^{125}I - Comments on evaluation of decay data by V. Chisté, E. Schönfeld and M.M. Bé

This evaluation was completed in July 2010. Literature by July 2010 was included.

1 Decay Scheme

Given the adopted Q_{EC} value of 185.77 keV, there are three levels in the daughter nuclide ^{125}Te available for the EC decay of the ^{125}I ground state. The level at 144.8 keV (Jπ=11/2-) would require a 3rd forbidden transition (ΔI = 3 and parity change) and one may expect log *ft >15* from systematics (Raman, 1973Ra10), which corresponds to a transition probability of < $1 \cdot 10^{-8}$ per disintegration.

A direct decay to the ground state of ^{125}Te (ΔI = 2, no parity change, non-unique 2nd forbidden) was not observed. Smith and Lewis (1966Sm05) have found that the transition probability of such a transition would be smaller than 0.01. From systematics (Raman, 1973Ra10), one may expect log *ft* > 11.0 which corresponds to a transition probability of $1 \cdot 10^{-6}$ per disintegration.

The adopted decay scheme of ^{125}I presented in this evaluation is complete. Good agreement is found between the effective Q value (185.66 (42) keV) calculated from the decay scheme data and that recommended from the atomic mass evaluation of Audi (2003Au03).

2 Nuclear Data

The Q_{EC} value of 185.77 (6) keV is taken from Audi (2003Au03), while the spins, parities and the lifetime of the excited 35-keV level (1.48 (1) ns) are from the ENSDF evaluation of J. Katakura (1999Ka26).

Experimental ^{125}I half-life values (in days) are given in Table 1:

Table 1: Experimental values of ^{125}I half-life.

Reference	Experimental value (days)	Comments
A. F. Reid (1946Re**)	56	Not used: no uncertainty.
G. Friedlander (1951Fr21)	60.0 (5)	
M. Ia. Kuznetsova (1958Ku**)	60	Not used: no uncertainty.
C. M. E. Matthews (1960Ma36)	57.4 (2)	
G. I. Gleason (1963Ge**)	58.8 (2)	Private communication. Cited by 1965An07
H. Leutz (1964Le05)	60.25 (6)	
S. C. Anspach (1965An07)	59.83 (11)	Superseded by 2002Un02.
C. R. Richmond (1966Ri14)	58.76 (13)	
F. Lagoutine (1968La10)	59.89 (18)	Superseded by 1995Ra32 (2).
J. F. Emery (1972Em01)	60.18 (17)	
W. Künding (1979Kü**)	59.666 (16)	
H. Houtermans (1980Ho17)	59.156 (20)	
D. D. Hoppes (1982HoZJ)	59.47 (21)	Superseded by 2002Un02.
H. Kubo (1983Ku**)	59.56 (17)	
H. Schrader (1987Sc20)	59.39 (2)	
B. R. S. Simpson (1989Si19)	59.40 (5)	
P. de Felice (1990De09)	59.38 (3)	
M. J. Woods (1990Wo03)	59.416 (10)	
T. Altzitzoglou (1991Al05)	59.37 (6)	

G. Ratel (1995Ra32) - 1	59.29 (7)	SIR: result of AECL.
G. Ratel (1995Ra32) - 2	59.90 (11)	SIR: result of LNHB.
G. Ratel (1995Ra32) - 3	59.26 (3)	SIR: result of NCR.
M. P. Unterweger (2002Un02)	59.49 (13)	
Recommended value	**59.388 (28)**	$\chi^2 = 3.3$

The first twelve values are only cited for reasons of completeness (1946Re**, 1951Fr21, 1958Ku**, 1960Ma36, 1963Ge**, 1964Le05, 1965An07, 1966Ri14, 1968La10, 1972Em01, 1979Kü**, 1980Ho17). The values of 1982HoZJ, 1983Ku**, 1987Sc20, 1989Si19, 1990De09, 1990Wo03, 1991Al05, 1995Ra32 (1, 2 and 3) and 2002Un02 are in good agreement and this indicates that the true value is very close to 59,4 d. Taking this into account, the evaluators can classify the older values (1946Re** until 1980Ho17) (when looking at the uncertainty given by the authors) into values which are too low (1960Ma36 by 10 σ, 1966Ri14 by 4 σ, 1980Ho17 by 12 σ) or too high (1964Le05 by 14 σ, 1968La10 by 10 σ, 1972Em01 by 5 σ, 1979Kü** by 17 σ). These values have a large spread. The evaluators consider it to be senseful to calculate an average of these values only after enlarging their uncertainties by reasonable (but more or less arbitrarily chosen) factors. Values of 1946Re** and 1958Ku** are excluded because no uncertainty is given. Value of 1951Fr21 is a good value but because of its large uncertainty it does not contribute very much to the average.

