^{231}U α decay (4.2 d) 1997Mu08

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Ictp-2014 Workshop Group	NDS 132, 257 (2016)	15-Jan-2016

Parent: ^{231}U: E=0.0; J^π=(5/2$^-$); $T_{1/2}$=4.2 d *1*; Q(α)=5576.3 *17*; %α decay=0.004 *1*

^{231}U-%α decay: from the measured ratio of the ^{232}U/^{231}Pa alpha intensity to the ^{232}U/^{231}U alpha intensity, corrected for relative half-lives (1994Li12).

1997Mu08: ^{231}U activity from the ^{232}Th(α,5n) reaction with E(α)=53 MeV followed by mass separation with the Bonn isotope separator. Measured Eα, Iα, α-γ coin, Eγ, Iγ, Ice, α-ε coin. using an ion-implanted silicon detector for α's, a cooled PIN diode for conversion electrons and a LEPS Ge detector for γ's.

1994Li12: ^{231}U activity from the ^{232}Th(α,5n) reaction with E(α)=45 MeV followed by chemical separation. Measured Eα, Iα for the three main alpha groups using an ion-implanted Si detector and $\alpha\gamma$ coincidences using intrinsic Ge crystal; deduce α branching ratio.

1997Mu08 performed a nuclear orientation experiment with ^{227}Th at low temperature. The angular distribution of the three main α groups from ^{227}Th was determined to be isotropic. This result suggests J=1/2 for ^{227}Th g.s. Also, they suggested to be in error previous experiments that showed γ-ray anisotropies.

Coexistence of reflection-symmetric (singlet rotational bands) and reflection-asymmetric (parity doublet rotational bands) shapes is expected in ^{227}Th. 1997Mu08 interpreted the low-lying levels of ^{227}Th in terms of a K^π=1/2± parity doublet, and a K^π=3/2$^+$ rotational band coupled to the J^π=3/2$^+$ member of the parity doublet by the Coriolis interaction.

Total energy release of 0.227 *1* is calculated by the evaluators using the RADLST code, which is in good agreement with the effective Q value of 0.22 *6*, confirming the consistency of the decay scheme.

^{227}Th Levels

E(level)†	J^π‡	$T_{1/2}$	Comments
0.0#	(1/2$^+$)	18.68 d *9*	$T_{1/2}$: from the Adopted Levels. J^π: 1/2 from isotropic angular distribution of three main alpha groups following ^{227}Th decay in low temperature nuclear orientation experiment (1997Mu08).
9.29# *3*	(5/2$^+$)		
24.38 *3*	(3/2$^+$)		J^π: proposed as 3/2$^+$ member of K^π=3/2$^+$ rotational band (1997Mu08).
37.863@ *25*	(3/2$^-$)		
73.67@ *4*	(7/2$^-$)		
76.23# *4*	(9/2$^+$)		
77.62 *3*	(3/2$^+$)		J^π: other: proposed as 5/2$^+$ member of K^π=3/2$^+$ rotational band (1997Mu08).
86.81? *7*			J^π: proposed as 9/2$^+$ member of K^π=1/2$^+$ rotational band (1997Mu08). This contradicts assignment by 2002Ha30 in ^{226}Ra(α,3nγ) where the 76.2-keV level was assigned as the 9/2$^+$ member.
99.19 *3*	(3/2$^+$,5/2$^+$)		J^π: proposed as 3/2$^+$ member of K^π=1/2$^+$ parity doublet rotational band (1997Mu08).
127.30 *4*	(3/2$^+$,5/2$^+$)		
183.71 *4*	(1/2$^-$,3/2$^-$,5/2$^-$)		
200.02 *7*	(−)		
228.48 *11*	(3/2$^-$,5/2$^-$)		J^π: proposed as 5/2$^-$ member of K^π=1/2$^-$ parity doublet rotational band (1997Mu08).
231.46 *9*	(5/2$^-$,7/2$^-$,9/2$^-$)		
289.04 *3*	(1/2$^+$,3/2$^+$,5/2$^+$)		
318.95 *7*	(5/2$^+$,7/2$^+$)		
400.14 *20*			

† From a least-squares fit to Eγ, by evaluators.
‡ From the Adopted Levels.
# Band(A): K^π=1/2$^+$ parity doublet rotational band.
@ Band(a): K^π=1/2$^-$ parity doublet rotational band.

