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

This evaluation was completed in 2007. Literature available by August 2007 has been included.

1 Decay Scheme

^{210}Tl disintegrates by beta minus emission to excited levels of ^{210}Pb. A weak delayed neutron emission was reported (1961St20 and 1957Ko42). Level energies, spins and parities are from the mass-chain evaluation of E. Browne (2003Br13) and B. Harmatz (1981Ha54).

This decay scheme is mainly based on the measurements of P. Weinzierl (1964We06). Several inconsistencies appeared :

- β branching to levels : 3879-, 3458-, and 3069-keV were deduced from γ-ray transition intensity imbalance. β^- feedings to the 1096- and 1192-keV levels are uncertain. There is no experimental evidence for β^- transitions with energy > 3 MeV to these levels. β^- feedings the 1869-, 2208- and 2412-keV levels, suggested by γ-ray transition intensity imbalances (< 10 %, < 9 % and < 12 % , respectively), are uncertain.

- An 83-keV γ-ray is not placed in the present decay scheme as suggested by B. Harmatz (1981Ha54) (transition between 1275-keV level and 1192-keV level), because there is no experimental evidence that the 1275-keV level in ^{210}Pb was populated in the β^- decay of ^{210}Tl.

These discrepancies cannot be resolved without new experimental results. New measurements are strongly suggested.

Some agreement was found between the adopted Q(β^-) value of Audi and the effective Q(β^-) value of 5470 (1000) keV calculated from decay scheme data, which indicates a consistency and correctness of the decay scheme.

2 Nuclear Data

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

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

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

Reference	Experimental value (min)	Comments
M. Curie (1931Cu01)	1.32	Not used. No uncertainty.
A.V. Kogan (1957Ko42)	1.50 (25)	
P. Weinzierl (1964We06)	1.30 (3)	
Recommended value	**1.30 (3)**	χ^2 = 0.63

A weighted average has been calculated using Lweight computer program (version 3). The largest contribution to the weighted average comes from P. Weinzierl (1964We06), amounting to a statistical weight of 98 %.

The recommended value of ^{210}Tl half-life is the weighted average of 1.30 minutes with an internal uncertainty of 0.03 minutes. The reduced-χ^2 value is 0.63.

2.1 b^{-} Transitions and Emissions.

The end-point energies of the β^{-} transitions in the decay of ^{210}Tl → ^{210}Pb have been obtained from the Q(β^{-}) value (2003Au03) and the level energies given by E. Browne (2003Br13).

The adopted β^{-} transition probabilities were deduced from the P(γ + ce) balance at each level of the decay scheme. Table 2 shows the adopted β^{-} transition probabilities compared with the only three β^{-} transitions reported by P. Weinzierl (1964We06). No β^{-} transitions with $E_{\beta-}$ > 3MeV were observed by these authors.

Table 2: Experimental and recommended (calculated) values of β^{-} transition probabilities.

Level	Energy (keV)	P. Weinzierl (1964We06)	Adopted values
11	1380 (12)	25 %	2 %
10	1603 (12)		7 %
9	1860 (12)	56 %	24 %
8	2024 (12)		10 %
7	2413 (12)	19 %	10 %
3	4290 (12)		31 %
2	4386 (12)		13 %

The sum of the adopted β^{-} transition probabilities is equal to 97 %. The 3 % missing cannot be placed in the decay scheme without more information about the β^{-} decay of ^{210}Tl.

The values of lg ft and the average β^{-} energies have been calculated using the computer program LOGFT for β^{-} transitions.

2.2 g Transitions.

The transition probabilities were deduced from the absolute γ-ray emission intensities and the relevant internal conversion coefficients. (see **5.2** g **Emissions**).

