^{212}Fr α decay

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. J. Martin	NDS 108,1583 (2007)	1-Jun-2007

Parent: ^{212}Fr: E=0.0; $J^{\pi}=5^+$; $T_{1/2}$=20.0 min *6*; Q(α)=6528.8 *18*; %α decay=43 *2*

^{212}Fr-%α decay: Iα=43 *2*% (1950Hy27); based on ($\varepsilon+\beta^+$)/α=1.3 *1* determined from growth and decay of daughter (^{212}Rn) α activity.

The level scheme is that proposed by 2005Ku06 based on $\alpha\gamma$ coincidence work. These authors introduce a new level at 681.4, and a tentative new level at 208.3.

^{208}At Levels

E(level)[†]	J^{π}[‡]	$T_{1/2}$	Comments
0.0	6^+	1.63 h *3*	
23.48 *7*	$(5)^+$		
63.65 *10*	$(4)^+$		
71.82 *16*	7^+		
113.75 *19*	$(3)^+$		
147.93 *8*	5^+		
208.3 *3*	$(4,5)^+$		E(level): proposed by 2005Ku06 on the basis of the α energies at which the $\alpha\gamma$ coincidences were observed, and the 40.1-keV energy difference between the two observed gammas. The 145γ's were observed in coincidence with broad α-energy distributions at 6189 *15* and 6228 *5*, while the 185γ's were in coincidence with α energies of 6209 *12*, and 6225 *6*. The authors show the 208 level as tentative; however, the 144 and 185γ's are seen in ε decay, and although unplaced by the authors, the branching agrees well with that in α decay.
227.17 *8*	$(4^+,5,6^+)$		
237.24 *13*	$(4)^+$		
283.56 *10*	$(4^+,5^+)$		
334.69 *8*	$(4^+,5,6^+)$		
429.44 *14*			
588.15 *15*	$(4^+,5,6^+)$		
681.7 *5*			

[†] From a least-squares fit to the Eγ data.
[‡] From Adopted Levels.

α radiations

Eα[†]	E(level)	Iα[†@b]	HF[a]	Comments
5738[#] *6*	681.7	≈0.002[#]	≈189	
5828[#] *6*	588.15	0.05[#] *3*	21 *13*	
5983 *4*	429.44	0.071 *24*	81 *28*	
6076 *3*	334.69	0.43 *5*	36 *5*	
6127	283.56	1.19 *12*	22 *3*	
6173 *4*	237.24	1.09 *12*	38 *5*	
6183 *3*	227.17	1.30 *12*	35 *4*	
6198[c]	208.3			This α group has not been observed. Eα is from Q(α) and E(level).
6261.9[‡] *22*	147.93	38 *2*	2.65 *21*	Iα: weighted average of 37 *2* from 1974Ho27 and 40 *4* from 1966Va21. These authors used a fresh sample that was free of the 6264α from ^{212}Rn following the ε decay of ^{212}Fr. The spectrum of 1981Va27 contained this contaminant, and the authors deduced Iα using an intensity balance of γ transitions at the 148 level.
(6292)	113.75	<1.0	>132	Eα,Iα: this α branch has not been observed. Iα is estimated by the evaluator, and Eα comes from Q(α) and the level energy.

Continued on next page (footnotes at end of table)

^{212}Fr α decay (continued)

α radiations (continued)

Eα[†]	E(level)	Iα[†@b]	HF[a]
6335 *3*	71.82	10.2 *10*	20.7 *24*
6342 *3*	63.65	3.08 *24*	74 *8*
6383.3[‡] *20*	23.48	23.9[&] *9*	14.0 *10*
6406.2[‡] *20*	0.0	21.9[&] *9*	19.0 *14*

[†] From 1981Va27 except where noted otherwise. The two sets of closely-spaced α's, at 6342, 6335, and 6183, 6173, are not resolved by other authors. See also 1974Ho27 and 1966Va21. Other Eα:1955Mo69.