^{231}U α decay (4.2 d) 1997Mu08 (continued)

α radiations

Eα[†]	E(level)	Iα[†#]	HF[‡]	Comments
5087	400.14			Iα: ≈0.019 deduced by evaluators from γ-ray transition intensity balance.
5167	318.95	0.22	149	Iα: 0.14 *2* deduced by evaluators from γ-ray transition intensity balance.
5196	289.04	0.77	65	Iα: 0.72 *8* deduced by evaluators from γ-ray transition intensity balance.
5252	231.46	0.20	549	Iα: 0.22 *4* deduced by evaluators from γ-ray transition intensity balance.
5255	228.48	≈0.05	≈2289	Iα: 0.05 *1* deduced by evaluators from γ-ray transition intensity balance.
5283	200.02	0.30	561	Iα: 0.093 *12* deduced by evaluators from γ-ray transition intensity balance.
5299	183.71	0.39	538	Iα: 0.26 *2* deduced by evaluators from γ-ray transition intensity balance.
5355	127.30	0.67	664	Iα: 0.73 *11* deduced by evaluators from γ-ray transition intensity balance.
5383	99.19	5.4	119	Iα: 3.5 *15* deduced by evaluators from γ-ray transition intensity balance.
5394	86.81?	≈1.4	≈541	Not observed. Eα is from Q(α) and level energy. Iα is from γ-ray transition intensity balance, assuming an E2 multipolarity for 77.52γ.
5404 *4*	77.62	21.1	40	Eα: from 1994Li12. Other: 5404 (1997Mu08). Iα: 23 *6* deduced by evaluators from γ-ray transition intensity balance. Iα: the α-particle groups to the 77.6- and 76.2-keV levels were not resolved. 1997Mu08 assumed α feeding to the 76.2-keV level, and odd parity for this state. However, if the parity were even, the 51.9- and 66.9-keV γ rays would have an M1 multipolarity, and consequently the 76.2-keV level would receive an ≈3% α feeding. Iα: other: 26% *3* (1994Li12).
5408	73.67	≤0.3	≥2243	Iα: 0.03 *4* deduced by evaluators from γ-ray transition intensity balance.
5443	37.863	≈0.6	≈2382	Iα: 0.60 *13* deduced by evaluators from γ-ray transition intensity balance.
5456 *3*	24.38	42.3	40	Eα: from 1994Li12. Others: 5456 (1997Mu08); ≈5455 (1950Cr28,1953Cr67). Iα: other: 40% *4* (1994Li12).
5471 *3*	9.29	27.9	74	Eα: from 1994Li12. Other: 5471 (1997Mu08). Iα: other: 34% *4* (1994Li12).
5480	0.0	≈0.7	≈3318	

[†] From 1997Mu08, unless otherwise specified.
[‡] Using $r_0(^{227}Th)$=1.530, average of $r_0(^{226}Th)$=1.531 *5* and $r_0(^{228}Th)$=1.5289 *5* (1998Ak04).
[#] For absolute intensity per 100 decays, multiply by 4×10^{-5} *1*.

$\gamma(^{227}Th)$

Iγ normalization: measured value (1997Mu08).

