^{127}Xe - Comments on evaluation of decay data
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This evaluation was completed in 2013, taking into account the available literature by December 2013. This radionuclide was first identified by 1940CR06 by using a (*p*,*n*) reaction on ^{127}I. The identification was confirmed later by using an (α,*n*) reaction on ^{124}Te (1950AN05).

1 Decay Scheme

The decay scheme is complete for this electron-capture decay. The ground state of ^{127}Xe is $1/2^+$ (1979AL14). From Q^+ = 662,3 (20) keV (2012WA38), eight levels of ^{127}I are reachable (1970AP02): ground state $5/2^+$, 57 keV $7/2^+$, 203 keV $3/2^+$, 375 keV $1/2^+$, 418 keV $5/2^+$, 618 keV $3/2^+$, 629 keV $7/2^+$, 651 keV $9/2^+$. Notice that the parity of the latter level is uncertain (2011HA31).

Only three transitions lead to allowed electron-capture decays, namely to the 203 keV, 375 keV and 618 keV states. Up-to-now, no other transition has been observed. The following comment can be found in 1977GE10: "The electron-capture to the ground state is second forbidden for which the minimum log *ft* value is ~ 11 and thus the maximum intensity of the feeding branch is ~ 0,003 %". The same comment can be applied for the electron-capture to the first excited state of ^{127}I since this transition is second forbidden unique. Identically, the 418 keV, 629 keV and 651 keV levels are not expected to be populated.

Consistency of the decay scheme was checked in Section 4.2.2. The decay scheme is consistent up to 99,9 (14) % confidence level. The effective Q value resulting from total energy balance considerations is: Q_{eff} = 662 (7) keV, consistent with Q^+ = 662,3 (20) keV from 2012WA38 adopted in this evaluation.

2 Nuclear Data

The Q value adopted in this evaluation, Q^+ = 662,3 (20) keV, is from Wang *et al.* 2012 (2012WA38).

2.1 ^{127}Xe Half-life

A full list of the half-life measurements available by December 2013 is summarized in Table 1. The most precise value comes from 2013UN, which is a corrected value of the NIST measurement from 2002UN02, originally being 36,3446 (28) d, due to a source positioning difficulty.

The value from 1954BA71 is 36,406 (16) d. It was extracted from the evolution of the abundance ratios ^{127}Xe/^{126}Xe and ^{127}Xe/^{128}Xe, assuming a constant ratio ^{126}Xe/^{128}Xe. But this latter ratio remained constant only within 0,5 %. The final uncertainty has thus been increased by 0,25 %, leading to: 36,41 (9) d.

The value from 1974CO05 is 36,3 (3) d, but after an average of their measured value with previous values and assuming a 4σ uncertainty. The measured value was preferred in this evaluation, namely 36,25 (9) d.

The LWEIGHT program excluded the results from 1940CR06, 1950AN05 and 1958FO48, which were found to be outliers by Chauvenet's criterion. A weighted average with its external uncertainty was adopted from the resulting consistent data set, with a reduced-χ^2 value of 1,0. The main contribution comes from 2013UN, amounting to 58 %. This quite large contribution is kept because the value from 2013UN is the only one that comes from a metrological laboratory. The recommended value for the ^{127}Xe half-life is then:

$$\mathbf{T_{1/2}(^{127}Xe) = 36{,}358\ (31)\ d}.$$

Note that the value from 1958FO48 agrees with other measurements within its uncertainty. A weighted average has been performed by the evaluator including this value. The result using the internal uncertainty is consistent with the recommended value: 36,357 (30) d.

Table 1: ^{127}Xe half-life measurements. The excluded value is crossed out.

Reference	$T_{1/2}$(^{127}I) in d	Comments
~~1940CR06~~	~~34 (2)~~	Excluded by Chauvenet's criterion
~~1950AN05~~	~~32 (2)~~	Excluded by Chauvenet's criterion
1954BA71	36,41 (9)	
~~1958FO48~~	~~36,0 (5)~~	Excluded by Chauvenet's criterion
1964BR26	36,4 (1)	
1965WI12	36,5 (1)	
1974CO05	36,25 (9)	
2013UN	36,34 (4)	Revised NIST value
Adopted	**36,358 (31)**	

2.2 Half-lives of ^{127}I 57 keV, 203 keV and 375 keV states

The measured half-life values of the first excited state of ^{127}I, at 57 keV, are given in Table 2. The LWEIGHT program excluded the result from 1964JH02, which was found to be an outlier by Chauvenet's criterion. A weighted average with its internal uncertainty was adopted with a reduced-χ^2 value of 0,2. The main contribution comes from 1976SA20, amounting to 96 %. The recommended value for the half-life of the first excited state of ^{127}I is:

$T_{1/2}$(^{127}I, 57 keV) = 1,95 (1) ns.

