^{199}Bi ε decay (27 min+24.70 min) 1978Ri04

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 108, 79 (2007)	15-Oct-2006

Parent: ^{199}Bi: E=0; J$^{\pi}$=9/2$^-$; T$_{1/2}$=27 min *1*; Q(ε)=4430 *29*; %ε+%β^+ decay=100.0
Parent: ^{199}Bi: E=680 *SY*; J$^{\pi}$=(1/2$^+$); T$_{1/2}$=24.70 min *15*; Q(ε)=4430 *29*; %ε+%β^+ decay=99 *1*
^{199}Bi(0)-T$_{1/2}$: 27 min *1* (1964Si11).
^{199}Bi(680)-T$_{1/2}$: 24.70 min *15* (1966Ma51).
^{199}Bi(680)-%ε+%β^+ decay: %IT<2, %α=0.01.
1978Ri04: produced by Pb(p,xnγ); mass, ion chem; measured Eγ, Iγ, ce, $\gamma\gamma$.
Others:
1964Si11, 1950Ne77, 1948Te01: measured T$_{1/2}$(^{199}Bi g.s.).
1966Ma51, 1964Si11, 1948Te01, 1970DaZM: measured T$_{1/2}$(^{199}Bi isomer) and α decay.

The partial decay scheme is that proposed by 1978Ri04 with the following changes: 1) the 3/2$^-$ state is the ground state and not at 19.58 keV as proposed by 1978Ri04; and 2) the 5/2$^-$ state is at 0+x keV (x≤9.3 keV) and not the g.s. All level energies of 1978Ri04 are therefore raised by x keV. These changes are indicated by the results of 1983Th03 (J(g.s.)=3/2$^-$) and 1962Ju05, 1957An53 (E(5/2$^-$ level)≤9.3). For tentative $\gamma\gamma$-coin results see table 6 of 1978Ri04.

The decay scheme of ^{199}Bi to ^{199}Pb is quite incomplete due to a large number of unplaced transitions and several others with uncertain placements.

^{199}Pb Levels

E(level)	J$^{\pi}$†	T$_{1/2}$‡	Comments
0	3/2$^-$	90 min *10*	%ε+%β^+=100 J$^{\pi}$: 5/2$^-$ (1978Ri04) is incorrect.
0+x	(5/2$^-$)		E(level): x≤9.3 from ^{199}Pb it decay.
19.1+x? *4*	($^-$)		E(level): This level energy is inconsistent with results of 1962Ju05, who concluded that the energy difference between the f$_{5/2}$ and p$_{3/2}$ levels is less than 9.3 keV. The placement of the two γ's feeding this first excited state may be inconsistent with some of the $\gamma\gamma$-coin results of 1978Ri04. J$^{\pi}$: 1978Ri04 assign (3/2)$^-$.
425.1+x *4*	(13/2$^+$)	12.2 min *3*	%IT<100; %ε+%β^+>0 J$^{\pi}$: 13/2$^+$ (1978Ri04).
945.9+x *3*	(7/2$^-$,9/2$^-$)		J$^{\pi}$: (7/2)$^-$ (1978Ri04).
1022.7+x *4*	(7/2$^-$,9/2$^-$)		J$^{\pi}$: (7/2,9/2)$^-$ (1978Ri04).
1052.8+x *4*	(7/2$^-$,9/2$^-$)		J$^{\pi}$: (7/2)$^-$ (1978Ri04).
1262.6+x *5*	(11/2$^+$)		J$^{\pi}$: (9/2,11/2)$^+$ (1978Ri04).
1266.7+x *5*	(11/2$^+$)		J$^{\pi}$: (9/2,11/2)$^+$ (1978Ri04).
1305.6+x *5*	(7/2$^-$,9/2$^-$)		J$^{\pi}$: (7/2,9/2)$^-$ (1978Ri04).
1337.1+x *5*	(7/2$^-$,9/2$^-$,11/2$^-$)		
1505.8+x *4*	(7/2$^-$,9/2$^-$)		J$^{\pi}$: − (1978Ri04).
1743.1+x *4*	(9/2$^-$,11/2$^-$)		
1799.6+x *4*	(9/2$^-$)		
2068.9+x *5*	(11/2$^-$)		J$^{\pi}$: (9/2,11/2)$^+$ (1978Ri04).
2083.1+x *5*	(11/2$^-$)		J$^{\pi}$: − (1978Ri04).
2108.4+x *5*	(11/2$^-$)		
2186.2+x *8*	(7/2$^-$,9/2$^-$,11/2$^-$)		

† From 'Adopted Levels', based on γ multipolarities and on the assumption that all the placed γ's are from the ε decay of 9/2$^-$ ^{199}Bi g.s. The assignments proposed by 1978Ri04 are given under comments.
‡ From 'Adopted Levels'.

