta)$ establishes J=9/2 (^{211}Pb β^- decay); M1+E2 427γ to 7/2$^-$ level. $T_{1/2}$: from $\beta\gamma$(t) (1963Va05) in β^- decay.
950.9 *7*			A DE	XREF: A(951).

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Adopted Levels, Gammas (continued)

^{211}Bi Levels (continued)

E(level)†	Jπ	$T_{1/2}$	XREF	Comments
				E(level): from ^{209}Bi(t,p); possibly same as E=951? level seen in ^{211}Pb β^- decay.
987 *10*			E	
1014.40 *4*	7/2⁻,9/2⁻,11/2⁻		A E	Jπ: M1+E2 95γ from 9/2⁻ 1109 level.
1050 *10*	(⁻)		E	E(level): possibly a doublet with L=(4+(2?)) from (t,p) on 9/2⁻ target.
1080.15 *5*	⁻		A E	XREF: E(1074). Jπ: L=2 from (t,p) on 9/2⁻ target.
1103.52 *20*			A E	XREF: E(1099).
1109.485 *23*	9/2⁻		A	Jπ: 5/2⁻,7/2⁻,9/2⁻ from M1+E2 705γ to 7/2⁻ 405 level; γγ(θ) in β^- decay rules out J=7/2; log *ft*=5.6 from 9/2⁺ ^{211}Pb rules out J=5/2.
1118 *10*			E G	
1129.81 *5*	(17/2)⁻		C F H	Jπ: E2 302γ to (13/2)⁻ level; shell-model calc.
1136 *10*			G	
1149.71 *11*	(15/2)⁻		EF	Jπ: M1 322γ to (13/2)⁻ 828 level; γγ data indicates 19.9 keV γ to (17/2)⁻ 1130 level; shell-model calculation (^{209}Bi(t,p)).
1196.33 *5*			A	
1227.2 *3*	(21/2⁻)	70 ns *5*	C EFGH	XREF: E(1195)G(1217). Jπ: from $T_{1/2}$ and shell model (^{209}Bi(t,pγ)). $T_{1/2}$: from γ(t) and pγ(t) (^{209}Bi(t,pγ), 1989Ma12).
1234.3 *4*			A	Jπ: 1234γ to 9/2⁻ g.s. favors J=(5/2 to 13/2).
1242 *10*			E	
1257 *10*	(25/2⁻)	1.4 μs *3*	C GH	%IT=100 E(level): from (d,p). $T_{1/2}$: From 1998Pf02 in (^{238}U,Xγ). Jπ: from S value and shell-model calculation. $J^\pi=(29/2^-)$ is possible. Possible configuration=$((\pi\ 1h_{9/2})(\nu\ 1g_{9/2})^{+2})$ for $J^\pi=25/2^-$, and configuration=$((\pi\ 1h_{9/2})(\nu\ 1g_{9/2})(\nu\ 1i_{11/2}))$ for $J^\pi=29/2^-$.
1270.72 *6*	(7/2,9/2,11/2)		A g	XREF: g(1270). Jπ: log *ft*=5.9 from 9/2⁺ ^{211}Pb; possibly π=+.
1304.4 *6*			Fg	XREF: g(1270). 155γ to (15/2)⁻ 1150 favors J=(11/2 to 19/2).
1307 *10*			E	
1354 *10*			E	
1369 *10*			E	
1389 *10*			G	
1398 *10*			E	
1420 *10*			E	
1442 *10*			E	
1472 *10*			E	
1489 *10*			E	
1553 *10*			E	
1579 *10*			E	
1589 *10*			E	
1614 *10*			E	
1630 *10*	(⁺)		E	Jπ: L=(3) from (t,p) on 9/2⁻ target; probable configuration=((^{210}Pb 3⁻)$(\pi\ 1h_{9/2})$).
1666 *10*			E	
1686 *10*			E	
1713? *10*			E	
1825 *10*			E	
1872 *10*			E	
1978 *10*			E	
1992 *10*			E	
2015 *10*			E	
2050 *10*	(⁺)		E	Jπ: L=(3) from (t,p) on 9/2⁻ target; probable configuration=((^{210}Pb 3⁻)$(\pi\ 1h_{9/2})$).