Table 2: $T_{1/2}$ half-life measurements of the 57 keV level of ^{127}I.

Reference	$T_{1/2}$ in ns	Comments
1962TH12	2,0 (2)	
~~1964JH02~~	~~1,25 (21)~~	Excluded by Chauvenet's criterion
1967GE10	1,86 (11)	Same authors as in 1965GE04
1967SV01	1,93 (7)	
1969BEZH	1,90 (15)	
1976SA20	1,95 (1)	
Adopted	**1,95 (1)**	Consistent with the value adopted in 2011HA31

The measured half-life values of the second excited state of ^{127}I, at 203 keV, are given in Table 3. The value from 1965LA01 is cited in 1966GE13 but is not explicitly given in 1965LA01.

The LWEIGHT program excluded the result from 1967SV01, which was found to be an outlier by Chauvenet's criterion. In the resulting consistent data set, a weighted average was used and the uncertainty of the value from 1967GE10 was expanded in order to take into account this value. The reduced-χ^2 value is 0,8. The two main contributions come from 1967GE10 and 1968KO01, amounting to 66 % and 32 % respectively. The recommended value for the half-life of the second excited state of ^{127}I is then:

$T_{1/2}$(^{127}I, 203 keV) = 0,387 (6) ns.

Table 3: $T_{1/2}$ half-life measurements of the 203 keV level of ^{127}I.

Reference	$T_{1/2}$ in ns	Comments
1965LA01	0,39 (6)	Cited in 1966GE13 but not explicitly given in 1965LA01
1967GE10	0,381 (7)	Same authors as in 1966GE13
~~1967SV01~~	~~0,326 (21)~~	Excluded by Chauvenet's criterion
1968KO01	0,40 (1)	
1975AN19	0,39 (6)	
Adopted	**0,387 (6)**	Consistent with the value adopted in 2011HA31

The value from 1969LA08 of the half-life value of the third excited state of ^{127}I, at 375 keV, is: $T_{1/2}$(^{127}I, 375 keV) = 22 (4) ps. The adopted half-life value of the third excited state of ^{127}I, at 375 keV, is from 2011HA31: **$T_{1/2}$(^{127}I, 375 keV) = 31 (8) ps**.

2.3 Electron Capture Transition

From the absolute emission probabilities given in Section 4.2.2, together with the comment regarding the nature of the transition highlighted in Section 1, only the electron-capture transitions to the 203 keV, 375 keV and 618 keV states have to be considered. These decays are all allowed transitions, which can be calculated by the LOGFT program. The EC-capture program provides the $P_{K,L,M,N}$. Other values are from LOGFT, and the ones which can be deduced from them are in Table 4. A minimum relative uncertainty of 1 % has been taken by the evaluator.

Table 4: Electron-capture probabilities given by LOGFT and EC-capture for these allowed transitions.

	E (keV)	**P_ε (%)**	**log *ft***	**P_K**	**P_L**	**P_M**	**P_{L2}/P_{L1}**	**P_{L1}**	**P_{L2}**
$\gamma_{0,2}$	459,4 (20)	52,7 (14)	6,61	0,842 (8)	0,125 (1)	0,0272 (5)	0,0276 (3)	0,122 (1)	0,003 (1)
$\gamma_{0,3}$	287,3 (20)	47,3 (7)	6,21	0,830 (8)	0,134 (1)	0,0294 (6)	0,0276 (3)	0,130 (1)	0,004 (1)
$\gamma_{0,4}$	43,9 (21)	0,0142 (9)	7,42	0,31 (6)	0,523 (44)	0,137 (12)	0,0281 (3)	0,509 (43)	0,014 (43)

2.4 Gamma Transitions and Internal Conversion Coefficients

The evaluated energies of gamma transitions are from 2011HA31 (see Section 4.2.1).

2.4.1 Mixing ratios and multipolarities

The 57 keV and 203 keV transitions are the only ones which require a careful evaluation. The measurements of their mixing ratios or multipolarities are shown in Table 5 for the 57 keV transition, and in Table 6 for the 203 keV transition. Data published in the various publications are in bold text.

