

**¹³³Xe - Comments on evaluation of decay data
by M. Galán**

1) Decay Scheme

¹³³Xe disintegrates by β^- emission to excited levels in ¹³³Cs.

¹³³Xe ground state has $J^\pi = 3/2^+$. The isomeric state is at 233 keV and has $J^\pi = 11/2^-$ (1989RA17).

2) Nuclear Data

The Q value is from AME2003 (2003AU03): $Q_{\beta^-} = 427,4$ (24) keV.

Level energies have been obtained from a least-squares fit to γ -ray energies (GTOL computer code). Spin and parities are from 1995RA12.

The half-life of the 81-keV level has been deduced (using the AveTool computer code) from the values reported in 1965GE14, 1963GO17, 1962TH12, 1959BO56, 1958AL98, 1955LE18 and 1953GR07. Half-lives for other levels are from 1995RA12.

The measured ¹³³Xe half-life values, in days, are:

Reference		Value (d)	Comments
2002UN02, 1992UN01		5,2475 (5)	
1975HO18		5,25 (2)	
1975WO10		5,250 (13)	
1974CA27		5,245 (6)	
1974FOZY		5,240 (6)	
1972EM01		5,29 (1)	Rejected by Chauvenet's criterion
1968AL16		5,312 (25)	Rejected by Chauvenet's criterion
1950MA15		5,270 (2)	Rejected by Chauvenet's criterion
Mean		Reduced χ^2	
LWM	5,2474 (5)	0,44	
NRM	5,2474 (5)	0,44	
RT	5,2474 (5)		

The AveTool computer code has been used with these seven input values. This code calculates averages using three statistical methods: LWM (Limitation of Relative Statistical Weight), NRM (Normalised Residual Method) and RT (Rajeval Technique).

The values in 1950MA15, 1968AL16, 1972EM01 were rejected based on the Chauvenet's criterion. For the remaining values, the largest contribution to the weighted average comes from the value of Unterweger (2002UN02). The LWM method increased the uncertainty of this value 3.895 times in order to reduce its relative weight to 50 %.

The recommended value is therefore the LWM mean, **5,2474 (5) d**. Its uncertainty has been expanded to 0,009 d, so the half-life range includes the most precise value of 5,2475 d (1992UN01, 2002UN02).

2.1) β Transitions

The energies of the β transitions have been deduced from the Q value and the level energies in ¹³³Cs, the later deduced from γ -ray transition energies. The adopted values have been verified against those produced by the computer code GTOL.

All beta transitions of ¹³³Xe are allowed. The β^- probabilities and associated uncertainties have been deduced from γ -ray transition intensity balance at each level of the decay scheme, assuming no β^- transition to the ground state.

$$\%b_{0,3} = P_{g+ce}(384) + P_{g+ce}(303) + P_{g+ce}(223) = 0,0029(4) + 0,0061(8) + 0,000187(69) = 0,0092(9)$$

$$\%b_{0,2} = P_{g+ce}(80) + P_{g+ce}(161) - P_{g+ce}(384) = 0,78(8) + 0,088(10) - 0,000187(69) = 0,87(8)$$

$$\%b_{0,1} = 100 - [\%b_{0,3} + \%b_{0,2}] = 100 - [0,0092(9) + 0,87(8)] = 99,12(8)$$

These values have been compared to the β^- emission probabilities measured by 1952BE55, 1961ER04 and 1986SC34. Also, the $\lg ft$ values have been calculated using the program LOGFT for allowed β^- transitions, and compared to values reported in these references.

Such a comparison is given in the following table:

Reference	$\%b_{0,1}$	$\lg ft$	$\%b_{0,2}$	$\lg ft$	$\%b_{0,3}$	$\lg ft$
1959JH17	0,1	5,7	2	7	98	5,6
1961ER04	0,006	-	0,71	7,5	99,28	5,7
1986SC34	0,0073	-	0,79	-	99,2	-
Recommended	0,0092 (9)	6,84	0,87 (8)	7,31	99,12 (8)	5,62

2.2) γ -ray Transitions

Transition Probabilities

The γ -ray transition probabilities have been calculated from the γ -ray emission probabilities using our recommended internal conversion coefficients.

Mixing ratios and internal conversion coefficients

For the 81, 223, 302 and 384 keV γ -ray transitions the adopted δ (mixing ratio) are from 1977KR13. The adopted values were deduced from angular correlation data. For the 80 and 161 γ -ray transitions the adopted δ values are from 1995RA12.