γ(^{199}Pb)

Iγ normalization:≈0.11 based on the following considerations: 1. I(ce+β+)(to 425.3+x level)<16% (from log $f^{1u}t$>8.5); 2. ∑I_γ(unplaced)/∑I_γ(total)=0.44; 3. the proposed partial level scheme. Setting the total γ intensity from E(level)>425.3+x to E(level)≤425.3+x as 70 *20*, one obtains normalization factor of 0.11 *3*. The intensity of 425γ has been omitted from this calculation since the measured relative intensity is uncertain due to long $T_{1/2\ 1/2}$=12 min and lack of reliable %IT decay from the 12.2-min 425.3+x level.

I($\gamma^{\pm}$)=18.1 *9* (relative to I(841γ)=100) corresponds to %β^{+}≈1.0.

E_γ	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[c]	Comments
(x)		0+x	(5/2⁻)	0	3/2⁻			
^{x}126.6 *10*	1.0 *2*							
^{x}183.6 *7*	1.5 *2*							
^{x}195.5 *7*	2.0 *2*							
^{x}216.3 *7*	5.8 *6*					M1+E2		α(K)exp=0.71 *12*
237.9[d] *7*	2.1 *2*	1743.1+x	(9/2⁻,11/2⁻)	1505.8+x	(7/2⁻,9/2⁻)	M1+E2	0.5 *3*	α(K)exp=0.48 *24* α(K)=0.4 *3*; α(L)=0.107 *11*; α(M)=0.0262 *15*; α(N+..)=0.0085 *5*
^{x}240.3 *7*	1.7 *2*							
^{x}245.4 *7*	2.0 *2*							
253.3 *7*	1.8 *2*	1305.6+x	(7/2⁻,9/2⁻)	1052.8+x	(7/2⁻,9/2⁻)	M1+E2	0.707	α(K)exp=0.7 *4* α(K)=0.577; α(L)=0.0992; α(M)=0.0233; α(N+..)=0.0075
^{x}279.2 *7*	2.0 *2*					M1		α(K)exp=0.72 *40*
284.3 *7*	4.5 *5*	1337.1+x	(7/2⁻,9/2⁻,11/2⁻)	1052.8+x	(7/2⁻,9/2⁻)	M1+E2	0.515	α(K)exp=0.36 *18* α(K)=0.420; α(L)=0.0720; α(M)=0.0169; α(N+..)=0.00547
^{x}288.4 *7*	3.5 *4*							
294.0 *7*	7.8 *8*	1799.6+x	(9/2⁻)	1505.8+x	(7/2⁻,9/2⁻)	M1[a]	0.470	α(K)exp=0.55 *30* α(K)=0.383; α(L)=0.0657; α(M)=0.0154; α(N+..)=0.00498
^{x}300.1 *7*	4.0 *4*							
^{x}302.6 *7*	1.2 *2*							
^{x}316.2 *7*	1.5 *2*					M1+E2		α(K)exp=0.13 *6*
^{x}320.3 *10*	0.5 *1*							
^{x}338.4 *7*	1.9 *2*							
^{x}341.6 *7*	1.9 *2*							
^{x}350.9 *7*	1.8 *2*							
^{x}370.7 *7*	4.9 *5*							
^{x}382.7 *7*	1.3 *2*							
391.3 *7*	7.2 *7*	1337.1+x	(7/2⁻,9/2⁻,11/2⁻)	945.9+x	(7/2⁻,9/2⁻)			
^{x}416.1 *7*	1.9 *2*							
^{x}420.2 *7*	4.5 *5*							
425.3 *5*	≈200[b]	425.1+x	(13/2⁺)	0+x	(5/2⁻)	M4	4.0	α(K)=2.42; α(L)=1.24; α(M)=0.334; α(N+..)=0.112
^{x}444.4 *7*	3.0 *3*							
^{x}451.8 *7*	2.8 *3*							
462.6[d] *7*	5.4 *5*	1799.6+x	(9/2⁻)	1337.1+x	(7/2⁻,9/2⁻,11/2⁻)	E2+M1	0.0359	α(K)exp=0.039 *2*

γ(^{199}Pb) (continued)