Table 5: Mixing ratio or multipolarity measurements for the 57 keV transition. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

Classification	**Reference**	**$\vert\delta\vert$**	**δ^2**	**Multipolarity**	**Adopted**
M1 plus a possible admixture of E2	1964JH02	0,08 (25)	0,006 (39)	**M1 + 0,6 (6) % E2**	**$\vert\delta\vert$ = 0,083 (5)** **δ^2 = 0,0069 (8)** **M1 + 0,68 (8) % E2**
	1965LA01	**0,08 (1)**	0,0064 (16)	M1 + 0,64 (16) % E2	
	1966LE09	**0,084 (6)**	0,0071 (10)	M1 + 0,70 (10) % E2	
	1967GE10	0,08 (4)	0,007 (6)	**M1 + 0,7 (1) % E2**	

For the 57 keV transition, no outlier was found by the LWEIGHT program in this consistent data set. A weighted average with its internal uncertainty was adopted with a reduced-χ^2 value of 0,04. The main contribution comes from 1966LE09, amounting to 72 %. The recommended value is given in Table 5.

Table 6: Mixing ratio or multipolarity measurements for the 203 keV transition. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

Classification	Reference	**$\vert\delta\vert$**	**δ^2**	**Multipolarity**	**Adopted**
M1 plus a possible admixture of E2	1966LE09	**0,52 (5)**	0,27 (5)	M1 + 21,3 (32) % E2	**$\vert\delta\vert$ = 0,517 (27)** **δ^2 = 0,267 (28)** **M1 + 21,1 (17) % E2**
	1967GE10	0,516 (32)	0,266 (33)	**M1 + 21 (3) % E2**	

For the 203 keV transition, no outlier was found by the LWEIGHT program in this consistent data set. A weighted average with its external uncertainty was adopted with a reduced-χ^2 value of 0,005. The main contribution comes from 1967GE10, amounting to 71 %. The recommended value is given in Table 6.

Considering the initial and final spins and parities, the 172 keV transition is classified as M1 plus a possible admixture of E2. 1967GE10 gives only an indication: M1 + (< 1%) E2. 1976LE23 provides two consistent values of the mixing ratios: δ = 0,088 (11) from the measurement of the 172 – 203 keV cascade and δ = 0,076 (45) from the 172 – 145 keV cascade. The recommended multipolarity of **the 172 keV transition** is the one from 2011HA31: **δ = -0,085 (6)**, namely **M1 + 0,72 (10) % E2**.

For the 145 keV and 375 keV transitions, there is only an indication of their multipolarities given in

1967GE10: E2 + (< 25 %) M1 for the 145 keV transition, and E2 + (< 30 %) M1 for the 375 keV transition. Considering the initial and final spins and parities, both transitions are classified as E2 plus a possible admixture of M3. As recommended in 1967GE10 and consistently with the classification, the recommended multipolarity is **pure E2 for both the 145 keV and 375 keV transitions**.

Considering the initial and final spins and parities, the 618 keV transition is classified as M1 plus a possible admixture of E2. The adopted multipolarity of **the 618 keV transition** is the one from 2011HA31 with symmetrized uncertainty according to the method described in 2012WA38: **δ = 0,083 (+16,-19)** which becomes **δ = 0,081 (18)**, namely **M1 + 0,65 (29) % E2**.

2.4.2 Internal conversion coefficients

The internal conversion coefficients measurements of the gamma transitions of ^{127}I were calculated with the BrIcc program (2008KI07) using the mixing ratios evaluated previously.

3 Atomic Data

3.1 Fluorescence yields

The fluorescence yields are taken from 1996SC06.

3.2 X Radiations and Auger electrons

The X-ray and Auger electron data were computed using the EMISSION program with the atomic data of Schönfeld and Janßen (1996SC06).

4 Gamma Emissions

4.2.1 Gamma-ray energies

The adopted energies of the ^{127}I levels are from 2011HA31. Independent evaluation, described below, was carried out by the evaluator. Results agree very well. The ones from 2011HA31 were preferred because of the completeness of their evaluation.

The gamma-ray energy measurements are given in Table 7. No value was excluded by the LWEIGHT program during the statistical process. All the data sets are consistent and a weighted average was used each time with the internal uncertainty. The adopted values are in red, and the reduced-χ^2 are also mentioned.

The energies of the gamma transitions were then deduced by adding the recoil energy of the nucleus. The proton and neutron masses, m_p and m_n, come from 2008MO18. The mass excess Δ of ^{127}I comes from 2012WA38. The largest recoil energy is for the 618 keV transition, with a value of 1,6 eV.