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Adopted Levels, Gammas (continued)

^{211}Bi Levels (continued)

E(level)†	Jπ	XREF	Comments
2059.0 *10*		H	Jπ: 802γ to (25/2⁻) 1257 favors J=(21/2 to 29/2).
2069 *10*		E	
2102 *10*		E	
2316.0 *15*		H	
2409 *15*		G	E(level): peak includes many levels.
2615 *10*		G	
2782.0 *17*		H	
3138.0 *17*		H	
3603.0 *20*		H	
4836.0 *22*	(41/2⁺)	H	Jπ: Probable configuration=((π $1i_{13/2}$)(ν $1j_{15/2}$)$^{+2}$).
4979.0 *24*		H	
5257.0 *24*		H	
5334.0 *24*		H	
5445.0 *24*		H	
5945		H	
6191		H	

† For levels deexcited by γ rays: from least-squares fit to Eγ, assigning 1 keV uncertainty to Eγ data for which uncertainties are unknown and excluding the 676γ and 362γ, both of which fit their placements particularly poorly. This results in a reduced χ^2 of 3.3 (cf. Critical value of 2.1), compared with 41 when all gammas are included, 26.5 if only the 676γ is omitted or 22.2 if only the 362γ is omitted. Level energies from other reactions are taken from the cross-referenced source unique to the level. Note that levels with E(level)=1195 *10* from (t,p), 1217 *10* from (d,p) and 1227.2 *3* from (t,pγ) are probably all the same (21/2⁻) level. It appears then, that the energy calibrations of the three experiments are not in good agreement; this complicates cross referencing for levels above 1227 keV.

Adopted Levels, Gammas (continued)

$\gamma(^{211}Bi)$

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.	δ	α[@]	Comments
404.866	7/2$^-$	404.853 *10*	100	0.0	9/2$^-$	M1+E2	−1.1 *1*	0.122 *8*	α(K)=0.095 *7*; α(L)=0.0206 *8*; α(M)=0.00498 *17*; α(N+..)=0.00156 *6* α(N)=0.00127 *5*; α(O)=0.000254 *10*; α(P)=2.79×10^{-5} *13* B(M1)(W.u.)=0.00042 *5*; B(E2)(W.u.)=1.07 *10* Mult.,δ: from ce data and $\gamma\gamma(\theta$,pol) in ^{211}Pb β^- decay.
766.539	(9/2,11/2)$^-$	362.072[&] *17*	6.9 *4*	404.866	7/2$^-$				Eγ fits placement poorly; datum excluded from least-squares fit. Implied final level energy is 404.467 *24* cf. Adopted value of 404.866 *9*.
		766.51 *3*	100.0 *25*	0.0	9/2$^-$	M1		0.0382	α(K)=0.0313 *5*; α(L)=0.00527 *8*; α(M)=0.001234 *18*; α(N+..)=0.000388 *6* α(N)=0.000316 *5*; α(O)=6.45×10^{-5} *9*; α(P)=7.71×10^{-6} *11* Mult.: from α(K)exp (^{211}Pb β^- decay, ^{209}Bi(t,pγ)).
828.13	(13/2)$^-$	(61.6[‡])	[‡]	766.539	(9/2,11/2)$^-$	[M1]		7.84	α(L)=5.99 *9*; α(M)=1.410 *20*; α(N+..)=0.443 *7* α(N)=0.361 *5*; α(O)=0.0737 *11*; α(P)=0.00877 *13* E$_\gamma$: existence of γ deduced from $\gamma\gamma$ coin data (^{209}Bi(t,pγ)).
		828.13[‡] *4*	100[‡]	0.0	9/2$^-$	E2		0.01017	α(K)=0.00790 *11*; α(L)=0.001725 *25*; α(M)=0.000417 *6*; α(N+..)=0.0001298 *19* α(N)=0.0001063 *15*; α(O)=2.12×10^{-5} *3*; α(P)=2.30×10^{-6} *4* Mult.: from ce data in ^{209}Bi(t,pγ).
831.960	9/2$^-$	65.420 *14*	2.20 *15*	766.539	(9/2,11/2)$^-$	M1		6.58	α(L)=5.02 *7*; α(M)=1.182 *17*; α(N+..)=0.372 *6* α(N)=0.302 *5*; α(O)=0.0618 *9*; α(P)=0.00735 *11* B(M1)(W.u.)>0.011 Mult.: from ce data (^{211}Pb β^- decay).
		427.088 *10*	49.8 *11*	404.866	7/2$^-$	M1+E2	−0.022 *9*	0.1784	α(K)=0.1457 *21*; α(L)=0.0250 *4*; α(M)=0.00586 *9*; α(N+..)=0.00184 *3* α(N)=0.001497 *21*; α(O)=0.000306 *5*; α(P)=3.65×10^{-5} *6* B(M1)(W.u.)>0.00088; B(E2)(W.u.)>0.00015 Mult.,δ: from ce data and $\gamma\gamma(\theta)$ (^{211}Pb β^- decay).
		832.01 *3*	100.0 *15*	0.0	9/2$^-$	M1+E2	0.39 *+18−25*	0.0281 *24*	α(K)=0.0229 *23*; α(L)=0.0039 *4*; α(M)=0.00092 *8*; α(N+..)=0.000287 *24* α(N)=0.000234 *20*; α(O)=4.8×10^{-5} *4*;