E_γ	I_γ[@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[†]	δ[†]	α[#]	$I_{(\gamma+ce)}$[@]	Comments
9.3 *1*	≈0.043	9.29	(5/2$^+$)	0.0	(1/2$^+$)	(E2)		3.26×10^5 *19*	≈14000	ce(M)/(γ+ce)=0.75 *3*; ce(N)/(γ+ce)=0.200 *15*; ce(O)/(γ+ce)=0.044 *4*; ce(P)/(γ+ce)=0.0072 *6*; ce(Q)/(γ+ce)=8.7×10^{-6} *7* α(M)=2.44×10^5 *4*; α(O)=1.44×10^4 *9*; α(P)=2.37×10^3 *14*; α(Q)=2.85 *15* Iγ: deduced by evaluators from γ-ray transition intensity balance, and Iα=27.9 to 9.3 level. Eγ: from the Adopted Gammas.
15.2 *1*	≈23	24.38	(3/2$^+$)	9.29	(5/2$^+$)	(M1)		238 *6*	≈5400	ce(M)/(γ+ce)=0.741 *13*; ce(N)/(γ+ce)=0.198 *6*; ce(O)/(γ+ce)=0.0469 *16*; ce(P)/(γ+ce)=0.0091 *4*; ce(Q)/(γ+ce)=0.00087 *3* α(M)=177 *12*; α(O)=11.2 *3*; α(P)=2.17 *6*; α(Q)=0.208 *5* Eγ: from the Adopted Gammas. Iγ: deduced by evaluators from γ-ray transition intensity balance, and Iα=42.3 to 24.4 level.
24.33 *5*	20 *4*	24.38	(3/2$^+$)	0.0	(1/2$^+$)	M1+E2	0.097 *5*	334 *12*		α(L)=250 *9*; α(M)=62.8 *23*; α(N)=16.8 *6*; α(O)=3.89 *14*; α(P)=0.721 *23*; α(Q)=0.0512 *8*
28.57 *5*	25 *5*	37.863	(3/2$^-$)	9.29	(5/2$^+$)	E1		3.23		α(L)=2.42 *4*; α(M)=0.616 *9*; α(N)=0.1595 *24*; α(O)=0.0341 *5*; α(P)=0.00517 *8* α(Q)=0.000182 *3*
37.90 *3*	26 *5*	37.863	(3/2$^-$)	0.0	(1/2$^+$)	E1		1.537		α(L)=1.155 *17*; α(M)=0.288 *4*; α(N)=0.0750 *11*; α(O)=0.01634 *24*; α(P)=0.00260 *4* α(Q)=0.0001035 *15*
39.88 *6*	8 *2*	77.62	(3/2$^+$)	37.863	(3/2$^-$)	E1		1.343		α(L)=1.010 *15*; α(M)=0.251 *4*; α(N)=0.0654 *10*; α(O)=0.01430 *21*; α(P)=0.00229 *4* α(Q)=9.33×10^{-5} *14*
[x]42.09 *6*	4.4 *10*									
51.85[&] *4*	7.9 *15*	76.23	(9/2$^+$)	24.38	(3/2$^+$)					Eγ: questionable placement as transition would require M3 or E4 multipolarities based on adopted J^π.
53.23 *2*	83 *8*	77.62	(3/2$^+$)	24.38	(3/2$^+$)	M1(+E2)	≤0.33	34 *10*		α(L)=25 *8*; α(M)=6.4 *21*; α(N)=1.7 *6*; α(O)=0.39 *12*; α(P)=0.072 *20*; α(Q)=0.00488 *20* Eγ: other: 53.3 *1* (1994Li12). Mult.,δ: from L and M conversion electron intensity (1997Mu08).

$\gamma(^{227}Th)$ (continued)

