^{210}Bi - Comments on evaluation of decay data by V. Chisté and M. M. Bé

This evaluation was completed in 2008. Literature available by January 2008 was included.

1 Decay Scheme

^{210}Bi disintegrates by beta minus emission to the ground state level of ^{210}Po. Weak alpha transitions to excited levels of ^{206}Tl have been observed (1.40 (15) 10^{-4} %). Spins and parities are from the ENSDF mass-chain evaluations E. Browne (2003Br13 for A = 210). For ^{206}Tl, spins and parities are from L. I. Rusinov measurements (1961Ru02).

2 Nuclear Data

The Q value is from the atomic mass evaluation of Audi *et al.* (2003Au03).

Experimental ^{210}Bi half-life values (in days) are given in Table 1:

Table 1: Experimental values of ^{210}Bi half-life.

Reference	Experimental value (d)	Comments
A. Pompéi (1935Po01)	5.02 (1)	Ionization chamber.
N. Hole (1944Ho**)	5.15 (10)	GM counter.
F. Begemann (1952Be22)	5.02 (2)	GM counter.
E. E. Lockett (1953Lo09)	4.989 (13)	Ionization chamber.
J. Robert (1956Ro18)	5.013 (5)	Ionization chamber.Superseded by 1959Ro51
J. Robert (1959Ro51)	5.013 (5)	Ionization chamber.
Recommended value	**5.012 (5)**	χ^2 = 1.32

The weighted average has been calculated using the LWEIGHT computer program (version 3).

The evaluators have chosen to use just five experimental values with uncertainties given in Table 1. The value of Hole (1944Ho**) has been rejected by the LWEIGHT program because it is an outlier, based on the Chauvenet's criterion. With this data set, the largest contribution to the weighted average comes from the value of Robert (1959Ro51) amounting to 68 % of the total statistical weight.

The recommended value of ^{210}Bi half-life is the weighted average of **5.012 d** with an external uncertainty of **0.005 d**. The reduced-χ^2 value is 1.32.

2.1 a Transitions and Emissions

The recommended values of emission energies of the α-particles are given by A. Rytz (1991Ry01).

Table 2: Experimental values of emission energies of the α-particles.

Reference	$\alpha_{0,1}$ (keV)	$\alpha_{0,2}$ (keV)	Comments
R. J. Walen (1960Wa14)	4686 (2)	4649 (2)	Uncertainty given by Rytz.
P. Kauranen (1962Ka27)	4700	4660	Not used: no uncertainty.
R. C. Lange (1969La18)	4697 (5)	4660 (5)	Uncertainty given by Rytz.
Recommended value (1991Ry01)	**4687 (4)**	**4650 (4)**	χ^2 = 4.2. External uncertainty.

Several experimental values of the α branching to ^{206}Tl are given in Table 3.

Table 3: Experimental and recommended values of total α branching for $^{210}Bi \rightarrow {}^{206}Tl$.

Reference	Experimental value (10^{-4} %)	Comments
E. Broda (1947Br36)	0.5	Not used: no uncertainty.
R. J. Walen(1959Wa05)	1.25	Not used: no uncertainty.
R. W. Fink (1956Fi09)	1.7 (2)	
M. Nurmia (1961Nu01)	1.9 (4)	Superseded by 1962Ka27
P. Kauranen (1962Ka27)	1.32 (10)	
Recommended value	**1.40 (15)**	$\chi^2 = 2.9$

The weighted average has been calculated using the LWEIGHT computer program (version 3).

The value given by M. Nurmia (1961Nu01) is from the same laboratory as 1962Ka27, thus, it was not included in the averaging procedure. Then, the recommended alpha transition branching is the average of the values given by R. W. Fink (1956Fi09) and P. Kauranen (1962Ka27).

The recommended value of α transitions to the excited levels of ^{206}Tl is the weighted average of **1.40 10^{-4} %** with an external uncertainty of **0.15 10^{-4} %**. The reduced-χ^2 value is 2.9.

The individual α particle probabilities to the 265-keV and 304-keV levels are (1959Wa05, 1960Wa14) 0.56 (6) 10^{-4} % and 0.84 (9) 10^{-4} %, respectively.

2.2 b$^-$ Transitions and Emissions

The end-point energy of the β^- transition in the decay of $^{210}Bi \rightarrow {}^{210}Po$ is from the Q_{β^-}(2003Au03). The recommended and experimental values are shown in Table 4.

Table 4: Experimental and recommended values of the end-point energy of the β^- transition.

Reference	E_{β^-} (keV)
A. Flammersfeld (1939Fl02)	1170
G. J. Neary (1940Ne04)	1170
E. A. Plassmann (1954Pl30)	1155 (5)
H. Daniel (1962Da03)	1160.5 (5)
S. T. Hsue(1967Hs01)	1161.5 (15)
D. Flothmann (1969Fl02)	1153
Recommended value (2003Au03)	**1162.1 (8)**

For the $\beta_{0,0}$ transition probability and associated uncertainty, the following relation was applied:
$P_{\beta 0,0} = 100\ \% - P_\alpha$,
where P_α = 1.40 (15) 10^{-4} % (see 2.2 α Transitions and Emissions). Then: $P_{\beta 0,0}$ = 99.99986 (2) %.

The lg ft value and the average β^- energy have been calculated with the program LOGFT for a 1st forbidden transition.

2.3 g Transitions and Emissions

Multipolarity of γ-ray transitions are from L. I. Rusinov (1961Ru02):
265-keV γ-ray: E2
304-keV γ-ray: M1

The γ-ray transition probabilities following the α-decay of $^{210}Bi \rightarrow {}^{206}Tl$ were deduced from the decay-scheme balance using the recommended α-particle intensity values given in section 2.1 α Transitions and Emissions, shown in Table 5.

Table 5: Adopted values of α transition and γ-ray emission probabilities.

γ-ray energy (keV)*	α probability (%)	γ-ray absolute transition probability (%)	γ-ray absolute emission probability (%)
265.832 (5)	0.000 056 (6)	0.000 056 (6)	0.000 048 (5)
304.896 (6)	0.000 084 (9)	0.000 084 (9)	0.000 061 (7)

*From 1999Br39

The γ-ray emission intensities were obtained using the γ-ray transition probabilities (given in Table 6) and the relevant internal conversion coefficients, calculated using the BrIcc computer code (calculation for 'hole'), which interpolated from theoretical values of I. M. Band (2002Ba85) .

3 Atomic Data

Atomic values, ω_K, ϖ_L and n_{KL} are from Schönfeld and Janβen (1996Sc06).

4 References

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