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Adopted Levels, Gammas (continued)

γ(^{211}Bi) (continued)

E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult.	δ	α @	Comments
									α(P)=5.7×10^{-6} *5* B(M1)(W.u.)>0.00018; B(E2)(W.u.)>0.0031 Mult.,δ: from α(K)exp (^{211}Pb β$^-$ decay).
950.9		546 &		404.866	7/2$^-$				E_γ: γ not seen; required by γγ data (^{211}Pb β$^-$ decay).
		951 &	100	0.0	9/2$^-$				
1014.40	7/2$^-$,9/2$^-$,11/2$^-$	609.38 *4*	100 *15*	404.866	7/2$^-$				
		1014.64 *5*	40.6 *12*	0.0	9/2$^-$				
1080.15	–	313.59 *9*	100 *13*	766.539	(9/2,11/2)$^-$				
		676.69 *7*	42 *13*	404.866	7/2$^-$				Eγ fits placement poorly; datum excluded from least-squares fit. Implied final level energy is 403.46 *9* cf. Adopted value of 404.866 *9*.
		1080.16 *6*	39.6 *21*	0.0	9/2$^-$				
1103.52		1103.52 *20*	100	0.0	9/2$^-$				
1109.485	9/2$^-$	95.0 *2*	3.9 *6*	1014.40	7/2$^-$,9/2$^-$,11/2$^-$	M1+E2	1.6 *+5−3*	9.4 *4*	α(K)=2.8 *9*; α(L)=4.9 *5*; α(M)=1.28 *12*; α(N+..)=0.39 *4* α(N)=0.32 *3*; α(O)=0.060 *6*; α(P)=0.0048 *4* Mult.,δ: from α(K)exp (^{211}Pb β$^-$ decay).
		342.91 *4*	7.5 *11*	766.539	(9/2,11/2)$^-$	[M1,E2]		0.20 *12*	α: for δ=1.
		704.64 *3*	100.0 *22*	404.866	7/2$^-$	M1+E2	−0.022 *7*	0.0476	α(K)=0.0390 *6*; α(L)=0.00657 *10*; α(M)=0.001540 *22*; α(N+..)=0.000484 *7* α(N)=0.000394 *6*; α(O)=8.05×10^{-5} *12*; α(P)=9.61×10^{-6} *14* Mult.,δ: from α(K)exp and γγ(θ) (^{211}Pb β$^-$ decay).
		1109.48 *5*	24.9 *8*	0.0	9/2$^-$				
1129.81	(17/2)$^-$	301.68 ‡ *3*	100 ‡	828.13	(13/2)$^-$	E2		0.1186	α(K)=0.0652 *10*; α(L)=0.0400 *6*; α(M)=0.01032 *15*; α(N+..)=0.00317 *5* α(N)=0.00263 *4*; α(O)=0.000498 *7*; α(P)=4.39×10^{-5} *7* Mult.: from ce data (^{209}Bi(t,pγ)).
1149.71	(15/2)$^-$	(19.9 ‡)	‡	1129.81	(17/2)$^-$	[M1]		219	α(L)=167.2 *24*; α(M)=39.7 *6*; α(N+..)=12.47 *18* α(N)=10.15 *15*; α(O)=2.07 *3*; α(P)=0.247 *4*
		321.58 ‡ *10*	100 ‡	828.13	(13/2)$^-$	M1		0.384	α(K)=0.313 *5*; α(L)=0.0540 *8*; α(M)=0.01269 *18*; α(N+..)=0.00399 *6* α(N)=0.00324 *5*; α(O)=0.000663 *10*; α(P)=7.90×10^{-5} *11* Mult.: from ce data (^{209}Bi(t,pγ)).
1196.33		430 *1*	63 *25*	766.539	(9/2,11/2)$^-$				
		1196.33 *5*	100 *4*	0.0	9/2$^-$				

