^{209}Tl β^- decay 2000Gr35,1998Ar03,1989Ko26

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. Chen # and F. G. Kondev	NDS 126, 373 (2015)	30-Sep-2013

Parent: ^{209}Tl: E=0.0; $J^\pi=1/2^+$; $T_{1/2}$=2.162 min *7*; Q(β^-)=3976 *8*; %β^- decay=100.0

^{209}Tl-J^π,$T_{1/2}$: From Adopted Levels of ^{209}Tl.

^{209}Tl-Q(β^-): From 2012Wa38.

2000Gr35:^{209}Tl source was prepared from the decay of ^{225}Ac at JINR. γ-rays were detected with a 200 cm^3 HPGe detector (FWHM=3.5 keV at Eγ=1.33 MeV), a 60 cm^3 Ge(Li) detector (FWHM=1.9 keV) and a 2 cm^3 HPGe detector (FWHM=1.0 keV); β-rays were detected with a Si(Li) detector (FWHM=2.1 keV for the ^{207}Bi K1063 line). Measured Eγ, Iγ, $\gamma\gamma$-coin, Iβ. Deduced levels, γ-branchings, β-branchings, log *ft*.

1998Ar03, 1994Ar23 and 1993El08: ^{209}Tl activities were produced from α decays of ^{213}Bi sources. γ-rays were detected with spectrometers of a n-type HPGe detector of 17% relative efficiency and a 30% p-type coaxial HPGe, FWHM=1.90 keV at 1.33 MeV. Measured Eγ, Iγ, γ(t), $\gamma\gamma$-coin. Deduced levels, J^π, log *ft*.

1989Ko26: ^{209}Tl was prepared from a ^{229}Th sample following α decays of ^{213}Bi at the C.E.N. at Fontenay aux Roses. γ-rays were detected with γ-spectrometers of a HPGe detector (17%, FWHM=1.9 keV), a low-energy photon spectrometer (LEPS, FWHM=190 eV at the Fe K_α x-line, and a 8% Ge(Li) detector. Measured Eγ, Iγ, $\gamma\gamma$-coin. Deduced levels.

1981Di14: ^{209}Tl was produced at ORNL. γ-rays were detected with a 90 cm^3 Ge(Li) detector and a 200 cm^3 HPGe detector. Measured Eγ, Iγ. Deduced levels, γ-branchings.

1980Da15: ^{209}Tl activities were produced from the ^{225}Ac source. γ-rays were detected with a Ge(Li) detector. Measured Eγ, Iγ, γ(t). Deduced the decay-branching to the E=2032 level and $T_{1/2}$ of the E=2150 level.

1977Vy02: ^{209}Tl was produced at JINR. γ-rays were detected with four Ge(Li) detectors and β-rays were detected with a Si(Li) detector. Measured Eγ, Iγ. Deduced levels, branching ratios.

1965Sa08: ^{225}Ac sample. γ-rays were detected with scintillators. Measured Eγ, $\gamma\gamma$(t). Deduced levels, $T_{1/2}$ from delayed coincidence.

1956St79: ^{225}Ac sample. β particles and γ-rays were detected by scintillation detectors. Measured Eγ, $\beta\gamma$(t). Deduced levels, $T_{1/2}$.

1999GrZT: Measured Eγ, Iγ. Deduced levels, branching ratios.

2003ChZV: Measured Eγ, Iγ with HPGe detectors. Deduced levels, branching ratios.

Others: 1950Ha64, 1952Wa24, 1955Ma61, 1955St04, 1972Dz14, 1986He06, 1998MaZO, 2006Va23.

^{209}Pb Levels

E(level)†	J^π‡	$T_{1/2}$	Comments
0.0	$9/2^+$		
1567.08 *3*	$5/2^+$	<45 ps	$T_{1/2}$: from (450γ)(1566γ)(Δt) (1965Sa08). Other: 1956St79 (<1500 ps).
2032.21 *4*	$1/2^+$	161 ps *8*	$T_{1/2}$: from (117γ)(467γ)(Δt) (1965Sa08).
2149.42 *4*	$1/2^-$	3.96 ns *4*	$T_{1/2}$: from B(582γ)(t) (1980Da15). Other: 3.1 ns *2* (1965Sa08), 3.1 ns *10* (1956St79).
2315.90 *16*	$3/2^-$		
2460.9 *3*	$(5/2)^-$		
2524.92 *21*	(1/2,3/2)		
2905.27 *25*	$3/2^-$		
3069.92 *16*	$3/2^-$		
3361.5 *3*	(1/2,3/2)		
3389.09 *16*	(1/2,3/2)		

† From a least-squares fit to γ-ray energies.

‡ From Adopted Levels.