As there are enough new accurate values the evaluators do not include all these old values into the averaging procedure. A weighted average of the eleven remaining values, of 1982HoZJ until 2002Un02, was calculated using the LWEIGHT computer code (version 3). The largest contribution to the weighted average comes from the value of M. J. Woods (1990Wo03), with a statistical weight of 63 %. The LWEIGHT computer code increases the uncertainty for the 1990Wo03 value from 0.010 to 0.013 in order to reduce its relative weight from 63 % to 50 %.

The adopted half-life value is 59.388 days with a final uncertainty of 0.028 days, expanded to include the most precise value of M. J. Woods (1990Wo03). The reduced-χ^2 value is 3.3.

2.1 Electron Capture Transition.

The energy of the electron capture transition has been obtained from the Q(EC) value (2003Au03) and the level energy given by J. Katakura (1999Ka26).

The adopted electron-capture transition probability and the associated uncertainty were deduced from the γ-ray transition probability balance at 35-keV level of the decay scheme.

The adopted P_K, P_L and P_M values were calculated from the table of Schönfeld (1995ScZY) using the adopted Q_{EC} value (program EC-Capture). The adopted P_K value of 0.8011 (17) can be compared with some experimental determination (Table 2):
Der Mateosian (1953De26) found P_L/P_K = 0.23 (3). Leutz and Ziegler (1964Le05) found $(P_L + P_M + P_N)/P_K$ = 0.2547 (33) and 0.2539 (21) using two different extrapolation methods. The mean value 0.2543 (27) corresponds to P_K = 0.797 (3). Smith and Lewis (1966Sm05) found for the above ratio 0.253 (5). Karttunen et al. (1969Ka08) measured $P_K\omega_K$ = 0.685 (18) (2 σ) whereas Plch and Zderadicka (1974Pl03) found 0.685 (12) and Tolea et al. (1974To04) 0.699 (30).

Table 2: Adopted and measured values of P_K.

1	0.797 (3)	Leutz and Ziegler (1964Le05) measured value.
2	0.798 (3)	Smith and Lewis (1966Sm05) measured value.
3	0.783 (11)	Karttunen et al. (1969Ka08) measured, recalculated and uncertainty related to 1 σ.
4	0.783 (15)	Plch and Zderadicka (1974Pl03) measured, recalculated.
5	0.799 (34)	Tolea et al. (1974To04) measured, recalculated.
6	0.801	Tolea et al. (1974To04); calculated from theory.
7	0.825 (35)	Kalyani et al. (1996Ka48) measured value.
8	0.8011 (17)	calculated from theory and adopted in the present evaluation.

Values 3, 4 and 5 are recalculated using the present adopted value of ω_K.

2.2 γ Transitions

The γ-ray transition probability for the 35-keV gamma-ray was calculated using the γ-ray emission intensity and the relevant internal conversion coefficient (see **5.2 Gamma Emissions**).

Multipolarity of the 35-keV γ-ray transition is M1 + E2. The mixing ratio (δ) was deduced by comparison between the experimental and theoretical total internal coefficients, the later calculated using the BrIcc computer code (2008Ki07).

The total coefficient of 35-keV γ-ray can be deduced from:

$$\alpha_T = \frac{P_{(\gamma+ce)35}}{I_{\gamma 35}} - 1$$

where:

- $P_{(\gamma+ce)35}$ (100 %) is the transition probability of 35-keV γ-ray.
- $I_{\gamma 35}$ (= 6.63 (6) %) is the weighted average of the experimental values of absolute emission intensity shown in Table 5 (see **5.2 Gamma Emissions**).

Table 3 shows the final results of experimental α_T, as well as the mixing ratio δ deduced from the comparison between experimental α_T value (column 2) and theoretical values of 13.63 (M1) and 77.3 (E2) given by the BrIcc computer code.

Table 3: Adopted conversion coefficient and mixing ratio.

E_γ (keV)	α_T experimental (given by equation above)	δ (mixing ratio)
35.4922 (5)	14.08 (14)	0.085 (13)

Then the internal conversion coefficients (ICC) and the associated uncertainties have been obtained using the BrIcc computer program with “the frozen orbital approximation” (2008Ki07).

These α_T and mixing ratio values can be compared with the experimental results:

- Geiger et al. (1965Ge04) compared their measured conversion electron results $L_1 / L_2 / L_3$ = 1 / 0.089 (4) / 0.024 (2) with the theoretical ratios derived from the table of Sliv and Band and found: 99.965 (20) % M1 + 0.035 (20) % E2.