Multipolarities of the γ-ray transitions were deduced from conversion electron measurements and K/L ratios of 1964We06:

83-keV γ-ray: [E2] 97-keV γ-ray: M1 + E2 296-keV γ-ray: E2
356-keV γ-ray: [M1] 356-keV γ-ray: [M1] 799-keV γ-ray: E2
1070-keV γ-ray: [E1]

The internal conversion coefficients (ICC's) for these γ-ray transitions were calculated using the BrIcc computer program (calculation for 'frozen orbital approximation'), which interpolates from theoretical values of I. M. Band *et al.* (2002Ba85).
Due to the large uncertainty on the 83- and 97-keV transition energy, only estimated ICC values are given.

3 Atomic Data.

Atomic values, ω_K, ϖ_L and n_{KL} and the X-ray relative probabilities are from Schönfeld and Janβen (1996Sc06).

4 Electron Emissions.

The conversion electrons emission probabilities have been deduced using the γ-ray emission intensities and ICC's.

5 Photon Emissions.

5.1 X-ray Emissions.

The X-ray absolute intensities have been calculated from γ-ray data and ICC using the EMISSION computer program. The KX-ray intensity is compared in Table 3 to the measured value of P. Weinzierl (1964We06).

Table 3: Experimental and recommended (calculated) values of X-ray absolute intensities.

	P. Weinzierl (1964We04)	Recommended value
K x-ray	20 (4) %	23 (11) %

5.2 g Emissions.

The energies of the γ-ray emissions given in Section 5 are from E. Browne (2003Br13).

The experimental relative γ-ray emission intensities measured by P. Weinzierl (1964We06) (single experimental data set found in the literature) given in Table 4 are relative to that of the 799-keV γ-ray. Only one set of measured data (1964We06) is available.

Table 4: The experimental data set of the relative γ-ray emission intensities.

Energy (keV)	Relative γ-ray Emission intensity (%) (1964We06)
83 [(a)]	2.0
97	4 (2)
296	80 (10)
356 [(a)]	4 (2)
382 [(a)]	3 (2)
480	2 (1)
670 [(a)]	2 (1)
799	100
860	7 (2)
910 [(a)]	3 (2)
1070	12 (5)
1110	7 (2)
1210	17 (4)
1316	21 (5)
1410	5 (2)
1490 [(a)]	2 (1)
1540 [(a)]	2 (1)
1590	2 (1)
1650 [(a)]	2 (1)
2010	7 (2)
2090 [(a)]	5 (2)
2270	3 (2)
2360	8 (3)
2430	9 (3)

(a) γ-ray not placed in level scheme as explained in Weinzierl (1964We06).

The normalization factor of **98.969 (30)** to convert the relative γ–ray emission intensities to absolute intensities was obtained using the formula of :

$$N = \left(\frac{100}{(1 + a_T) P_{rel}(799g)} \right)$$

The uncertainties were calculated through their propagation on the above formula.

The evaluated relative and absolute γ-ray emission intensities are given in Table 5.

Table 5: Evaluated relative and absolute γ-ray emission intensities.

Energy (keV)	Relative γ-ray Emission intensity (%)	Absolute γ-ray emission intensity (%)
83 [(a)]	2.0	1.98 (40)
97	4 (2)	4 (2)
296	80 (10)	79 (10)
356 [(a)]	4 (2)	4 (2)
382 [(a)]	3 (2)	3 (2)
480	2 (1)	2 (1)
670 [(a)]	2 (1)	2 (1)
799	100	98.969 (30)
860	7 (2)	6.9 (20)
910 [(a)]	3 (2)	3 (2)
1070	12 (5)	11.9 (49)
1110	7 (2)	6.9 (20)
1210	17 (4)	16.8 (40)
1316	21 (5)	20.8 (50)
1410	5 (2)	4.9 (20)
1490 [(a)]	2 (1)	2 (1)
1540 [(a)]	2 (1)	2 (1)
1590	2 (1)	2 (1)
1650 [(a)]	2 (1)	2 (1)
2010	7 (2)	6.9 (20)
2090 [(a)]	5 (2)	4.9 (20)
2270	3 (2)	3 (2)
2360	8 (3)	7.9 (30)
2430	9 (3)	8.9 (30)

(a) γ-ray not placed in level scheme as explained in Weinzierl (1964We06).

6 References

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