^{209}Tl β^- decay 2000Gr35,1998Ar03,1989Ko26 (continued)

β^- radiations

E(decay)	E(level)	Iβ^-[†][‡]	Log *ft*	Comments
(587 *8*)	3389.09	0.439 *17*	5.77 *3*	av Eβ=177.8 *28*
(615 *8*)	3361.5	0.10 *3*	6.48 *14*	av Eβ=187.3 *28*
(906 *8*)	3069.92	0.644 *23*	6.255 *21*	av Eβ=292.8 *30*
(1071 *8*)	2905.27	0.70 *9*	6.48 *6*	av Eβ=355.4 *31*
(1451 *8*)	2524.92	0.070 *15*	7.95 *10*	av Eβ=505.9 *33*
(1515 *8*)	2460.9	0.031 *16*	9.20[1*u*] *23*	av Eβ=518.0 *31*
(1660 *8*)	2315.90	0.25 *8*	7.62 *14*	av Eβ=591.1 *33*
(1827 *8*)	2149.42	97 *4*	5.186 *20*	av Eβ=660.0 *34*
				E(decay): E=1800 *200* from 1955Ma61. Others: 1952Wa24, 1950Ha64.
(1944 *8*)	2032.21	<0.1	>8.3	av Eβ=708.9 *34*
				Iβ^-: from $\beta\gamma$(t) (1980Da15). The limit is quoted at the 99% confidence level.

[†] From an intensity balance at each level, except for the branch to the 2149 level, which is constrained by the condition Σ Iβ=100.
[‡] Absolute intensity per 100 decays.

$\gamma(^{209}Pb)$

Iγ normalization: From Ti(1567.087γ)+Ti(2315.8γ)=100, assuming no direct feeding to the ground state.
Kα_1 x ray=11.0 *11*, Kα_2 x ray=6.5 *7* (1972Dz14), relative to Iγ(465)=100.

E$_\gamma$[@]	I$_\gamma$[&][c]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[a]	α[b]	Comments
117.21 *5*	76 *3*	2149.42	1/2$^-$	2032.21	1/2$^+$	E1	0.295	α(K)=0.235 *4*; α(L)=0.0455 *7*; α(M)=0.01073 *15* α(N)=0.00268 *4*; α(O)=0.000507 *8*; α(P)=4.03×10^{-5} *6* %Iγ=76 *3*, using the calculated normalization. E$_\gamma$: weighted average of 117.211 *21* (1977Vy02), 117.25 *5* (1981Di14), 117.21 *1* (1989Ko26), 117.24 *5* (1998Ar03) and 117.18 *10* (2000Gr35). I$_\gamma$: weighted average of 73 *4* (1998Ar03) and 78 *4* (2000Gr35) Others: 90.3 *22* (1977Vy02), 85 *3* (1981Di14) and 85 *4* (1989Ko26), Mult.: α(K)exp=0.25 *2* (2000Gr35).
284.04[‡] *23*	0.14[‡] *7*	2315.90	3/2$^-$	2032.21	1/2$^+$	[E1]	0.0335	α(K)=0.0275 *4*; α(L)=0.00467 *7*; α(M)=0.001091 *16* α(N)=0.000275 *4*; α(O)=5.33×10^{-5} *8*; α(P)=4.91×10^{-6} *7* %Iγ=0.14 *7*, using the calculated normalization.
311.5[‡] *3*	0.028[‡] *14*	2460.9	(5/2)$^-$	2149.42	1/2$^-$	[E2]	0.1034	α(K)=0.0596 *9*; α(L)=0.0329 *5*; α(M)=0.00842 *13* α(N)=0.00213 *3*; α(O)=0.000392 *6*; α(P)=2.44×10^{-5} *4* %Iγ=0.028 *14*, using the calculated normalization.
375.5[‡] *2*	0.070[‡] *15*	2524.92	(1/2,3/2)	2149.42	1/2$^-$			α(K)=0.190 *3*; α(L)=0.0322 *5*; α(M)=0.00754 *11*; α(N+..)=0.00234 *4* α(N)=0.00192 *3*; α(O)=0.000382 *6*;

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^{209}Tl β^- decay 2000Gr35,1998Ar03,1989Ko26 (continued)

$\gamma(^{209}Pb)$ (continued)