- Mazets et al. (1966Ma49) found in the ^{125}Sb decay $L_1 / L_2 / L_3$ = 10.7 / 1.0 / 0.2 corresponding to 99.92 (3) % M1 + 0.08 (3) % E2.

- Karttunen et al. (1969Ka08) deduced from a comparison of experimental results with those of the Hager-Seltzer theory that a possible E2 admixture is smaller than 0.4 %.

- Casey et al. (1969Ca01) measured $L_1 / L_2 / L_3$ = 1 / 0.106 (22) / 0.041 (2).

- Coursol (1979CoZG) measured more precisely $L_1 / L_2 / L_3$ = 1 / 0.0820 (13) / 0.0190 (10) and derived from analysis an E2 admixture of 0.03 (2) %.

- Brabec et al. (1982Ba16) measured $L_1 / L_2 / L_3$ = 1.00 (1) / 0.0954 (18) / 0.0229 (49) and derived from analysis of these and other data δ = 0.029 (+ 3 - 2) and 99.916 (+ 18 - 11) % M1 and 0.084 (+ 18 - 11) % E2.

The experimental conversion coefficient values of the 35.5 keV transition are compiled in the following table (Table 4).

	1 (1952Bo16)	2 (1969Ka08)	3 (1970Ma51)	4 (1979CoZG)[µ]	Adopted values (given by BrIcc)
α_K	11.7 (25)	11.78 (11)	11.8 (3)	11.90 (31)	11.70 (17)
α_L	1.6 (5)	1.62			1.91 (8)
α_M	0.3 (1)	0.25			0.386 (16)
α_N		0.044			0.075 (3)
α_O					0.00766 (23)
α_T	13.6 (26)[*]	13.65 (28)[£]		14.25 (64)	14.08 (22)

*$\alpha_T = \alpha_K + \alpha_L + \alpha_M$.
£ Value from the article.
µ The original uncertainties, given in this paper, are 3σ.

1 - Bowe and Axel (1952Bo16): α_L and α_M calculated from α_K and the measured ratio K / L / M = 0.80 (5) / 0.11 (2) / 0.020 (4). ($\alpha_T = \alpha_K + \alpha_L + \alpha_M$)
2 - Karttunen et al. (1969Ka08): α_K recalculated from $\alpha_K\omega_K$ with ω_K (0.875 (4)) as adopted here. The originally published value is α_K = 12.01 (18) (2σ uncertainty). The values of α_L, α_M, α_N are calculated from α_K using the ratio K / L / M / N = 80 / 11 / 1.7 / 0.3 as measured by Narcisi (1959Na06).
3 - Marelius et al. (1970Ma51).
4 - Coursol (1979CoZG, see also IAEA TecDoc-619 (1991)): measured values and the original uncertainties are 3σ (include in the Table 4).

3 Atomic Data

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

4 Electron emissions

The conversion electron emission probabilities have been deduced from the ICC and γ-ray emission probability values.

5 Emissions

5.1 K x-rays

The X-ray absolute intensities were deduced from the decay data using the EMISSION computer code.

For the total K X ray emission intensities some experimental values (per 100 % disintegrations) have been found:

1	137.9 (27)	Karttunen et al. (1969Ka08)
2	139.3 (25)	Tolea et al. (1974To04)
3	137.9 (23)	Plch and Zderadicka (1974Pl03)
4	138.3 (20)	Konstantinov et al. (1989Ko**), recalculated from *P*(KX + γ) = 1.45 (2)
5	138.3 (12)	Weighted mean of four experimental values (1-4). χ^2 = 0.07
6	137.9 (10)	Adopted value.

5.2 Photon emissions

The energy of the 35-keV γ-ray given in section 5.2 is from J. Katakura (1999Ka26).
The experimental absolute 35-keV γ-ray emission intensities from the decay of ^{125}I are given in the table 5.

Table 5: Absolute experimental γ-ray emission intensities for the 35-keV transition.

Reference	Absolute γ-ray intensity (%)	Comments
J. C. Bowe (1952Bo16)	7 (2)	
E. Karttunen (1969Ka08)	6.83 (14)	Original uncertainty = 2σ.
N. F. Coursol (1979CoZG)¤	6.56 (9)	Original uncertainty = 3σ.
W. B. Mann (1985Ma**)	6.67 (22)	Not used: evaluated value.
A. Iwahara (1990Iw04)	6.68 (14)	Superseded by 2006Da20
U. Schötzig (1992ScZZ)	6.55 (13)	
M. A. L. da Silva (2006Da20)	6.67 (14)	
Recommended value	**6.63 (6)**, χ^2 = 0.78	

¤ see also IAEA TecDoc-619 (1991).

The adopted value is the weighted average of 6.63 % with an external uncertainty of 0.06 %. The reduced-χ^2 value is 0.78.

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