E$_\gamma$	I$_\gamma$[†]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[‡]	α[c]	Comments
								α(K)=0.0247; α(L)=0.00841; α(M)=0.00210; α(N+..)=0.00068
^{x}473.0 *7*	1.1 *2*							
480.4 *7*	3.7 *4*	1743.1+x	(9/2$^-$,11/2$^-$)	1262.6+x	(11/2$^+$)			
483.3[d] *7*	5.0 *5*	1505.8+x	(7/2$^-$,9/2$^-$)	1022.7+x	(7/2$^-$,9/2$^-$)			
^{x}507.3 *7*	6.0 *6*							
^{x}521.6 *7*	2.1 *2*					M1+E2		α(K)exp=0.08 *4*
533.1 *5*	10.3 *5*	1799.6+x	(9/2$^-$)	1266.7+x	(11/2$^+$)	[a]		α(K)exp=0.055 *32* Mult.: M1+E2 from α(K)exp=0.055 *32* inconsistent with negative parity of 1799.9+x level As suggested by mult of 294.0γ and 462.6γ.
^{x}539.3 *7*	6.1 *6*							
^{x}546.9 *7*	4.2 *4*							
560.1[d] *7*	2.4 *2*	1505.8+x	(7/2$^-$,9/2$^-$)	945.9+x	(7/2$^-$,9/2$^-$)	M1+E2[a]	0.084	α(K)exp=0.061 *3* α(K)=0.0685; α(L)=0.0115
563.2[d] *7*	1.6 *2*	2068.9+x	(11/2$^-$)	1505.8+x	(7/2$^-$,9/2$^-$)	M1,E2	0.0826	α(K)exp=0.009 *4* α(K)=0.0676; α(L)=0.00113
^{x}584.1 *7*	1.4 *2*							
^{x}590.8 *7*	2.3 *2*							
^{x}596.6 *7*	1.5 *2*							
^{x}606.0 *7*	1.9 *2*							
^{x}610.1 *7*	2.5 *3*							
^{x}627.6 *7*	4.6 *5*					M1+E2		α(K)exp=0.06 *3*
^{x}646.5 *7*	3.0 *3*							
^{x}658.5 *7*	8.0 *8*					M1+E2		α(K)exp=0.09 *3*
^{x}663.1 *7*	3.2 *3*					M1+E2		α(K)exp=0.067 *4*
^{x}674.6 *7*	3.2 *3*					M1+E2		α(K)exp=0.065 *3*
^{x}678.6 *7*	2.1 *2*					M1+E2		α(K)exp=0.078 *3*
^{x}703.0 *7*	2.3 *2*							
^{x}709.1 *7*	2.5 *3*							
^{x}713.9 *10*								
720.3 *5*	12.2 *6*	1743.1+x	(9/2$^-$,11/2$^-$)	1022.7+x	(7/2$^-$,9/2$^-$)			
^{x}779.4 *5*	11.9 *6*					(M1+E2)		α(K)exp=0.050 *26*
^{x}786.0 *7*	2.1 *2*					M1+E2		α(K)exp=0.037 *2*
797.0 *7*	3.0 *3*	1743.1+x	(9/2$^-$,11/2$^-$)	945.9+x	(7/2$^-$,9/2$^-$)			
802.1 *7*	5.9 *6*	2068.9+x	(11/2$^-$)	1266.7+x	(11/2$^+$)			
806.4 *7*	8.7 *9*	2068.9+x	(11/2$^-$)	1262.6+x	(11/2$^+$)			
820.5[d] *7*	2.8 *3*	2083.1+x	(11/2$^-$)	1262.6+x	(11/2$^+$)			
837.4 *5*	86 *5*	1262.6+x	(11/2$^+$)	425.1+x	(13/2$^+$)	E2+M1	0.0096	α(K)exp=0.0098 *20* α(K)=0.00747; α(L)=0.00159
841.7 *5*	100	1266.7+x	(11/2$^+$)	425.1+x	(13/2$^+$)	E2+M1	0.0095	α(K)exp=0.010 *4* α(K)=0.00739; α(L)=0.00157
^{x}859.5 *7*	2.4 *3*							
^{x}914.1 *5*	13.7 *7*							

γ(^{199}Pb) (continued)