E_γ[@]	I_γ[&c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	α[b]	Comments
								α(P)=4.09×10^{-5} *6* %Iγ=0.070 *15*, using the calculated normalization.
465.14 *1*	95.7 *10*	2032.21	1/2$^+$	1567.08	5/2$^+$	E2	0.0350	α(K)=0.0242 *4*; α(L)=0.00815 *12*; α(M)=0.00204 *3* α(N)=0.000515 *8*; α(O)=9.70×10^{-5} *14*; α(P)=7.34×10^{-6} *11* %Iγ=95.4 *10*, using the calculated normalization. E$_\gamma$: weighted average of 465.065 *25* (1977Vy02), 465.1 *2* (1981Di14), 465.4 *1* (1986He06), 465.14 *1* (1989Ko26), 465.10 *5* (1998Ar03) and 465.21 *4* (2000Gr35). I$_\gamma$: weighted average of 98.5 *20* (1981Di14), 94.5 *13* (1986He06), 97 *4* (1989Ko26), 95 *5* (1998Ar03), 97 *5* (2000Gr35) and 95 *3* (2003ChZV). The value from 1986He06 is deduced from I(465γ)=2.022 *26* per 100 ^{213}Bi decays in 1986He06 and %α(^{213}Bi)=2.140 *10* in 2013Ma13. Others: 108 *3* deduced by the evaluators from data in 1977Vy02. Mult.: α(K)exp=0.027 *4* (1998MaZO,2000Gr35).
[x]469.7[‡] *3*	0.03[‡] *2*							%Iγ=0.030 *20*, using the calculated normalization. I$_\gamma$: 0.12 *3* from 2000Gr35.
582.4 *2*	0.31 *3*	2149.42	1/2$^-$	1567.08	5/2$^+$	[M2]	0.200	α(K)=0.1574 *22*; α(L)=0.0322 *5*; α(M)=0.00774 *11* α(N)=0.00198 *3*; α(O)=0.000392 *6*; α(P)=4.07×10^{-5} *6* %Iγ=0.31 *3*, using the calculated normalization. E$_\gamma$: from 2000Gr35. I$_\gamma$: weighted average of 0.28 *4* from 2000Gr35 and 0.32 *4* from 2003ChZV.
748.3 *3*	0.080 *21*	2315.90	3/2$^-$	1567.08	5/2$^+$	[E1]	0.00428	α(K)=0.00356 *5*; α(L)=0.000553 *8*; α(M)=0.0001280 *18* α(N)=3.24×10^{-5} *5*; α(O)=6.39×10^{-6} *9*; α(P)=6.48×10^{-7} *9* %Iγ=0.080 *21*, using the calculated normalization. E$_\gamma$: weighted average of 748.0 *3* (1998Ar03) and 748.5 *3* (2000Gr35). I$_\gamma$: weighted average of 0.09 *3* (1998Ar03) and 0.07 *3* (2000Gr35).
755.6[†#] *3*	0.11[†] *2*	2905.27	3/2$^-$	2149.42	1/2$^-$	[M1]	0.0366	α(K)=0.0301 *5*; α(L)=0.00500 *7*; α(M)=0.001168 *17* α(N)=0.000297 *5*; α(O)=5.92×10^{-5} *9*; α(P)=6.36×10^{-6} *9* %Iγ=0.110 *20*, using the calculated normalization.
[x]860.5[†#d] *3*	0.26[†] *4*							%Iγ=0.26 *4*, using the calculated normalization.
873.5[†#] *4*	0.59[†] *8*	2905.27	3/2$^-$	2032.21	1/2$^+$	[E1]	0.00320	α(K)=0.00267 *4*; α(L)=0.000410 *6*;

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^{209}Tl β^- decay 2000Gr35,1998Ar03,1989Ko26 (continued)

$\gamma(^{209}Pb)$ (continued)

