^{198}Au - Comments on evaluation of decay data
by V.P. Chechev and N.K. Kuzmenko

The first DDEP evaluation of ^{198}Au decay data was completed by E. Schönfeld and R. Dersch in 1998 with a minor update in 2004 (2004BeZQ). The current evaluation was completed in January 2014 with a literature cut-off by the same date.

1. DECAY SCHEME

The structure of the adopted scheme of ^{198}Au is based on the ENSDF evaluation by Huang Xiaolong (2009Hu11). ^{198}Au disintegrates by β^- emission via ^{198}Hg excited levels of 411.8 keV (2^+) and 1087.7 keV (2^+). In addition to these levels, ^{198}Hg has an excited level at 1048.5 keV (4^+, half-life of 7.2 (3) ps) which is below the Q^- value. A β^- transition from the ^{198}Au ground state (2^-) to this level ($\Delta J = 2$ and the parity changes, E_β = 324.3 keV) would be unique 1st forbidden and was not observed. In 2004BeZQ an upper limit of 0.004 for the transition probability to this level was derived from *lg ft* systematics (*lg ft* $\geq$ 8.5).

Iwata and Yoshizawa (1980Iw03) estimated the probability of a possible EC decay of ^{198}Au to the ground state of ^{198}Pt (unique first forbidden EC transition) to be less than 0.0017 % from *lg ft* systematics, i.e. negligible for most purposes.

2. NUCLEAR DATA

The Q^- value is from the 2012 mass evaluation by Wang *et al.* (2012Wa38).

The recommended half-life of ^{198}Au is based on the experimental results given in Table 1.

Table 1. Experimental values of the ^{198}Au half-life (in days)

N	Author(s) and year	Reference	$T_{1/2}$	Method [c] and comments
1	Amaldi *et al.* (1935)	1935Am01	2.7	β counting; *omitted*
2	McMillan *et al.* (1937)	1937Mc04	2.7	β counting; *omitted*
3	Pool *et al.* (1937)	1937Po04	2.5	β counting; *omitted*
4	Sherr *et al.* (1941)	1941Sh08	2.7	β counting; *omitted*
5	Diemer and Groendijk (1946)	1946Di**	2.73 (2)	Ionization chamber; *omitted*
6	Seren *et al.* (1947)	1947Se33	2.7	β counting, Geiger counter; *omitted*
7	Saxon (1948)	1948Sa36	2.66 (1)	β counting, magnetic spectrometer; *omitted*
8	Saxon and Heller (1949)	1949Sa18	2.69 (2)	β counting, magnetic spectrometer; *omitted*
9	Steffen *et al.* (1949)	1949St17	2.7	β and γ counting; *omitted*
10	Cavanagh *et al.* (1951)	1951Ca06	2.66 (1)	β counting, Geiger counter; *omitted*
11	Silver (1951)	1951Si91	2.69 (1)	Ionization chamber, electrometer; *omitted*
12	Sinclair and Holloway (1951)	1951Si25	2.73 (1)	β counting, liquid counter, electroscope; *omitted*