E_γ	I_γ [@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[†]	δ[†]	α[#]	Comments
56.41 *2*	30 *3*	183.71	(1/2$^-$,3/2$^-$,5/2$^-$)	127.30	(3/2$^+$,5/2$^+$)	E1		0.535	α(L)=0.403 *6*; α(M)=0.0991 *14*; α(N)=0.0259 *4*; α(O)=0.00576 *8*; α(P)=0.000965 *14* α(Q)=4.53×10^{-5} *7* Mult.: from $\alpha\gamma$ intensity balance (1997Mu08).
[x]58.1 *2*	3 *1*								
60.6 *2*	1.3 *4*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	228.48	(3/2$^-$,5/2$^-$)	[E1]		0.442 *8*	α(L)=0.334 *6*; α(M)=0.0818 *14*; α(N)=0.0214 *4*; α(O)=0.00478 *8*; α(P)=0.000806 *14* α(Q)=3.89×10^{-5} *7*
61.33 *3*	20 *2*	99.19	(3/2$^+$,5/2$^+$)	37.863	(3/2$^-$)	E1		0.429	α(L)=0.323 *5*; α(M)=0.0792 *12*; α(N)=0.0207 *3*; α(O)=0.00463 *7*; α(P)=0.000782 *11* α(Q)=3.79×10^{-5} *6* Mult.: from an upper limit on the L-conversion electron intensity (1997Mu08).
64.38[‡] *2*	39 *3*	73.67	(7/2$^-$)	9.29	(5/2$^+$)	E1		0.377	α(L)=0.284 *4*; α(M)=0.0696 *10*; α(N)=0.0182 *3*; α(O)=0.00407 *6*; α(P)=0.000692 *10* α(Q)=3.42×10^{-5} *5* Mult.: from an upper limit on the L-conversion electron intensity (1997Mu08).
66.94 *3*	31 *3*	76.23	(9/2$^+$)	9.29	(5/2$^+$)				E_γ: other: unplaced 64.3 transition in 1994Li12. E_γ: other: unplaced 67.0 transition in 1994Li12. 1995Li04 proposed a 67.0-keV level (J^π=(1/2$^-$)), which is populated mostly from a 142-keV level and deexcited by a 67.0-keV γ ray. The 142-keV level has been proven to be inconsistent with α-γ coin data of 1997Mu08. The existence of the 67.0-keV level is therefore uncertain.
68.33 *2*	100 *5*	77.62	(3/2$^+$)	9.29	(5/2$^+$)	M1(+E2)	≤0.50	17 *6*	α(L)=13 *5*; α(M)=3.2 *12*; α(N)=0.9 *4*; α(O)=0.20 *7*; α(P)=0.037 *11*; α(Q)=0.00224 *21* E_γ: other: 68.4 *1* (1994Li12). Mult.,δ: from L and M conversion electron intensity (1997Mu08).
[x]72.14 *7*	13 *3*								
72.78 *7*	10 *2*	200.02	(−)	127.30	(3/2$^+$,5/2$^+$)	E1		0.272	α(L)=0.205 *3*; α(M)=0.0501 *8*; α(N)=0.01314 *19*; α(O)=0.00295 *5*; α(P)=0.000508 *8* α(Q)=2.62×10^{-5} *4* Mult.: from $\alpha\gamma$ intensity balance (1997Mu08).
74.85[‡] *5*	12 *2*	99.19	(3/2$^+$,5/2$^+$)	24.38	(3/2$^+$)	[M1+E2]		26 *18*	α(L)=19 *13*; α(M)=5 *4*; α(N)=1.4 *10*; α(O)=0.32 *22*; α(P)=0.05 *4*; α(Q)=0.0011 *8*
77.52[&] *6*	7.8 *15*	86.81?		9.29	(5/2$^+$)				
89.88 *5*	25 *6*	99.19	(3/2$^+$,5/2$^+$)	9.29	(5/2$^+$)	[M1+E2]		12 *7*	α(L)=9 *5*; α(M)=2.3 *14*; α(N)=0.6 *4*; α(O)=0.14 *9*; α(P)=0.024 *13*; α(Q)=0.0006 *5*
99.09 *8*	6.4 *15*	99.19	(3/2$^+$,5/2$^+$)	0.0	(1/2$^+$)	[M1+E2]		8 *4*	α(L)=6 *3*; α(M)=1.5 *9*; α(N)=0.41 *23*; α(O)=0.09 *5*; α(P)=0.016 *8*; α(Q)=0.0005 *4*

$\gamma(^{227}Th)$ (continued)