E_γ[@]	I_γ[&c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	α[b]	Comments
								α(M)=9.47×10^{-5} *14* α(N)=2.40×10^{-5} *4*; α(O)=4.74×10^{-6} *7*; α(P)=4.86×10^{-7} *7* %Iγ=0.59 *8*, using the calculated normalization.
x890.0†#d *4*	0.12† *3*							%Iγ=0.12 *3*, using the calculated normalization.
x902.8†#d *4*	0.10† *2*							%Iγ=0.100 *20*, using the calculated normalization.
920.53 *17*	0.632 *22*	3069.92	3/2$^-$	2149.42	1/2$^-$	[M1]	0.0220	α(K)=0.0181 *3*; α(L)=0.00299 *5*; α(M)=0.000698 *10* α(N)=0.0001772 *25*; α(O)=3.54×10^{-5} *5*; α(P)=3.80×10^{-6} *6* %Iγ=0.630 *22*, using the calculated normalization. E_γ: weighted average of 920.2 *3* (1989Ko26), 920.34 *9* (1998Ar03), and 920.8 *1* (2000Gr35). I_γ: weighted average of 0.63 *6* (1989Ko26), 0.70 *7* (1998Ar03), 0.63 *5* (2000Gr35) and 0.62 *3* (2003ChZV). Note, Iγ=0.127 *7* in 2003ChZV is a typo and should read as 0.0127 *7*.
1239.73 *15*	0.440 *17*	3389.09	(1/2,3/2)	2149.42	1/2$^-$			%Iγ=0.439 *17*, using the calculated normalization. E_γ: weighted average of 1239.5 *5* (1989Ko26), 1239.76 *15* (1998Ar03), and 1239.7 *2* (2000Gr35). Placement of this γ-ray is based on a 117γ-1239γ coincidence observed in 1998Ar03. 2000Gr35 placed this γ-ray as a transition from a level at 2806 to 1567, based on the observed 1239γ-1567γ coincidence. 1999GrZT assigned this γ-ray from 3271 keV to 2032 keV. I_γ: weighted average of 0.42 *4* (1989Ko26), 0.31 *12* (1998Ar03), 0.42 *7* (2000Gr35) and 0.45 *2* (2003ChZV).
1329.3 *3*	0.10 *3*	3361.5	(1/2,3/2)	2032.21	1/2$^+$			%Iγ=0.10 *3*, using the calculated normalization. E_γ: weighted average of 1329.3 *3* (1998Ar03) and 1329.3 *3* (2000Gr35). I_γ: from 2000Gr35. Others: 0.26 *5* (1998Ar03) and 0.14 (2003ChZV). Note, that 0.026 *5* in the table of 1998Ar03 is a typo.
1567.08 *2*	100	1567.08	5/2$^+$	0.0	9/2$^+$	E2	0.00294	α(K)=0.00234 *4*; α(L)=0.000395 *6*; α(M)=9.25×10^{-5} *13*

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^{209}Tl β^- decay 2000Gr35,1998Ar03,1989Ko26 (continued)

$\gamma(^{209}Pb)$ (continued)

E_γ[@]	I_γ[&][c]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	α[b]	Comments
								α(N)=2.35×10^{-5} *4*; α(O)=4.64×10^{-6} *7*; α(P)=4.77×10^{-7} *7*; α(IPF)=8.56×10^{-5} *12* %Iγ=99.663 *7*, using the calculated normalization. E_γ: weighted average of 1566.95 *6* (1977Vy02), 1566.9 *2* (1981Di14), 1567.11 *2* (1989Ko26), 1566.96 *5* (1998Ar03) and 1566.9 *3* (2000Gr35). Mult.: α(K)exp=0.0024 *9* (2000Gr35).
[x]1661.1[†] *5*	0.10[†] *2*							%Iγ=0.100 *20*, using the calculated normalization.
[x]1673.2[†] *4*	0.48[†] *4*							%Iγ=0.48 *4*, using the calculated normalization.
[x]1781.7[†] *5*	0.04[†] *2*							%Iγ=0.040 *20*, using the calculated normalization.
[x]2032.1[†] *5*	<0.001[†]							%Iγ=0.0005 *5*, using the calculated normalization. I_γ: <0.02 from 2003ChZV.
2149.0[†][d] *10*	0.015[†] *5*	2149.42	1/2$^-$	0.0	9/2$^+$	[M4]	0.01529	α(K)=0.01218 *18*; α(L)=0.00237 *4*; α(M)=0.000565 *8* α(N)=0.0001441 *21*; α(O)=2.86×10^{-5} *4*; α(P)=2.98×10^{-6} *5* %Iγ=0.015 *5*, using the calculated normalization. I_γ: Others:<0.00064 in 2003ChZV,<0.013 from 2006Va23.
2315.9 *3*	0.0285 *24*	2315.90	3/2$^-$	0.0	9/2$^+$	[E3]	0.00292	α(K)=0.00216 *3*; α(L)=0.000380 *6*; α(M)=8.93×10^{-5} *13* α(N)=2.27×10^{-5} *4*; α(O)=4.49×10^{-6} *7*; α(P)=4.65×10^{-7} *7*; α(IPF)=0.000262 *4* %Iγ=0.0284 *24*, using the calculated normalization. E_γ: from 2000Gr35. I_γ: weighted average of 0.03 *1* (2000Gr35) and 0.0284 *25* (2003ChZV). Other: 0.027 *12* (2006Va23).

[†] From 2000Gr35.
[‡] From 1998Ar03.
[#] The authors of 2000Gr35 state that these transitions may belong to the decay of ^{213}Bi nucleus rather than ^{209}Tl.
[@] 2000Gr35 supersedes 1999GrZT. 1998Ar03 supersedes 1993El08 and 1994Ar23.
[&] Normalized to Iγ(1567)=100.
[a] From Adopted Gammas.
[b] Additional information 1.
[c] For absolute intensity per 100 decays, multiply by 0.99663 *7*.
[d] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

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Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays