

$^{213}\text{Bi}$   $\beta^-$  decay (45.59 min) 1998Ar03,1997Wa27,1994Ar23

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia	NDS 181, 475 (2022)	1-Jan-2022

Parent:  $^{213}\text{Bi}$ :  $E=0.0$ ;  $J^\pi=9/2^-$ ;  $T_{1/2}=45.59$  min 6;  $Q(\beta^-)=1422$  6;  $\% \beta^-$  decay=97.860 10

Others: 2020Go11, 2010Fi10, 2003ChZV, 2002Mo46, 2000Gr35, 1998MaZO, 1989Ko26, 1986He06, 1981Di14, 1977Vy02, 1972Dz14, 1969ArZV, 1969Dz06, 1969DzZZ, 1968Va17, 1967LoZZ, 1955Ma61, 1952Wa24.

1998Ar03,1994Ar23: Source: Chemically separated  $^{213}\text{Bi}$ ; Detector: p-type coaxial HPGe and planar HPGe; Measured:  $E_\gamma$ ,  $I_\gamma$ ,  $\gamma\gamma$  coin.

1997Wa27: Source:  $^{213}\text{Bi}$  was accumulated on an Al foil from the recoil of  $^{217}\text{At}$  decay; Measured:  $T_{1/2}$  by the method of delayed coincidences in  $^{213}\text{Bi}$   $\beta^-$  decay.

1989Ko26: Source: Chemically separated  $^{213}\text{Bi}$ ; Detector: HPGe and LEPS (Low Energy Photon Spectrometer);  $E_\gamma$ ,  $I_\gamma$ ,  $\gamma\gamma$  coin.

 $^{213}\text{Po}$  Levels

E(level) <sup>†</sup>	$J^\pi$ <sup>‡</sup>	$T_{1/2}$	Comments
0.0	9/2 <sup>+</sup>	3.706 $\mu\text{s}$ 1	$J^\pi, T_{1/2}$ : From Adopted Levels.
292.805 8	(11/2 <sup>+</sup> )	78 ps 14	$J^\pi$ : 292.78 $\gamma$ (M1+E2) to 9/2 <sup>+</sup> state.
440.446 9	(7/2 <sup>+</sup> )	93 ps 3	$T_{1/2}$ : From delayed $\gamma\gamma$ -coin in $^{213}\text{Bi}$ $\beta^-$ decay (1997Wa27). $\% \alpha < 0.001$ (1997Wa27).
600.87? 17	(5/2 <sup>+</sup> )		$T_{1/2}$ : From $\beta$ - $\gamma$ coincidences in $^{213}\text{Bi}$ $\beta^-$ decay (1997Wa27).
867.98 3	(13/2 <sup>+</sup> )		
1003.605 22	(9/2 <sup>+</sup> )		
1045.65 9	(9/2 <sup>+</sup> , 11/2 <sup>+</sup> )		
1100.173 8	(7/2, 9/2, 11/2)		
1119.38 4	(7/2, 9/2, 11/2)		
1328.2 3	(7/2, 9/2, 11/2)		

<sup>†</sup> Deduced by evaluator from a least square fit to the  $\gamma$ -ray energies.

<sup>‡</sup> From 1998Ar03, except otherwise noted. In 1998Ar03, semiempirical shell-model calculation results were compared as a guide for parity and spin assignments.

 $\beta^-$  radiations

E(decay) <sup>†</sup>	E(level)	$I\beta^-$ <sup>‡</sup>	Log $ft$	Comments
(94 6)	1328.2	0.00039 14	7.67 18	av $E\beta=24.3$ 17
(303 6)	1119.38	0.059 2	7.08 4	av $E\beta=84.6$ 19
(322 6)	1100.173	0.578 11	6.17 3	av $E\beta=90.5$ 19
(376 6)	1045.65	0.020 3	7.85 7	av $E\beta=107.6$ 19
(418 6)	1003.605	0.065 3	7.49 3	av $E\beta=121.1$ 20
(554 6)	867.98	0.0144 13	8.64 <sup>1u</sup> 5	av $E\beta=172.9$ 20
(821 6)	600.87?	0.0042 8	10.03 <sup>1u</sup> 9	av $E\beta=261.7$ 21
(982 6)	440.446	30.1 4	6.08 1	av $E\beta=320.0$ 23 $I\beta^-$ : 35% 3 of $^{213}\text{Bi}$ $\beta^-$ decay was measured by 1968Va17, and 32% by 1952Wa24, 1955Ma61.
(1129 6)	292.805	0.21 5	8.45 10	av $E\beta=376.5$ 24
(1422 6)	0.0	66.8 5	6.31 1	av $E\beta=491.8$ 24 $E(\text{decay})$ : 1420 10 measured value in 1968Va17. Others measurements by 1952Wa24, 1955Ma61. $I\beta^-$ : 65% 3 of $^{213}\text{Bi}$ $\beta^-$ decay was measured by 1968Va17 and 68% (1955Ma61).

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$^{213}\text{Bi}$   $\beta^-$  decay (45.59 min)    **1998Ar03,1997Wa27,1994Ar23** (continued)

$\beta^-$  radiations (continued)

† From excited level energy and  $Q(\beta^-)$ . Measured value to g.s is listed in comments.

‡ From intensity balance at each level.

# Absolute intensity per 100 decays.

γ(<sup>213</sup>Po)

x-rays (Po): 1972Dz14  
 I(Kα<sub>1</sub> x ray)=1.6%  
 I(Kα<sub>2</sub> x ray)=0.93%  
 I(Kβ<sub>1</sub> x ray)=0.35%  
 I(Kβ<sub>2</sub> x ray)=0.12%

these x-ray intensities were measured by 1972Dz14 in γ spectrum of <sup>225</sup>Ac and its daughters in equilibrium with it; intensities were normalized to <sup>225</sup>Ac γ's, given per 100 decays of <sup>225</sup>Ac. The uncertainties were assigned as 10-15%. The expected total x-ray intensity from level scheme is 4.00% 5.

<u>E<sub>γ</sub><sup>†</sup></u>	<u>I<sub>γ</sub><sup>#b</sup></u>	<u>E<sub>i</sub>(level)</u>	<u>J<sub>i</sub><sup>π</sup></u>	<u>E<sub>f</sub></u>	<u>J<sub>f</sub><sup>π</sup></u>	<u>Mult.&amp;</u>	<u>δ</u>	<u>α<sup>a</sup></u>	<u>Comments</u>
147.66 5	0.0149 12	440.446	(7/2 <sup>+</sup> )	292.805	(11/2 <sup>+</sup> )	(E2)		1.454 20	α(K)=0.307 4; α(L)=0.851 12; α(M)=0.2263 32 α(N)=0.0580 8; α(O)=0.01109 16; α(P)=0.001015 14 E <sub>γ</sub> : Others: 147.1 1 (2000Gr35), 147.63 8 (1989Ko26). I <sub>γ</sub> : Weighted average of 0.0147 12 (1998Ar03 – 0.0148 12) and 0.022 8 (2000Gr35). Others: 0.011 1 (1989Ko26). Mult.: B(E2)=0.0031 6 (1997Wa27) is close to the B(E2, 2 <sup>+</sup> to 0 <sup>+</sup> ) values of the neighboring nuclei.
292.80 1	0.419 8	292.805	(11/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>	M1+E2	1.0 +5-4	0.34 10	α(K)=0.26 9; α(L)=0.063 7; α(M)=0.0153 13 α(N)=0.00394 34; α(O)=0.00080 8; α(P)=9.4×10 <sup>-5</sup> 15 E <sub>γ</sub> : Weighted average of 292.76 5 (1998Ar03), 292.81 1 (2000Gr35), 292.86 10 (1977Vy02), and 292.80 1 (1989Ko26). I <sub>γ</sub> : Weighted average of 0.413 23 (1998Ar03 – 0.416 23), 0.429 7 (1986He06), 0.41 1 (2000Gr35 – 0.40 1), 0.31 4 (2002Mo46), 0.403 23 (1981Di14 – 0.426 24), 0.41 2 (1989Ko26). Mult.,δ: From α(K)exp=0.24 7 (1998MaZO), mixing ratio was deduced using the bricMixing code.
402.8 3	0.00010@ 3	1003.605	(9/2 <sup>+</sup> )	600.87?	(5/2 <sup>+</sup> )	[E2]		0.0552 8	α(K)=0.0349 5; α(L)=0.01515 22; α(M)=0.00387 6 α(N)=0.000993 14; α(O)=0.0001961 28; α(P)=2.066×10 <sup>-5</sup> 29 E <sub>γ</sub> : Weak gamma – not observed by 2000Gr35 and suggested for confirmation.
440.45 1	25.9 2	440.446	(7/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>	M1+E2	0.39 +15-19	0.161 13	α(K)=0.130 11; α(L)=0.0234 14; α(M)=0.00553 30 α(N)=0.00142 8; α(O)=0.000297 17; α(P)=3.80×10 <sup>-5</sup> 25 E <sub>γ</sub> : Weighted average of 440.43 5 (1998Ar03) and 440.44 1 (2000Gr35), 440.420 20 (1977Vy02), 440.46 1 (1989Ko26). Other: 440.4 (2003ChZV). I <sub>γ</sub> : Weighted average of 26.2 3 (2010Fi10), 26.1 3 (1986He06), 25.4 3 (2000Gr35), and 25.8 3 (2020Go11). Others: 21 1 (1989Ko26 quoted from 1969DZ06), 27.4

γ(<sup>213</sup>Po) (continued)

<u>E<sub>γ</sub><sup>†</sup></u>	<u>I<sub>γ</sub><sup>#b</sup></u>	<u>E<sub>i</sub>(level)</u>	<u>J<sub>i</sub><sup>π</sup></u>	<u>E<sub>f</sub></u>	<u>J<sub>f</sub><sup>π</sup></u>	<u>Mult.&amp;</u>	<u>α<sup>a</sup></u>	<u>Comments</u>
574.9 3	0.0025 10	867.98	(13/2 <sup>+</sup> )	292.805	(11/2 <sup>+</sup> )	[M1+E2]	0.056 32	(1981Di14), ~25.4 (2003ChZV). Mult.,δ: From α <sub>K</sub> =I <sub>e</sub> /I <sub>γ</sub> =[3.15 15 (1969DzZZ)/25.9 2]=0.12 1. Other conversion electron measurements in 1967LoZZ. α(K)=0.044 28; α(L)=0.009 4; α(M)=0.0021 8 α(N)=5.3×10 <sup>-4</sup> 22; α(O)=1.1×10 <sup>-4</sup> 5; α(P)=1.4×10 <sup>-5</sup> 7 E <sub>γ</sub> : Weighted average of 574.8 3 (1998Ar03), and 575.2 5 (2000Gr35).
600.9 2	0.0043 8	600.87?	(5/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>			I <sub>γ</sub> : From 2000Gr35. Other: 0.00063 17 (1998Ar03). E <sub>γ</sub> : Weighted average of 600.7 3 (1998Ar03) and 601.0 2 (2000Gr35).
604.94 21	0.0023 6	1045.65	(9/2 <sup>+</sup> ,11/2 <sup>+</sup> )	440.446	(7/2 <sup>+</sup> )			I <sub>γ</sub> : From 2000Gr35 (0.0042 8). Other: 0.00069 22 (1998Ar03 – 0.00070 22). E <sub>γ</sub> ,I <sub>γ</sub> : From 2000Gr35. Other: E <sub>γ</sub> =604.9 3 and I <sub>γ</sub> =0.00050 18 (1998Ar03).
<sup>x</sup> 646.03 9	0.00229 <sup>@</sup> 22							E <sub>γ</sub> ,I <sub>γ</sub> : I <sub>γ</sub> from 0.00231 22 (1998Ar03). Other: E <sub>γ</sub> 646.0 1 and I <sub>γ</sub> 0.0024 10 in 2000Gr35.
659.75 2	0.0374 21	1100.173	(7/2,9/2,11/2)	440.446	(7/2 <sup>+</sup> )			E <sub>γ</sub> : Weighted average of 659.77 2 (1994Ar23) and 659.74 2 (2000Gr35), 659.81 10 (1977Vy02). Others: 659.8 1 (1989Ko26), 659.5 (2003ChZV), 659.77 5 (1998Ar03) (not listed earlier). I <sub>γ</sub> : Weighted average of 0.0358 20 (1998Ar03 – 0.0361 20), 0.035 11 (2002Mo46), 0.044 3 (2000Gr35 – 0.044 3), and 0.05 2 (1969ArZV – 0.04 2), 0.043 4 (2003ChZV – 0.042 4), 0.031 3 (1989Ko26).
710.82 3	0.0114 5	1003.605	(9/2 <sup>+</sup> )	292.805	(11/2 <sup>+</sup> )	[M1+E2]	0.033 18	α(K)=0.026 15; α(L)=0.0049 22; α(M)=0.0012 5 α(N)=3.0×10 <sup>-4</sup> 13; α(O)=6.2×10 <sup>-5</sup> 27; α(P)=8.E-6 4 E <sub>γ</sub> : From 2000Gr35. Others: 710.81 21 (1998Ar03), 710.8 1 (1989Ko26), 710.8 (2003ChZV). I <sub>γ</sub> : Weighted average of 0.0101 11 (1998Ar03 – 0.0102 11), 0.0121 10 (2000Gr35 – 0.0119 10), and 0.015 8 (2002Mo46), 0.0118 8 (2003ChZV – 0.116 probably is a misprint of 0.0116 8), 0.011 1 (1989Ko26).
807.36 <sup>‡</sup> 1	0.289 7	1100.173	(7/2,9/2,11/2)	292.805	(11/2 <sup>+</sup> )			E <sub>γ</sub> : Others: 807.37 1 (2000Gr35), 807.38 5 (1998Ar03), 807.355 37 (1977Vy02), 807.4 (2003ChZV). I <sub>γ</sub> : Weighted average of 0.290 12 (1986He06 – 0.292 12), 0.289 18 (2000Gr35 – 0.283 18), 0.239 15 (1998Ar03 – 0.241 15), 0.27 2 (2002Mo46), 0.30 4 (1969ArZV – 0.24 3), 0.303 10 (2003ChZV – 0.297 10), 0.271 16 (1989Ko26), 0.299 7 (1981Di14 – 0.316 7).
826.55 5	0.0067 5	1119.38	(7/2,9/2,11/2)	292.805	(11/2 <sup>+</sup> )			E <sub>γ</sub> : Weighted average of 826.59 5 (2000Gr35), 826.8 2 (1989Ko26), 826.47 6 (1998Ar03). Other: 826.5 (2003ChZV). I <sub>γ</sub> : Weighted average of 0.0077 13 (2000Gr35 – 0.0077 13), 0.0075 5 (2003ChZV – 0.0074 5), 0.0057 5 (1998Ar03), and 0.0070 7 (1989Ko26).

γ(<sup>213</sup>Po) (continued)

<u>E<sub>γ</sub><sup>†</sup></u>	<u>I<sub>γ</sub><sup>#b</sup></u>	<u>E<sub>i</sub>(level)</u>	<u>J<sub>i</sub><sup>π</sup></u>	<u>E<sub>f</sub></u>	<u>J<sub>f</sub><sup>π</sup></u>	<u>Comments</u>
867.98 3	0.0118 6	867.98	(13/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Weighted average of 867.98 3 ( <a href="#">1998Ar03</a> ) and 867.93 3 ( <a href="#">2000Gr35</a> ). Other: 867.9 ( <a href="#">2003ChZV</a> ). I <sub>γ</sub> : Weighted average of 0.0110 11 ( <a href="#">1998Ar03</a> – 0.0111 11) and 0.0125 11 ( <a href="#">2000Gr35</a> – 0.0123 11), 0.0117 8 ( <a href="#">2003ChZV</a> – 0.0115 8), and 0.023 13 ( <a href="#">2002Mo46</a> ).
<sup>x</sup> 880.91 1	0.0041 5					E <sub>γ</sub> : From <a href="#">2000Gr35</a> . Other: 880.2 3 ( <a href="#">1998Ar03</a> ). I <sub>γ</sub> : Weighted average of 0.0029 10 ( <a href="#">1998Ar03</a> ) and 0.0043 4 ( <a href="#">2000Gr35</a> – 0.0042 4).
<sup>x</sup> 884.6 3	0.00029 <sup>@</sup> 10					E <sub>γ</sub> : Weak gamma – not observed by <a href="#">2000Gr35</a> and suggested for confirmation.
886.66 <sup>c</sup> 14	0.00101 19	1328.2	(7/2,9/2,11/2)	440.446	(7/2 <sup>+</sup> )	I <sub>γ</sub> : From 0.00102 19 ( <a href="#">1998Ar03</a> ).
<sup>x</sup> 897.0 3	0.00031 <sup>@</sup> 9					E <sub>γ</sub> : Weak gamma – not observed by <a href="#">2000Gr35</a> and suggested for confirmation.
1003.58 3	0.053 3	1003.605	(9/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Weighted average of 1003.58 3 ( <a href="#">1998Ar03</a> ), 1003.59 3 ( <a href="#">2000Gr35</a> ), 1003.57 3 ( <a href="#">1989Ko26</a> ). Other: 1003.6 ( <a href="#">2003ChZV</a> ). I <sub>γ</sub> : Weighted average of 0.050 5 ( <a href="#">1998Ar03</a> ), 0.054 3 ( <a href="#">2000Gr35</a> – 0.053 3), and 0.04 1 ( <a href="#">2002Mo46</a> ). Others: 0.0565 13 ( <a href="#">2003ChZV</a> – 0.0554 13), 0.043 4 ( <a href="#">1989Ko26</a> ).
1045.70 9	0.018 <sup>@</sup> 3	1045.65	(9/2 <sup>+</sup> ,11/2 <sup>+</sup> )	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Others: 1045.10 40 ( <a href="#">2000Gr35</a> ), 1045.7 ( <a href="#">2003ChZV</a> ). I <sub>γ</sub> : Others: 0.015 3 ( <a href="#">2003ChZV</a> – 0.15 probably is a misprint), 0.035 19 ( <a href="#">2000Gr35</a> – 0.034 19).