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Adopted Levels, Gammas (continued)

$\gamma(^{211}Bi)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.	α[@]	Comments
1227.2	(21/2$^-$)	97.4[‡] *3*	100[‡]	1129.81	(17/2)$^-$	(E2)	7.59 *15*	α(K)=0.459 *7*; α(L)=5.30 *11*; α(M)=1.41 *3*; α(N+..)=0.428 *9* α(N)=0.357 *8*; α(O)=0.0658 *14*; α(P)=0.00505 *11* B(E2)(W.u.)=1.44 *11* Mult.: from ce data in (t,pγ).
1234.3		1234.3 *4*	100	0.0	9/2$^-$			
1257	(25/2$^-$)	(30[#])		1227.2	(21/2$^-$)	[E2]	2.52×10^3	
1270.72	(7/2,9/2,11/2)	504.12 *12*	85 *11*	766.539	(9/2,11/2)$^-$			
		865.93 *14*	87 *6*	404.866	7/2$^-$			
		1270.71 *8*	100 *8*	0.0	9/2$^-$			
1304.4		154.7[‡] *5*	100[‡]	1149.71	(15/2)$^-$			
2059.0		802[#]	100	1257	(25/2$^-$)			
2316.0		257[#]	100	2059.0				
2782.0		466[#]	100	2316.0				
3138.0		356[#]		2782.0				
		822[#]		2316.0				
3603.0		465[#]	100	3138.0				
4836.0	(41/2$^+$)	1233[#]	100	3603.0				
4979.0		143[#]	100	4836.0	(41/2$^+$)			
5257.0		421[#]	100	4836.0	(41/2$^+$)			
5334.0		498[#]	100	4836.0	(41/2$^+$)			
5445.0		609[#]	100	4836.0	(41/2$^+$)			
5945		687[#]	100	5257.0				
6191		934[#]	100	5257.0				

[†] From ^{211}Pb β^- decay, unless otherwise noted.
[‡] From ^{209}Bi(t,pγ).
[#] From ^{238}U(^{208}Pb,Xγ); incertainty unstated by authors.
[@] 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.

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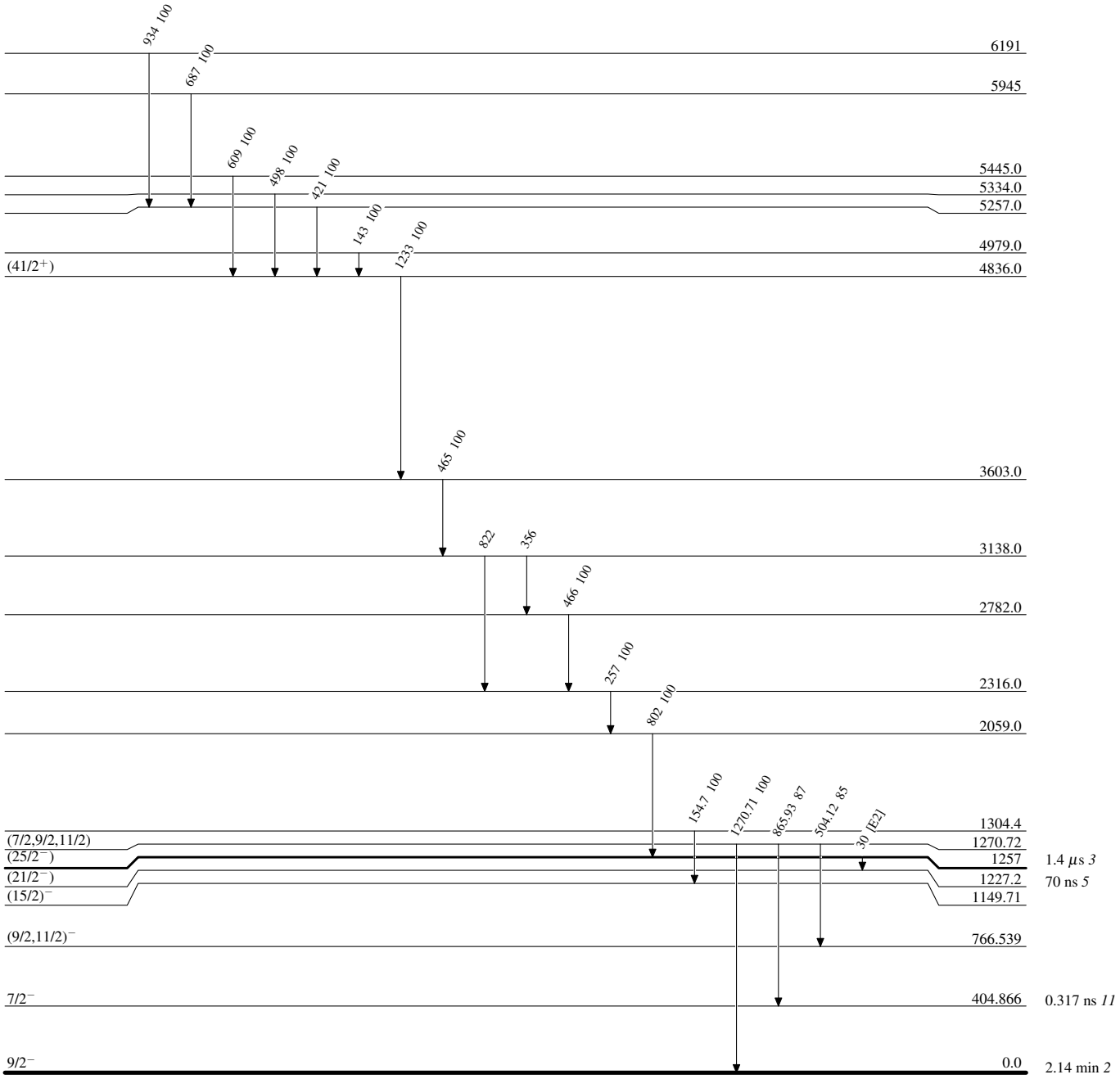
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