[‡] From 1981Va27, 1974Ho27, and 1966Va21 as recommended by 1991Ry01. The energies of these authors were corrected by 1991Ry01 for changes in calibration energies as follows: −0.4 keV (1981Va27), +0.7 keV (1974Ho27), +0.8 (1966Va21).

[#] Eα is from 2005Ku06. 1966Va21 report Eα=5829 *8* with Iα=0.05 *3*. The 5738α is reported only by 2005Ku06, and Iα is deduced relative to Iα(5828).

[@] From 1981Va27 except where noted otherwise.

[&] Weighted average from 1981Va27, 1974Ho27, and 1966Va21.

[a] $r_0(^{208}At)$=1.454 *7*.

[b] For absolute intensity per 100 decays, multiply by 0.43 *2*.

[c] Existence of this branch is questionable.

^{212}Fr α decay (continued)

γ(^{208}At)

Iγ normalization, I(γ+ce) normalization: see comment on Iγ,I(γ+ce).

E_γ [†]	I_γ [‡&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[a]	$I_{(\gamma+ce)}$ [‡&]	Comments
23.5 *2*	0.396 *11*	23.48	$(5)^+$	0.0	6^+	M1(+E2)[@]	≤0.027[@]	166 *3*	66.2 *14*	I_γ: from I(γ+ce) and α. The measured I(ce(M))=12 *6* gives Iγ=0.40 *20*. $I_{(\gamma+ce)}$: from an intensity balance at the 23.5 level. The measured ce(M)=12 *6* gives I(γ+ce)=67 *33*.
40.1 *2*	0.48 *6*	63.65	$(4)^+$	23.48	$(5)^+$	M1(+E2)[@]	≤0.026[@]	33.8 *2*	16.7 *21*	I_γ: ce(L1)=13 *4*, ce(L2)=2.0 *7*, ce(M)=3.9 *5*. These intensities, along with the adopted mult give Iγ=0.57 *18*, 0.78 *27*, and 0.64 *8*, respectively. A weighted average gives Iγ=0.64 *7* and thus I(γ+ce)=22.3 *24*. The normalization to the Iα values gives Iγ=0.48 *6* and I(γ+ce)=16.7 *21*.
50.3 *3*		113.75	$(3)^+$	63.65	$(4)^+$	M1(+E2)	≤0.046	18.6 *2*	1.1 *5*	$I_{(\gamma+ce)}$: from the decay scheme, I(γ+ce)≥I(γ+ce)(169.9γ) (=0.63 *13*). I(γ+ce) is deduced by taking Iα≤1%.
71.9 *2*	1.44 *14*	71.82	7^+	0.0	6^+	M1		6.065	10.2 *10*	I_γ: from I(γ+ce) and α. $I_{(\gamma+ce)}$: from an intensity balance at the 72 level. Mult.: the directly measured quantities are Iγ=1.6 *5*, ce(L12)=6.3 *5*, and ce(N)=0.21 *7*. These data are mutually inconsistent, with α(N)exp and ce(N)/ce(L12) both lying outside the M1 and E2 theory values. α(L12)exp gives δ<0.36 and thus α=7.8 *17*. The measured Iγ and the adopted I(γ+ce) give α=5.4 *+29−15*. The evaluator adopts mult=M1 from (α,5nγ).
84.1	2.5 *8*	147.93	5^+	63.65	$(4)^+$	[M1]		3.84	12 *4*	E_γ: seen only in the ce spectrum of 1973GoXM. Not reported by 2005Ku06. I_γ: from I(γ+ce) for mult=M1. Mult.,$I_{(\gamma+ce)}$: the measured quantities are ce(L12)=4.5 *8*, ce(M)=1.8 *6*, and ce(N)=0.3. These data do not distinguish between M1 and E2. The authors assign a tentative M1 multipolarity. For mult=M1, one gets I(γ+ce)=7.5 *14* from ce(L12), and 13 *4* from ce(M). The evaluator adopts I(γ+ce)=12 *4* from an intensity balance at the 63.6 level. See general comment on I(γ+ce) and Iγ.
[x]92										E_γ: from 1983Fa03 observed in coincidence with 6.28-MeV α group from the decay of mass=212.2 *14*.
124.5 *1*	3.3 *4*	147.93	5^+	23.48	$(5)^+$	M1		6.48	25 *3*	Mult.,δ: the measured quantities are Iγ=5.7 *5*, ce(K)=19.7 *50*, and ce(L12)=4.3 *4*. From K/L12 one gets δ<0.77. The measured Iγ appears to be too large since it yields a value of α(L12)exp that is smaller than the M1 theory value. The evaluator adopts mult=M1.