E_γ	I_γ[@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[†]	α[#]	Comments
102.93 *4*	21 *2*	127.30	(3/2$^+$,5/2$^+$)	24.38	(3/2$^+$)	M1	3.49	α(L)=2.63 *4*; α(M)=0.634 *9*; α(N)=0.1691 *24*; α(O)=0.0400 *6*; α(P)=0.00777 *11* α(Q)=0.000739 *11* Mult.: from γ-ray transition intensity balance and comparison with measured K x ray intensity (1997Mu08).
111.1 *2*	≈4	400.14		289.04	(1/2$^+$,3/2$^+$,5/2$^+$)			
117.98 *7*	9.2 *18*	127.30	(3/2$^+$,5/2$^+$)	9.29	(5/2$^+$)	M1	11.58	α(K)=9.23 *13*; α(L)=1.78 *3*; α(M)=0.427 *6*; α(N)=0.1140 *16*; α(O)=0.0270 *4*; α(P)=0.00524 *8* α(Q)=0.000498 *7* Mult.: from γ-ray transition intensity balance and comparison with measured K x ray intensity (1997Mu08).
[x]124.80 *8*	7.5 *15*							
150.7 *2*	4 *2*	228.48	(3/2$^-$,5/2$^-$)	77.62	(3/2$^+$)	E1	0.185	α(K)=0.1446 *21*; α(L)=0.0305 *5*; α(M)=0.00737 *11*; α(N)=0.00194 *3*; α(O)=0.000446 *7* α(P)=8.07×10^{-5} *12*; α(Q)=5.26×10^{-6} *8*
157.79 *8*	7.7 *15*	231.46	(5/2$^-$,7/2$^-$,9/2$^-$)	73.67	(7/2$^-$)	(M1)	5.08	α(K)=4.06 *6*; α(L)=0.773 *11*; α(M)=0.186 *3*; α(N)=0.0496 *7*; α(O)=0.01173 *17* α(P)=0.00228 *4*; α(Q)=0.000216 *3* Mult.: from measured K x-ray intensity (1997Mu08).
159.39 *8*	7.7 *15*	183.71	(1/2$^-$,3/2$^-$,5/2$^-$)	24.38	(3/2$^+$)	[E1]	0.1618	α(K)=0.1268 *18*; α(L)=0.0264 *4*; α(M)=0.00638 *9*; α(N)=0.001684 *24*; α(O)=0.000387 *6* α(P)=7.02×10^{-5} *10*; α(Q)=4.65×10^{-6} *7*
189.9 *3*	2.2 *7*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	99.19	(3/2$^+$,5/2$^+$)	[M1+E2]	1.9 *11*	α(K)=1.3 *12*; α(L)=0.457 *7*; α(M)=0.117 *8*; α(N)=0.0314 *22*; α(O)=0.0072 *3*; α(P)=0.00130 *5* α(Q)=7.E−5 *6*
190.62 *10*	6.1 *14*	200.02	(−)	9.29	(5/2$^+$)	[E1]	0.1057	α(K)=0.0835 *12*; α(L)=0.01681 *24*; α(M)=0.00405 *6*; α(N)=0.001070 *15*; α(O)=0.000247 *4* α(P)=4.52×10^{-5} *7*; α(Q)=3.13×10^{-6} *5*
204.2 *2*	4.1 *10*	228.48	(3/2$^-$,5/2$^-$)	24.38	(3/2$^+$)	E1	0.0899	α(K)=0.0711 *10*; α(L)=0.01416 *21*; α(M)=0.00341 *5*; α(N)=0.000901 *13*; α(O)=0.000208 *3* α(P)=3.82×10^{-5} *6*; α(Q)=2.69×10^{-6} *4*
211.4 *2*	4.9 *10*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	77.62	(3/2$^+$)	[M1+E2]	1.4 *9*	α(K)=1.0 *9*; α(L)=0.314 *25*; α(M)=0.0800 *16*; α(N)=0.0214 *4*; α(O)=0.00493 *20* α(P)=0.00090 *10*; α(Q)=5.E−5 *5*
219.6 *4*	2.7 *10*	228.48	(3/2$^-$,5/2$^-$)	9.29	(5/2$^+$)	E1	0.0758	α(K)=0.0602 *9*; α(L)=0.01183 *18*; α(M)=0.00285 *5*; α(N)=0.000752 *11*; α(O)=0.000174 *3* α(P)=3.21×10^{-5} *5*; α(Q)=2.30×10^{-6} *4*
241.2[&] *3*	0.7 *3*	318.95	(5/2$^+$,7/2$^+$)	77.62	(3/2$^+$)	[M1+E2]	0.9 *6*	α(K)=0.7 *6*; α(L)=0.20 *4*; α(M)=0.051 *6*; α(N)=0.0135 *14*; α(O)=0.0031 *4*; α(P)=0.00058 *11* α(Q)=4.E−5 *3*
242.7 *2*	1.7 *6*	318.95	(5/2$^+$,7/2$^+$)	76.23	(9/2$^+$)			
264.66 *3*	36 *3*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	24.38	(3/2$^+$)	M1	1.191	α(K)=0.953 *14*; α(L)=0.180 *3*; α(M)=0.0432 *6*; α(N)=0.01152 *17*; α(O)=0.00273 *4*