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Legend

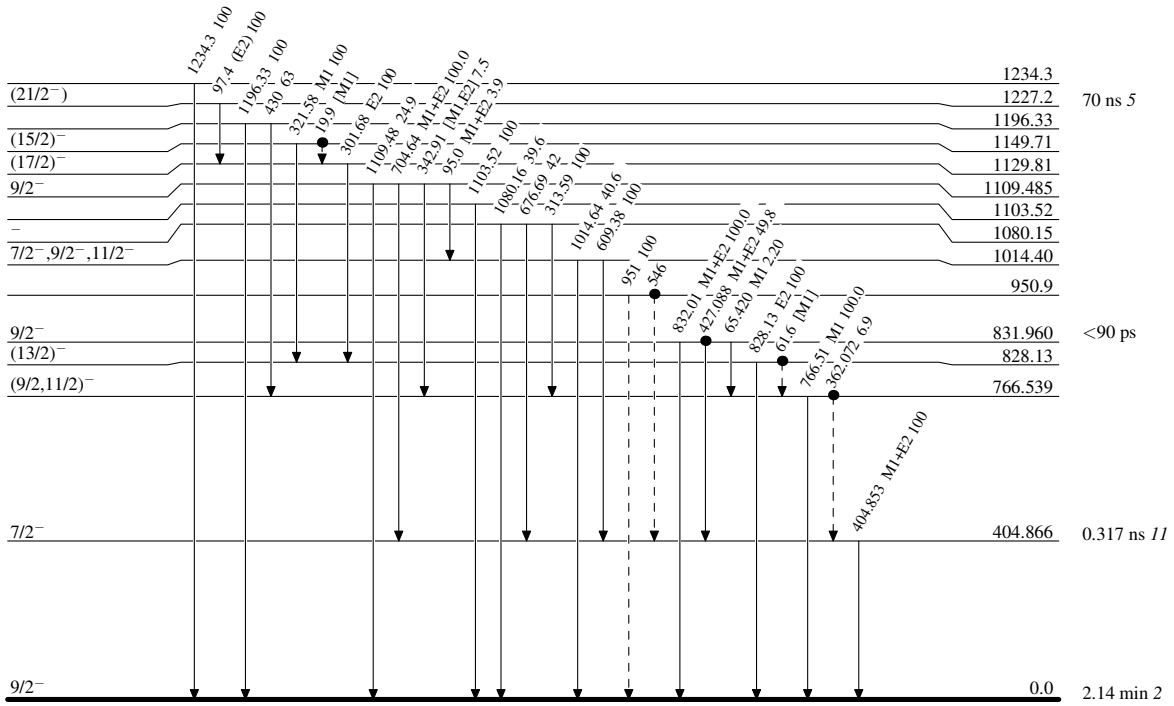
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)

Coincidence



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