Table 7: E_γ measurements of the levels of ^{127}I. Final adopted values in red are from 2011HA31.

Reference	E_γ (keV)	E_γ (keV)	E_γ (keV)	E_γ (keV)	E_γ (keV)	E_γ (keV)
1958FO48	58,0 (10)	146,5 (5)	173,0 (5)	204,5 (5)	377,5 (5)	
1967GE10	57,60 (2)	145,22 (3)	172,10 (3)	202,84 (3)	374,96 (5)	
1968SC14			172,5 (3)			Evidence
1969GUZV		145,22 (20)	172,10 (20)	202,84 (20)	374,96 (20)	
1970AP02	57,63 (8)	142,2 (1)	172,1 (5)	202,9 (1)	375,0 (4)	618,6 (3)
1974CO05	57,6 (2)	145,2 (1)	172,1 (1)	202,8 (1)	375,0 (1)	
1977GE10	57,61 (2)	145,252 (10)	172,132 (10)	202,860 (10)	374,991 (12)	
Weighted average	57,606 (14)	145,248 (9)	172,100 (28)	202,858 (9)	374,989 (12)	618,6 (3)
χ^2	0,07	0,4	$2 \cdot 10^{-9}$	0,2	0,1	
2011HA31	**57,61 (2)**	**145,252 (10)**	**172,132 (10)**	**202,860 (10)**	**374,991 (12)**	**618,41 (14)**

4.2.2 Gamma-ray emission intensities

The measurements used to evaluate the gamma-ray emission intensities are summarized in the following tables. The data given in Table 8 from 1958FO48 are relative to the 203 keV gamma-ray intensity. This is the reference gamma-ray throughout this evaluation. The data crossed out were excluded by LWEIGHT according the Chauvenet's criterion during the statistical process.

The data from 1967GE10 given in Table 9 were recording from electron measurements. The use of internal conversion coefficients from BrIcc (see Section 2.4.2) allows calculating the corresponding relative gamma-ray emission intensities.

Data from 1974CO05 in Table 10 were given as absolute intensity measurements. The efficiency calibration was performed using standard calibrated sources, but no activity measurement of the ^{127}Xe source was given in the publication. We cannot therefore use the absolute intensity of the 203 keV transition to evaluate the other absolute gamma-ray intensities.

The data from 1977GE10 and from 2013RO are absolute intensity measurements and are given in Table 11 and Table 12. The efficiency calibration was performed using standard calibrated sources and an activity measurement of the ^{127}Xe source was given in each publication.

The relative gamma-ray intensities were evaluated with the LWEIGHT program and are given in Table 13. All the data sets are consistent and a weighted average was used each time. The type of uncertainty used and the reduced-χ^2 are also mentioned in Table 13.

Table 8: Relative data from 1958FO48 and their normalization to the 203 keV gamma-ray. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator. Data crossed out were excluded by LWEIGHT.

E (keV)	Relative I_γ	Relative I_γ	Comments
K X-rays	**1170 (70)**	117 (8)	Not used
57	**21 (2)**	2,10 (22)	
145	**64 (10)**	6,4 (10)	
~~172~~	**~~342 (17)~~**	~~34,2 (22)~~	Excluded by Chauvenet's criterion
203	**1000 (40)**	100	
~~375~~	**~~301 (12)~~**	~~30,1 (17)~~	Excluded by Chauvenet's criterion

Table 9: Relative electron data from 1967GE10. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

E (keV)	I_{ceK}	Multipol.	δ	α_K BrIcc	I_γ	Relative I_γ
57	**0,632 (25)**	M1+E2	-0,083 (5)	3,16 (5)	0,200 (9)	1,91 (9)
145	**0,226 (4)**	Pure E2		0,357 (5)	0,633 (14)	6,06 (17)
172	**0,554 (10)**	M1+E2	-0,085 (6)	0,1419 (20)	3,90 (9)	37,4 (10)
203	**1**	M1+E2	0,517 (27)	0,0964 (15)	10,45 (16)	100,0
375	**0,0457 (10)**	Pure E2		0,01671 (24)	2,73 (7)	26,2 (8)

Table 10: Absolute intensity measurements from 1974CO05, normalized to the 203 keV gamma-ray. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

E (keV)	Absolute I_γ	Relative I_γ
57	**1,31 (8)**	1,92 (12)
145	**4,24 (21)**	6,23 (33)
172	**24,7 (10)**	36,3 (16)
203	**68,1 (13)**	100,0
375	**17,4 (10)**	25,6 (15)

Table 11: Absolute intensity measurements from 1977GE10, normalized to the 203 keV gamma-ray. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

E (keV)	Absolute I_γ	Relative I_γ
57	**1,22 (7)**	1,79 (10)
145	**4,29 (13)**	6,28 (19)
172	**25,5 (8)**	37,3 (12)
203	**68,3 (4)**	100,0
375	**17,2 (5)**	25,2 (7)
618	**0,014 (1)**	0,0205 (15)

Table 12: Absolute and relative intensities measurements from 2013RO. Bold text stands for the original data given in the publications. Otherwise, the data were calculated by the evaluator.