13	Lockett and Thomas (1953)	1953Lo09	2.697 (3)	Ionization chamber
14	Bell and Yaffe (1954)	1954Be61	2.699 (3)	Ionization chamber
15	Tobailem (1955)	1955To07	2.686 (5)	γ counting, ionization chambers
16	Johansson (1956)	1956Jo24	2.697 (5)	γ timing, NaI(Tl) detector
17	Sastre and Price (1956)	1956Sa75	2.694 (6)	Geiger counter
18	Keene (1958)	1958Ke26	2.704 (4)	Ionization chamber
19	Robert (1960)	1960Ro22	2.699 (4)	Calorimetry on gold samples
20	Starodubtsev *et al.* (1963)	1963St20	2.687 (5)	β counting, β spectrometer
21	Anspach *et al.* (1965)	1965An07	2.694 (4)	4π, 2π ionization chambers, proportional counter
22	Goodier (1968)	1968Go22	2.695 (7)	4π ionization chamber; *omitted* as superseded by 29
23	Lagoutine *et al.* (1968)	1968La10	2.697 (5)	Ionization chambers, 4π β counters, γ counter
24	Reynolds *et al.* (1968)	1968Re04	2.693 (5)	End window Geiger counter
25	Cabell and Wilkins (1969)	1969Ca23	2.6946 (10)	γ counting
26	Vuorinen and Kaloinen (1969)	1969Vu04	2.695 (2)	4π β γ coincidence counter
27	Costa Paiva and Martinho (1970)	1970Co14	2.696 (4)	γ counting, NaI(Tl) detector
28	Debertin (1971)	1971De**	2.693 (3)	γ counting, Ge(Li) detector
29	Goodier (1971)	1971GoYM	2.695 (3)	4π ionization chamber
30	Hoppes *et al.* (1982)	1982HoZJ	2.695 (2)	4π ionization chamber, γ counting; *omitted* as superseded by 33
31	Rutledge *et al.* (1982)	1982RuZV	2.6935 (4)	γ counting, GeLi detector
32	Abzouzi *et al.* (1990)	1990Ab02	2.6966 (7)	γ counting, GeLi detector
33	Unterweger *et al.* (1992)	1992Un01	2.69517 (21)	4π ionization chamber; *omitted* as superseded by 35
34	Mignonsin (1994)	1994Mi03	2.6837 (50)	γ counting, GeLi detector
35	Unterweger *et al.* (2002)	2002Un02	2.69516 (21)	4π ionization chamber; *omitted* as superseded by 36
36	Unterweger and Lindstrom (2004)	2004Un01	2.69555 (30)	4π ionization chamber; *omitted* as superseded by 48
37	Lindstrom *et al.* (2005)	2005Li66	2.6924 (11)	γ counting, Ge detector, 4π ionization chamber
38	Novkovic *et al.* (2006)	2006No10	2.6947 (6)	γ counting, Ge detector
39	Goodwin *et al.* (2007)	2007Go39	2.6951 (8)[a]	γ counting, Ge detector; *omitted* as superseded by 44
40	Spillane *et al.* (2007)	2007Sp01	2.726 (22)[a]	γ counting, Ge detector; *omitted* on the Chauvenet's criterion
41	Kumar *et al.* (2008)	2008Ku09	2.6973 (20)[a]	γ counting, Ge detector;
42	Ruprecht *et al.* (2008)	2008Ru05	2.6937 (4)[a]	γ counting, 2 Ge detectors
43	Fortak *et al.* (2010)	2010Fo13	2.6847 (51)[a]	γ counting, Ge detector
44	Goodwin *et al.* (2010)	2010Go25	2.6948 (9)	γ counting, Ge detector; *omitted* as superseded by 46

45	Lindstrom *et al.* (2011)	2011Li52	2.6782 (3) [b]	γ counting, Ge detector; *omitted* on the Chauvenet's criterion
46	Hardy *et al.* (2012)	2012Ha23	2.69445 (32)	γ counting, Ge detector; stat. unc.: (20), syst. unc.: (25)
47	Fitzgerald (2012)	2012Fi12	2.69516 (21)	4π ionization chamber; *omitted* as superseded by 48
48	Unterweger and Fitzgerald (2014)	2014Un**	2.6934 (37)	4π ionization chamber
Recommended value			**2.6943 (3)**	LWM

[a] Average of measurement results at room and low (10-12 K) temperatures; measurements 39-43 showed temperature independence of ^{198}Au half-life.

[b] Average of all reported data for two sources (sphere, wire); measurements 2010Li48 and 2011Li52 showed independence of ^{198}Au half-life on the source shape.

[c] For measurements 1 to 44, the method is as listed in the compilation of 2011Ch22.

Values 1 to 12 from very early measurements (1935-1951) have been omitted as they are much less accurate. Values 22, 30, 33, 35, 36, 39, 44, 47 were not used because they were replaced ultimately by later results of the same laboratory.