E_γ	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	α[c]	Comments
926.4[#d] 5	48 3	945.9+x	(7/2⁻,9/2⁻)	19.1+x?	(⁻)	M1+E2	0.015 7	α(K)exp=0.011 6 α(K)=0.012 6; α(L)=0.0022 18
946.0 5	98 5	945.9+x	(7/2⁻,9/2⁻)	0+x	(5/2⁻)	E2	0.0075	α(K)exp=0.0088 23 α(K)=0.00593; α(L)=0.00119
[x]955.6 10								
[x]961.2 7	2.1 2					(M1)		α(K)exp=0.051 29
[x]966.1 5	17.7 8					M1,E2		α(K)exp=0.014 9
[x]977.5 5	14.6 7					M1,E2		α(K)exp=0.015 1
[x]985.0 5	11.0 6					M1,E2		α(K)exp=0.023 16
[x]991.6 7	4.6 5							
[x]998.5 7	3.7 4							
[x]1004.3 7	2.4 2							
[x]1013.5 7	6.3 6					M1,E2		α(K)exp=0.010 6
1022.8 5	40 2	1022.7+x	(7/2⁻,9/2⁻)	0+x	(5/2⁻)	M1,E2	0.012 6	α(K)exp=0.011 5
1034.0[@d] 5	53 3	1052.8+x	(7/2⁻,9/2⁻)	19.1+x?	(⁻)	E2,M1		α(K)exp=0.0045 22
1052.8 5	67 4	1052.8+x	(7/2⁻,9/2⁻)	0+x	(5/2⁻)	E2,M1		α(K)exp=0.0046 17
[x]1069.1 7	3.8 4							
[x]1076.2 7	2.9 3							
1085.8[&d] 7	2.1 3	2108.4+x	(11/2⁻)	1022.7+x	(7/2⁻,9/2⁻)			
[x]1089.0 10	0.8 2							
[x]1097.8 7	2.3 2							
[x]1102.9 7	3.4 3							
[x]1110.2 7	2.6 3							
[x]1121.1 7	4.2 4							
1137.0 5	50 3	2083.1+x	(11/2⁻)	945.9+x	(7/2⁻,9/2⁻)	M1,E2	0.009 4	α(K)exp=0.0047 23
[x]1146.4 5	40.9 20					M1+E2		α(K)exp=0.009 4
[x]1153.2 7	7.8 8					M1,E2		α(K)exp=0.011 9
[x]1156.9 10								
1162.4 7	7.1 7	2108.4+x	(11/2⁻)	945.9+x	(7/2⁻,9/2⁻)			
[x]1172.5 7	2.4 2							
[x]1179.4 7	5.1 5							
[x]1188.2 7	5.2 5							
[x]1206.6 7	9.1 9					M1,E2		α(K)exp=0.014 7
[x]1212.2 5	39.6 20					E2(+M1)		α(K)exp=0.0057 3
[x]1221.8 10	1.0 2							
1240.3 7	7.4 7	2186.2+x	(7/2⁻,9/2⁻,11/2⁻)	945.9+x	(7/2⁻,9/2⁻)			
[x]1243.8 7	3.5 4							
[x]1255.6 7	6.1 6							
[x]1268.2 5	10.1 5							
[x]1274.1 7	1.7 2							
[x]1300.1 10								
1305.6 5	64 3	1305.6+x	(7/2⁻,9/2⁻)	0+x	(5/2⁻)	M1+E2	0.007 3	α(K)exp=0.0045 20
[x]1312.9 7	4.1 4							

$^{199}_{82}$Pb$_{117}$-4

γ(^{199}Pb) (continued)

E_γ	I_γ†	E_i(level)	J^π_i	E_f	J^π_f
^{x}1325.5 7	3.1 3				
^{x}1343.6 7	1.9 2				
^{x}1347.4 7	6.9 7				
1374.3[d] 7	6.2 6	1799.6+x	(9/2$^-$)	425.1+x	(13/2$^+$)
^{x}1398.3 7	2.7 3				
^{x}1402.4 7	1.3 2				
^{x}1410.9 7	4.7 5				
^{x}1424.1 7	7.8 8				
^{x}1432.1 7	2.3 2				
^{x}1435.3 7	6.2 6				
^{x}1448.6 5	16.2 8				
^{x}1461.5 7	8.5 9				
^{x}1480.3 7	1.5 2				
1505.9 5	50 3	1505.8+x	(7/2$^-$,9/2$^-$)	0+x	(5/2$^-$)
^{x}1517.3 5	13.2 7				
^{x}1529.9 7	4.3 4				
^{x}1540.5 7	8.4 8				
^{x}1550.7 7	2.9 3				
^{x}1575.2 7	5.9 6				
^{x}1588.7 7	2.0 2				
^{x}1622.3 7	7.1 7				
1643.8 7	5.6 6	2068.9+x	(11/2$^-$)	425.1+x	(13/2$^+$)
^{x}1647.0 7	4.0 4				
1658.3[d] 7	2.8 3	2083.1+x	(11/2$^-$)	425.1+x	(13/2$^+$)
^{x}1668.4 7	7.0 7				
^{x}1679.1 7	4.6 5				
1683.2[d] 7	2.3 2	2108.4+x	(11/2$^-$)	425.1+x	(13/2$^+$)
^{x}1696.5 7	3.9 4				
^{x}1707.9 7	4.5 5				
^{x}1716.0 7	4.9 5				
^{x}1725.3 7	3.8 4				
^{x}1757.6 7	4.4 4				
^{x}1775.5 7	2.3 2				
1780.8[d] 7	8.6 9	1799.6+x	(9/2$^-$)	19.1+x?	($^-$)
^{x}1785.3 7	3.6 4				
1799.0[d] 7	4.3 4	1799.6+x	(9/2$^-$)	0+x	(5/2$^-$)
^{x}1803.5 7	2.1 2				
^{x}1807.5 7	7.0 7				
^{x}1839.0 7	2.5 3				
^{x}1841.8 7	2.5 3				