$^{208}_{85}At_{123}$-3

^{212}Fr α decay (continued)

$\gamma(^{208}At)$ (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	α[a]	$I_{(\gamma+ce)}$[‡&]	Comments
										I_γ,$I_{(\gamma+ce)}$: from ce(K) one gets Iγ=3.8 *10*, I(γ+ce)=28 *7* and from ce(L12) one gets Iγ=4.6 *4* and I(γ+ce)=34 *3*. A weighted average gives I(γ+ce)=33 *4* and from α one gets Iγ=4.4 *4*. Normalization to the Iα values then gives I(γ+ce)=25 *3* and Iγ=3.3 *4*.
144.6 *2*		208.3	(4,5)$^+$	63.65	(4)$^+$					I_γ: see comment on the 185γ.
147.9 *1*	0.17 *4*	147.93	5$^+$	0.0	6$^+$	(M1+E2)	≈2.3	≈2.0	≈0.5	I_γ: from Iγ/Iγ(124γ)=0.05 *1* (2005Ku06). 1973GoXM report Iγ≈0.5. Mult.,δ: the measured quantities are Iγ=0.5 and I(ce(K))=0.4, with no uncertainties quoted. These data give δ≈2.3 and α≈2.0.
163.5 *2*	0.030 *13*	227.17	(4$^+$,5,6$^+$)	63.65	(4)$^+$	[M1,E2]		2.0 *10*	0.09 *5*	
169.9 *2*	0.23 *5*	283.56	(4$^+$,5$^+$)	113.75	(3)$^+$	[M1,E2]		1.8 *9*	0.63 *13*	
173.6 *1*	0.25 *6*	237.24	(4)$^+$	63.65	(4)$^+$	[M1,E2]		1.7 *9*	0.69 *14*	
184.7 *1*		208.3	(4,5)$^+$	23.48	(5)$^+$					I_γ: 2005Ku06 report Iγ/Iγ(145γ)=0.71 *13*, but since the possible α feeding to the 208 level has not been observed, no absolute Iγ or I(γ+ce) intensities can be deduced.
202.3 *8*	0.006 *4*	429.44		227.17	(4$^+$,5,6$^+$)	[M1,E2]		1.1 *6*	0.011 *8*	
203.7 *1*	0.23 *6*	227.17	(4$^+$,5,6$^+$)	23.48	(5)$^+$	[M1,E2]		1.0 *6*	0.45 *14*	
213.7 *2*	0.22 *6*	237.24	(4)$^+$	23.48	(5)$^+$	[M1,E2]		0.9 *5*	0.40 *12*	
219.9 *1*	0.12 *3*	283.56	(4$^+$,5$^+$)	63.65	(4)$^+$	[M1,E2]		0.8 *4*	0.21 *7*	
227.2 *1*	0.46 *10*	227.17	(4$^+$,5,6$^+$)	0.0	6$^+$	[M1,E2]		0.8 *5*	0.80 *15*	
260.1 *1*	0.23 *4*	283.56	(4$^+$,5$^+$)	23.48	(5)$^+$	[M1,E2]		0.51 *30*	0.34 *9*	
271.0 *2*	0.070 *12*	334.69	(4$^+$,5,6$^+$)	63.65	(4)$^+$	[M1,E2]		0.45 *27*	0.101 *22*	
281.6 *2*	0.019 *4*	429.44		147.93	5$^+$	[M1,E2]		0.41 *25*	0.027 *10*	
283.2 *5*	0.005 *3*	283.56	(4$^+$,5$^+$)	0.0	6$^+$	[M1,E2]		0.40 *24*	0.007 *5*	
304.7 *2*	0.006 *4*	588.15	(4$^+$,5,6$^+$)	283.56	(4$^+$,5$^+$)	[M1,E2]		0.33 *20*	0.008 *6*	
311.2 *1*	0.061 *7*	334.69	(4$^+$,5,6$^+$)	23.48	(5)$^+$	[M1,E2]		0.31 *19*	0.081 *16*	
334.7 *1*	0.20 *3*	334.69	(4$^+$,5,6$^+$)	0.0	6$^+$	[M1,E2]		0.25 *16*	0.247 *36*	
357.7 *2*	0.013 *5*	429.44		71.82	7$^+$	[M1,E2]		0.21 *13*	0.015 *6*	
361.3 *3*	0.015 *9*	588.15	(4$^+$,5,6$^+$)	227.17	(4$^+$,5,6$^+$)	[M1,E2]		0.20 *13*	0.018 *11*	
405.8 *2*	0.015 *6*	429.44		23.48	(5)$^+$	[M1,E2]		0.15 *9*	0.017 *7*	
440.6[b] *7*	0.0036 *21*	588.15	(4$^+$,5,6$^+$)	147.93	5$^+$	[M1,E2]		0.12 *7*	0.004 *3*	E_γ: due to a lack of statistics, the authors give a tentative assignment to this transition.
524.2 *3*	0.011 *7*	588.15	(4$^+$,5,6$^+$)	63.65	(4)$^+$	[M1,E2]		0.08 *5*	0.012 *8*	
587.9 *3*	0.008 *5*	588.15	(4$^+$,5,6$^+$)	0.0	6$^+$	[M1,E2]		0.06 *4*	0.008 *5*	
681.7 *5*	≈0.002	681.7		0.0	6$^+$				≈0.002	

$^{208}_{85}At_{123}$-4

^{212}Fr α decay (continued)

$\gamma(^{208}At)$ (continued)

† From 2005Ku06.
‡ Photon and total intensities deexciting the 227 and higher levels have been deduced by the evaluator using the adopted Iα values, the relative photon branchings from each level of 2005Ku06, the requirement of an intensity balance at each level, and the assumption that the multipolarities are M1 or E2. The relative photon branchings of 2005Ku06 are given in adopted gammas. For the lower levels, the intensities are deduced from the ce data of 1973GoXM as noted in each case, and the normalization to the Iα intensities is achieved by intensity balances. From intensity balances at the g.s. and 23.5 levels, one obtains Iγ normalization=I(γ+ce) normalization=0.745 *63*, and from intensity balances at the 63.6 and 147.9 levels one obtains Iγ normalization=I(γ+ce) normalization=0.764 *65*. The evaluator adopts a weighted average of 0.75 *5*. This factor is included in the intensities given, so that the intensities of both the low- and high-lying levels are on the same scale, that is, intensities per 100 α decays. The intensity of the 84.1γ as deduced from the ce data is inconsistent with that deduced from the α branch feeding the 63.3 level. The evaluator has adopted the value required by an intensity balance at the 63.6 level.
# From α(exp). Values from 1973GoXM are deduced from the authors′ measured ce data and Iγ data, as noted, normalized such that α(K)(227.72γ)=0.126. The 227.72γ is a known E2 transition following ^{212}Fr ε decay.
@ From adopted gammas.
& For absolute intensity per 100 decays, multiply by 0.43 *2*.
a Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
b Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