1100.17 1	0.252 8	1100.173	(7/2,9/2,11/2)	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Weighted average of 1100.18 2 ( <a href="#">2000Gr35</a> ), 1100.12 5 ( <a href="#">1998Ar03</a> ), 1100.16 2 ( <a href="#">1989Ko26</a> ), 1100.14 6 ( <a href="#">1977Vy02</a> ). Other: 1100.2 ( <a href="#">2003ChZV</a> ). I <sub>γ</sub> : Weighted average of 0.257 16 ( <a href="#">1998Ar03</a> – 0.259 16), 0.256 15 ( <a href="#">2000Gr35</a> – 0.251 17), 0.259 7 ( <a href="#">1981Di14</a> – 0.274 7), 0.284 17 ( <a href="#">1989Ko26</a> ), 0.219 12 ( <a href="#">2003ChZV</a> – 0.215 12), and 0.23 2 ( <a href="#">2002Mo46</a> ).
1119.40 6	0.052 2	1119.38	(7/2,9/2,11/2)	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Unweighted average of 1119.50 4 ( <a href="#">2000Gr35</a> ), 1119.29 5 ( <a href="#">1998Ar03</a> ), 1119.4 1 ( <a href="#">1989Ko26</a> ). Other: 1119.3 ( <a href="#">2003ChZV</a> ). I <sub>γ</sub> : Weighted average of 0.050 3 ( <a href="#">1998Ar03</a> ), 0.052 3 ( <a href="#">2000Gr35</a> – 0.051 3), 0.053 4 ( <a href="#">2003ChZV</a> – 0.052 4), 0.04 1 ( <a href="#">2002Mo46</a> ), and 0.062 6 ( <a href="#">1989Ko26</a> ).
1328.2 3	0.00039 <sup>@</sup> 14	1328.2	(7/2,9/2,11/2)	0.0	9/2 <sup>+</sup>	E <sub>γ</sub> : Weak gamma – not observed by <a href="#">2000Gr35</a> and suggested for confirmation.

<sup>†</sup> From [1998Ar03](#), except otherwise noted.

<sup>‡</sup> From [1989Ko26](#).

<sup>#</sup> γ-ray intensities were reported with respect to %I<sub>γ</sub>(440)=26.1 3 in [1986He06](#), [1998Ar03](#), [2002Mo46](#); %I<sub>γ</sub>(440)=25.4 3 in [2000Gr35](#), [2003ChZV](#); %I<sub>γ</sub>(440)=21 1 in [1989Ko26](#), [1969ArZV](#); %I<sub>γ</sub>(440)=27.4 in [1981Di14](#). All values are normalized with respect to %I<sub>γ</sub>(440)=25.9 (of this dataset) and listed in the comments, if different.

<sup>@</sup> From [1998Ar03](#).

<sup>&</sup> From ce measurements of [1955Ma61](#) and [1969DzZZ](#), except otherwise noted.

<sup>a</sup> [Additional information 1](#).

<sup>b</sup> Absolute intensity per 100 decays.

<sup>c</sup> Placement of transition in the level scheme is uncertain.

<sup>x</sup> γ ray not placed in level scheme.

$^{213}\text{Bi}$   $\beta^-$  decay (45.59 min) 1998Ar03,1997Wa27,1994Ar23