E_γ	I_γ†	E_i(level)
^{x}1853.5 7	3.4 3	
^{x}1866.1 7	4.1 4	
^{x}1872.0 7	5.2 5	
^{x}1874.8 7	1.6 2	
^{x}1921.6 7	8.1 8	
^{x}1928.8 7	1.6 2	
^{x}1951.4 7	1.7 2	
^{x}1989.2 7	5.1 5	
^{x}2021.5 7	9.7 10	
^{x}2048.4 7	1.0 2	
^{x}2058.7 5	12.0 6	
^{x}2065.0 7	1.5 2	
^{x}2070.7 7	1.1 2	
^{x}2124.5 7	1.3 2	
^{x}2155.5 7	1.5 3	
^{x}2182.0 7	1.3 2	
^{x}2202.2 7	1.7 2	
^{x}2222.9 7	1.2 2	
^{x}2354.4 7	2.6 3	
^{x}2391.7 7	1.6 2	
^{x}2416.0 10	0.8 2	
^{x}2454.9 10	0.6 2	
^{x}2459.0 7	2.6 3	
^{x}2616.0 7	1.7 2	
^{x}2643.9 7	1.9 2	
^{x}2666.9 7	5.8 6	
^{x}2799.3 7	1.8 2	
^{x}2869.0 10	0.9 2	
^{x}2877.3 7	1.7 2	
^{x}2887.4 7	1.7 2	
^{x}3102.1 7	1.8 2	
^{x}3190.2 10	0.4 1	
^{x}3194.4 10	0.6 2	
^{x}3205.1 10	0.6 2	
^{x}3214.5 10	0.20 4	
^{x}3235.2 10	0.20 4	
^{x}3239.0 10	0.20 4	
^{x}3244.2 10	0.7 2	
^{x}3246.0 10	0.20 4	
^{x}3598.5 10	0.20 4	

γ(^{199}Pb) (continued)

† The ^{199}Bi source was produced by 1978Ri04 in (p,xn) reactions on natural lead followed by mass and radio-chemical separation. 1978Ri04 assumed that all the γ's are from the 9/2$^-$ ^{199}Bi g.s. ε decay; however, it is expected that some of the γ rays are from ε decay of the 25-min 1/2$^+$ isomer of ^{199}Bi. Some of the γ's deexciting levels of ^{199}Pb fed directly from the ε decay of the 1/2$^+$ isomer may populate the 3/2$^-$ g.s. of ^{199}Pb rather than the 5/2$^-$ first excited state.

‡ Based on α(K)exp of 1978Ri04 (425.3 M4 transition was used for normalization). The experimental precision did not allow a meaningful extraction of δ.

1978Ri04 list two γ's in coin with 926.4γ and five γ's in coin with 945.96γ; only the 391.28γ is in coin with both of the above γ's. This result may be inconsistent with the decay scheme.

@ 1978Ri04 list seven γ's possibly in coin with the 1034.0γ; none of these γ's is the same as the three γ's in coin with the 1052.8γ, and the coin with the 720.3γ is inconsistent with the decay scheme proposed by 1978Ri04.

& Listed as 1086.79 in figure 7 of 1978Ri04.

[a] The multipolarities of the 294.0γ, 533.1γ and 560.1γ lead to contradictory π assignments for the 1804 level according to the proposed level scheme.

[b] The uncertainty could be greater than 20% because of the long half-life of the isomeric state (1978Ri04).

[c] 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.

[d] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

^{199}Bi ε decay (27 min+24.70 min) 1978Ri04