$^{208}_{85}At_{123}$-5

^{212}Fr α decay

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

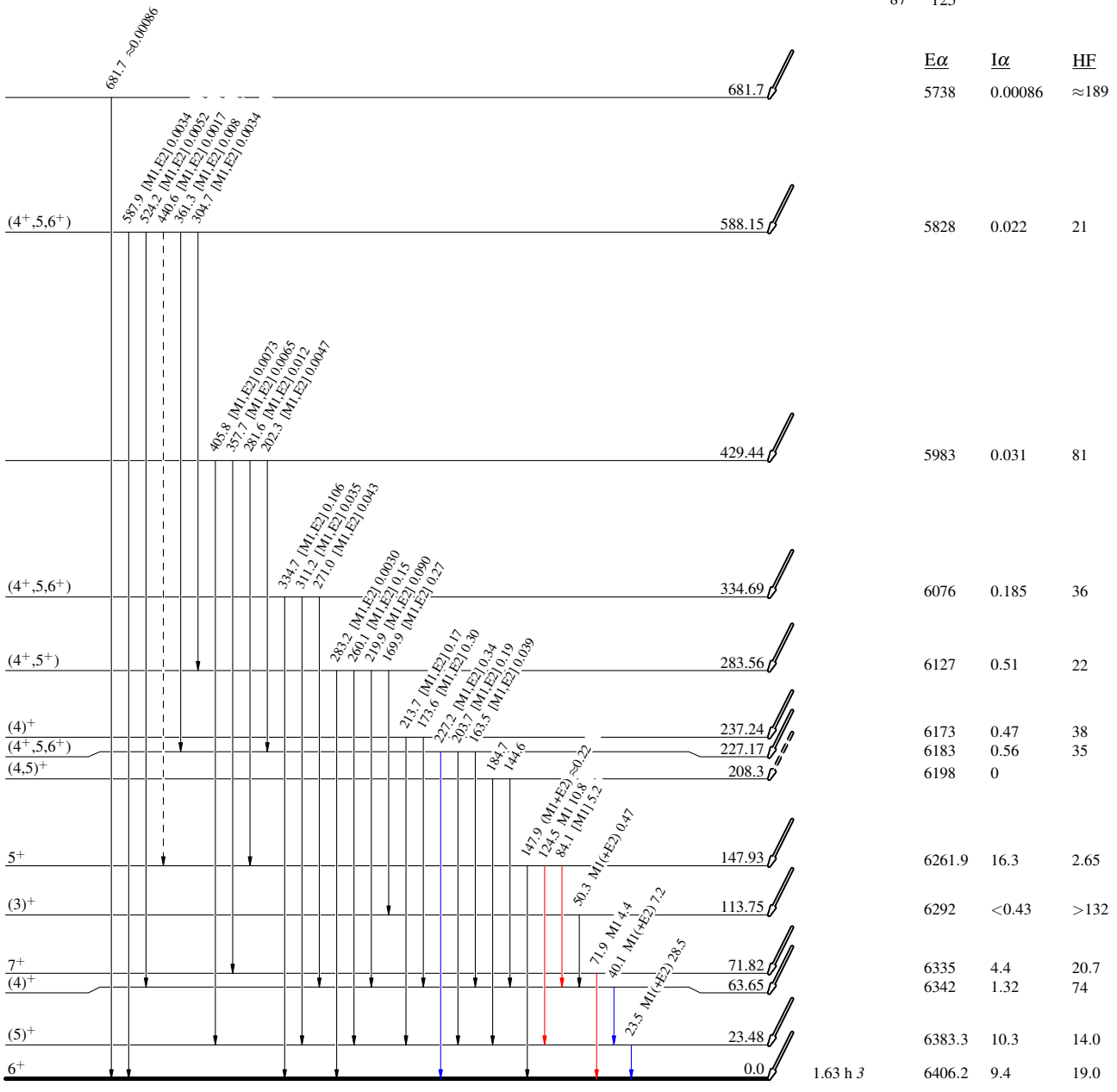
Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)

5^+ 0.0 20.0 min *6*

Q_α=6528.8 *18* %α=43

$^{212}_{87}Fr_{125}$



		Eα	Iα	HF
681.7		5738	0.00086	≈189
588.15		5828	0.022	21
429.44		5983	0.031	81
334.69		6076	0.185	36
283.56		6127	0.51	22
237.24		6173	0.47	38
227.17		6183	0.56	35
208.3		6198	0	
147.93		6261.9	16.3	2.65
113.75		6292	<0.43	>132
71.82		6335	4.4	20.7
63.65		6342	1.32	74
23.48		6383.3	10.3	14.0
0.0	1.63 h *3*	6406.2	9.4	19.0

$^{208}_{85}At_{123}$