Values 40 and 45 have been rejected by the LWEIGHT computer program based on Chauvenet's criterion. An unweighted average of the remaining twenty six values is 2.6940 (9) d. A weighted average is 2.69427 d. The LWEIGHT program, using the limitation of relative statistical weights method (LWM), has chosen the weighted average with the internal uncertainty of 0.00021 d. The external uncertainty is 0.00024 d. The largest contributions to the weighted average are the values 38 (12 %), 42 (26 %) and 46 (47 %). The ratio of the reduced $\chi^2 / (\chi^2)_{crit}$ is 1.35/1.80. The smallest experimental uncertainty is 0.00032 d.

The recommended value of ^{198}Au half-life is thus **2.6943 (3) days**. It can be compared with earlier evaluations of 2.6944 (8) (2004BeZQ), 2.6947 (3) (2009Hu11) and 2.6948 (12) (2011Ch22).

2.1. Beta Transitions

The energies of the β^- transitions have been obtained using the Q^- value and the ^{198}Hg level energies adopted from 2009Hu11 (Table 2). The probabilities of β^--transitions $P_{\beta-}$ have been deduced from the P(γ+ce) balance at each level of ^{198}Hg.

Table 2. ^{198}Hg levels populated in ^{198}Au β^--decay

Level	Energy (keV)	Multipolarity	Half-life	$P_{\beta-}$ (%)
0	0	0^+	Stable	0.025 (5)
1	411.80250 (17)	2^+	23.16 (12) ps	98.99 (6)
2	1087.6874 (5)	2^+	2.5 (2) ps	0.985 (5)

The adopted energies of the β^- transitions can be compared with the experimental values. $E\beta_{0,2}$ (keV): 285.1 (5) – adopted and 290 (15) - measured (1951Br52).

$E\beta_{0,0}$ (keV): 1372.8 (5) – adopted and 1371 (4) measured (1955El11).

For $E\beta_{0,1}$, the adopted value of 961.0 (5) keV can be compared with the averaged value of 960.4 (10) keV evaluated by Schönfeld and Dersch (2004BeZQ) which came from many measurement results of 1954-1965.

2.2. Gamma Transitions and Internal Conversion Coefficients

Gamma-ray transition probabilities have been deduced from their gamma-ray emission probabilities and the total ICC(s). The adopted ICC(s) are the theoretical values interpolated by the BrIcc computer program (2008Ki07) from the tables of Band et al. (2002Ba85), accepting the “frozen orbital (no hole)” approximation. The multipolarities and mixing ratio δ have been taken from 2009Hu11.

For the 411.8 keV γ-ray transition:

- The adopted α_K of 0.0300 (5) can be compared with the experimental values: 0.0301 (5) – 1963Le11 ; 0.0302 (4) – 1964Be33 ; 0.0299 (2) – 1965Ke04 ; 0.0308 (9) – 1965Pe05 ; 0.0299 (2) – 1965Pa08 ; 0.0302 (4) – 1967BoZZ ; 0.0301 (3) – 1972Na22 ; 0.03035 (45) – 1973El10 and 0.0300 (3) – 1976Re**.

- The adopted α_T of 0.0439 (7) can be compared with the experimental values of 0.0444 (5) – 1965Ke04 ; 0.0447 (6) – 1967BoZZ ; 0.043 (4) – 1976Re** and 0.0445 (9) - 1980Iw03.

For γ 676 keV: the adopted value of α_K is 0.0216 (17) and the measured values are 0.0224 (19) – 1954El04 ; 0.019 (5) – 1956Vo20 and 0.03 (1) – 1967BoZZ.

For γ 1088 keV, the adopted value of α_K is 0.00414 (6) and the measured values are 0.00450 (31) – 1954El04 ; 0.0046 (6) – 1956Vo20, 0.0046 (6) – 1967BoZZ.

The adopted mixing ratio δ of 1.07 (14) for the (M1+E2) 676 keV γ-ray transition is based on the results of angular correlation measurements of 1971Pa06, 1971Be09 and 1969BeZR for 676 keV - 412 keV gamma-gamma cascade in the decay of 5.3 h ^{198}Tl, corrected for the current values of constants including the mean lifetime and g-factor of the 412 keV level in ^{198}Hg (2009Hu11). The most careful investigation was made in 1971Pa06 using Ge(Li), NaI(Tl), plastic detectors and a Ge(Li)-Ge(Li) setting. Earlier measurements of δ (before 1968) did not include two Ge(Li) and could contain systematic errors. Their uncorrected results are 0.96 (10) – 1953Sc19; 1.22 (22) – 1953Sc23; 1.43 (14) – 1964Sa11; 1.26 (8) – 1966Uh01; 1.34 (9) – 1967Ko13.