E (keV)	Absolute I_γ	Relative I_γ	Comments
X K_α		**83,4 (17)**	Not used
X K_β		**20,35 (42)**	Not used
57	**1,23 (7)**	**1,76 (10)**	
145	**4,33 (7)**	**6,20 (13)**	
172	**26,23 (44)**	**37,6 (8)**	
203	**69,8 (12)**	**100,0**	
375	**17,32 (28)**	**24,8 (5)**	
618	**0,0147 (20)**	**0,0211 (29)**	

Table 13: Adopted relative gamma-ray emission intensities, the corresponding absolute emission intensities and the corresponding transition probabilities.

E (keV)	Relative I_γ	Comments	I_γ x 100	Multipol.	δ	α_T BrIcc	$P_{\gamma+ce}$ x 100
57	1,858 (49)	External, χ^2 = 0,8	1,272 (35)	M1+E2	-0,083 (5)	3,72 (6)	6,00 (18)
145	6,18 (9)	Internal, χ^2 = 0,22	4,23 (7)	Pure E2		0,471 (7)	6,22 (11)
172	37,3 (5)	Internal, χ^2 = 0,18	25,53 (38)	M1+E2	-0,085 (6)	0,1649 (24)	29,74 (45)
203	100		68,45 (45)	M1+E2	0,517 (27)	0,1142 (18)	76,3 (5)
375	25,21 (36)	Internal, χ^2 = 0,73	17,26 (27)	Pure E2		0,0199 (3)	17,60 (28)
618	0,0206 (13)	Internal, χ^2 = 0,03	0,0141 (9)	M1+E2	0,081 (18)	0,00609 (9)	0,0142 (9)

Only 1977GE10 and 2013RO can be conserved to evaluate the absolute gamma intensity of the 203 keV emission. The data are consistent. A weighted average using its internal uncertainty, with a reduced χ^2 of 1,4, gives: **I_γ(203 keV) = 68,45 (45) %**. The gamma transition probabilities are calculated from this value with the corresponding total internal conversion coefficients calculated with the BrIcc program (see Section 2.4.2) and given in Table 13.

Consistency of the decay scheme is tested summing all the gamma-rays falling to the ground state of ^{127}I. This sum is equal to: $\Sigma\ P_{\gamma+ce}$ = 99,9 (14) %. On the other hand, this sum can be set to 100 in order to determine the absolute gamma intensity I_γ(203 keV):

$\Sigma\ (1+\alpha_T)\cdot I_{\gamma rel.}$ =145,9 (19),

and as I_γ(203 keV)$\cdot\Sigma\ (1+\alpha_T)\cdot I_{\gamma rel.}$ = 100,

we have: I_γ(203 keV) = 68,5 (9) %.

The best uncertainty associated with a consistent decay scheme is therefore obtained using the first method, which is used in this evaluation.

Consistency of the decay scheme is also tested from total energy balance considerations. The resulting effective Q value, Q_{eff} = 662 (7) keV, is consistent with Q^+ = 662,3 (20) keV from 2012WA38 adopted in this evaluation.

From these absolute emission intensities, together with the comment regarding the nature of the transitions highlighted in Section 1, the following probabilities of electron-capture transitions were found: **$P(\varepsilon_{0,2})$ = 52,7 (14) %**, **$P(\varepsilon_{0,3})$ = 47,3 (7) %**, **$P(\varepsilon_{0,4})$ = 0,0142 (9) %**.

5. Electron Emissions

The energies of the conversion electrons were calculated from the gamma-transition energies given in Section 4.2.1 and the electron binding energies.

The emission probabilities of the conversion electrons were calculated using the internal conversion coefficients (see Section 2.4.2). The emission probabilities of K-Auger electrons were calculated using the transition probabilities given in Sections 2.3 and 2.4, the atomic data given in Section 3, and the internal conversion coefficients.

6. References

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