The internal conversion coefficients (ICC) have been calculated using the BrIcc computer code, which interpolated ICC values from tables of Band et al. (2002BA85). Associated uncertainties are 1,4 %.

3) Atomic Data

Atomic values (ω_K , ω_L and η_{KL}) are from 1996SC06.

ω_K	$0,894 \pm 0,004$
ω_L	$0,104 \pm 0,005$
η_{KL}	$0,895 \pm 0,004$

The X-ray and Auger electron emission probabilities have been deduced from γ -ray and conversion electron data by using the computer code EMISSION. Results were verified with the RADLST computer code. Differences between these results were < 1 %.

4) Electron Emissions

The conversion electron emission probabilities have been computed from γ -ray emission probabilities and theoretical ICC values.

5) Photon Emissions

Energies

γ -ray energies and uncertainties are from 2000HE14. These values have been deduced on a revised energy scale.

g-ray emissions

The available experimental relative gamma emission intensities are:

Reference	g79,6	g81	g161	g223	g303	g384
1958PL55	-	-	-	-	0,010	0,005
1959JH17	-	100	1,4	-	0,084	0,043
1961ER04	0,8 (1)	100	0,109 (10)	0,0004 (⁺⁴ ₋₃)	0,0123 (12)	0,0062 (9)
1968AL16	100 1,6 (7)	98,2 (59)	0,174 (9)	0,000647 (613)	0,0135 (4)	0,00618 (19)
1992MA05	100		0,242 (25)	0,00044 (18)	0,0193 (7)	0,000901 (41)
Weighted average			0,182	0,00046	0,0155	
Reduced χ^2			6,55	0,1	24	
Internal uncertainty			0,008	0,00017	0,0004	
External uncertainty			0,022	0,00006	0,0021	
Recommended	0,76 (9)	99,24 (9)	0,182 (22)	0,00046 (17)	0,0155 (21)	0,0076 (10)

1968AL16 relative intensities were reported to the group $\gamma_{79,6} + \gamma_{81} = 1000$. In the table they have been reported to 100 for that of the group $\gamma_{79,6} + \gamma_{81}$.

1995MA02 relative intensities were reported to the group $\gamma_{80} + \gamma_{81}$ and multiplied 10^5 . In this table they have been reported to 100 for that of group $\gamma_{79,6} + \gamma_{81}$.

To evaluate all relative intensities, the group $\gamma_{79,6} + \gamma_{81}$ has been taken as the reference line as measured 1968AL16 and 1992MA05.

The 79.6 keV line has been deduced using the ratio $\gamma_{79,6}/\gamma_{161}$ from ¹³³Ba decay (Chechev and Kuzmenko, 2004).

$$g_{79,6} = 0,182(22) \times \frac{4,27(8)}{1,028(8)} \Big|_{^{133}\text{Ba}} = 0,76(9)$$

Therefore, $g_{81} = 100 - 0,76(9) = 99,24(9)$

The relative γ -ray emission intensities for the 384 keV γ -ray has been deduced from the 303 keV γ -ray emission probability and the averaged ratio $\gamma_{384}/\gamma_{303}$ measured by:

Reference	$\gamma_{384}/\gamma_{303}$
1958PL55	0,50 (11)
1959JH17	0,512 (13)
1961ER041	0,504 (88)
1968AL16	0,458 (20)
1992MA05	0,467 (27)
Weighted mean	0,492
Reduced χ^2	1,53
Internal uncertainty	0,010
External uncertainty	0,012
Recommended	0,492 (12)

So that, $g_{384} = g_{303} \times \frac{g_{384}}{g_{303}} \Big|_{w.m.} = 0,0155(21) \times 0,492(12) = 0,0076(10)$

The normalization factor has been deduced from the decay scheme using the formulas:

$$N = \frac{100}{\sum_i I_{g_i} [1 + a_{T_i}]} \quad \text{and} \quad dN^2 = \sum_i \left(\frac{\partial N}{\partial I_{g_i}} dI_{g_i} \right)^2 + \sum_i \left(\frac{\partial N}{\partial a_{T_i}} da_{T_i} \right)^2,$$

where the sum is over all γ -ray transitions to the ground state (g.s.), thus considering no direct β^- feeding to the g.s. Therefore:

$$N = \frac{100}{99,24(9) \times [1 + 1,698(24)] + 0,182(22) \times [1 + 0,294(5)] + 0,0076(10) \times [1 + 0,0202(3)]}$$

The deduced normalization factor is 0,373 (3).

Additional reference:

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