The δ = 1.07 (14) corresponds to the adopted M1 contribution of 46.6 (65) %.

The latest angular correlation measurements, after 1971, gave the results of 54 (2) % (1972Ve03) and 39.4 (25) % (1974Ka18), divergent with each other, but compatible to the adopted value within the uncertainty limits.

3. ATOMIC DATA

The atomic data (fluorescence yields, X-ray energies and relative probabilities, and Auger electrons energies and relative probabilities) have been deduced by using the SAISINUC software.

4. ELECTRON EMISSIONS

The energies of the conversion electrons have been obtained from the gamma-ray transition energies and the electron binding energies.

The absolute emission probabilities of the conversion electrons have been deduced using recommended Pγ and ICC values.

The absolute emission probabilities of K and L Auger electrons have been calculated using the EMISSION computer program.

β^- average energies have been calculated using the LOGFT computer program.

5. PHOTON EMISSIONS

5.1. X-ray Emissions

The absolute emission probabilities of Hg KX- and LX-rays have been calculated using the EMISSION computer program. In Table 3 the calculated values are compared to experimental data.

Table 3. Experimental and recommended Hg X-ray emission probabilities in decay of ^{198}Au

X-ray	1989Ch45	2010Mo06	Recommended (calculated)
Ll	0.027 (3)		0.0270 (8)
Lα	0.592 (17)		0.527 (13)
Lη	0.0105 (15)		0.0105 (3)
Lβ	0.643 (19)		0.536 (12)
Lγ	0.124 (5)		0.1024 (23)
Kα2	0.816 (2)	0.813 (10)	0.807 (15)
Kα1	1.41 (4)	1.374 (17)	1.369 (24)
K'β1	0.485 (12)	0.460 (7)	0.465 (11)
K'β2	0.137 (7)	0.135 (3)	0.136 (4)

5.2. Gamma ray emissions

The energies of the gamma rays in ^{198}Hg have been adopted from 2009Hu11

The measured relative intensities and the adopted values obtained with the LWEIGHT program are listed in Table 4. Absolute gamma ray emission probabilities measured by Hammed *et al.* (1992Ha02) and Moreira *et al.* (2010Mo06) have been converted into relative intensities.

Table 4. Experimental and adopted relative gamma-ray intensities in decay of ^{198}Au

Reference	411.8 keV	675.9 keV	1087.7 keV
1951Ca06	100	1.5	0.4
1951Hu18	100	1.4 (1)	0.25 (5)
1951Br52	100	1	0.2
1954Ma19	100	1.3	0.25
1954El04	100	0.842 (56)	0.170 (12)
1955Dz41	100	1.11 (5)	0.26 (2)
1965Ke04	100	1.0	0.28
1967BoZZ	100	0.75	0.15
1980Iw03	100	0.841 (5)	0.1664 (22)
1989Ch45	100	0.846 (11)	0.165 (4)
1992Ha02	100	0.842 (11)	0.1669 (29)
2010Mo06	100	0.840 (8)	-
Recommended	**100**	**0.841 (5)**	**0.1664 (22)**

The normalization factor (0.956 17 (64) %) to convert the adopted relative gamma ray intensities to absolute emission probabilities has been deduced from the gamma ray transition intensity balance for the ground state assuming that the recommended probability of the beta transition to the ground state is equal to the measured value of 0.025 (5) % (1955El11).

6. ENERGY CONSERVATION

The total average energy of 1372.8 (9) keV, for one disintegration, calculated from the current evaluated data, corresponds very well to the available energy of 1372.8 (5) keV (Q^-) from the mass tables (2012Wa38) confirming the consistency of the decay scheme and the reliability of this evaluation.

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