$^{227}_{90}Th_{137}$-5

$\gamma(^{227}\text{Th})$ (continued)

E_γ	I_γ [@]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [†]	α [#]	Comments
								α(P)=0.000529 *8*; α(Q)=5.02×10^{-5} *7* Mult.: from measured K x-ray intensity (1997Mu08).
279.76 *5*	19 *2*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	9.29	(5/2$^+$)	[M1+E2]	0.6 *4*	α(K)=0.5 *4*; α(L)=0.12 *3*; α(M)=0.031 *6*; α(N)=0.0083 *16*; α(O)=0.0019 *5*; α(P)=0.00036 *10* α(Q)=2.4×10^{-5} *19*
289.01 *6*	16 *2*	289.04	(1/2$^+$,3/2$^+$,5/2$^+$)	0.0	(1/2$^+$)	[M1+E2]	0.6 *4*	α(K)=0.4 *4*; α(L)=0.11 *3*; α(M)=0.028 *6*; α(N)=0.0074 *16*; α(O)=0.0017 *4*; α(P)=0.00032 *10* α(Q)=2.2×10^{-5} *18*
294.5 *2*	3 *1*	318.95	(5/2$^+$,7/2$^+$)	24.38	(3/2$^+$)	[M1+E2]	0.5 *4*	α(K)=0.4 *4*; α(L)=0.10 *3*; α(M)=0.026 *6*; α(N)=0.0070 *16*; α(O)=0.0016 *4*; α(P)=0.00030 *9* α(Q)=2.1×10^{-5} *17*
309.68 *7*	12 *2*	318.95	(5/2$^+$,7/2$^+$)	9.29	(5/2$^+$)	M1	0.772	α(K)=0.618 *9*; α(L)=0.1162 *17*; α(M)=0.0279 *4*; α(N)=0.00744 *11*; α(O)=0.001762 *25* α(P)=0.000342 *5*; α(Q)=3.24×10^{-5} *5* Mult.: from measured K x-ray intensity (1997Mu08).

[†] From the Adopted Gammas. In cases where information on the multipolarity and δ originate from this dataset, support is provided in the comments.
[‡] 1995Li04 proposed a 142-keV level deexcited by 64.3- and 74.7-keV γ rays. This assignment, however, is inconsistent with the observation of these γ rays in coincidence with 5370-5425 keV α particles (1997Mu08).
[#] From BrIcc v2.3 (29-Mar-2013) 2008Ki07, "Frozen Orbitals" appr. α value overlaps M1 and E2, when δ(E2/M1) not given.
[@] For absolute intensity per 100 decays, multiply by 1.9×10^{-7} *5*.
[&] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

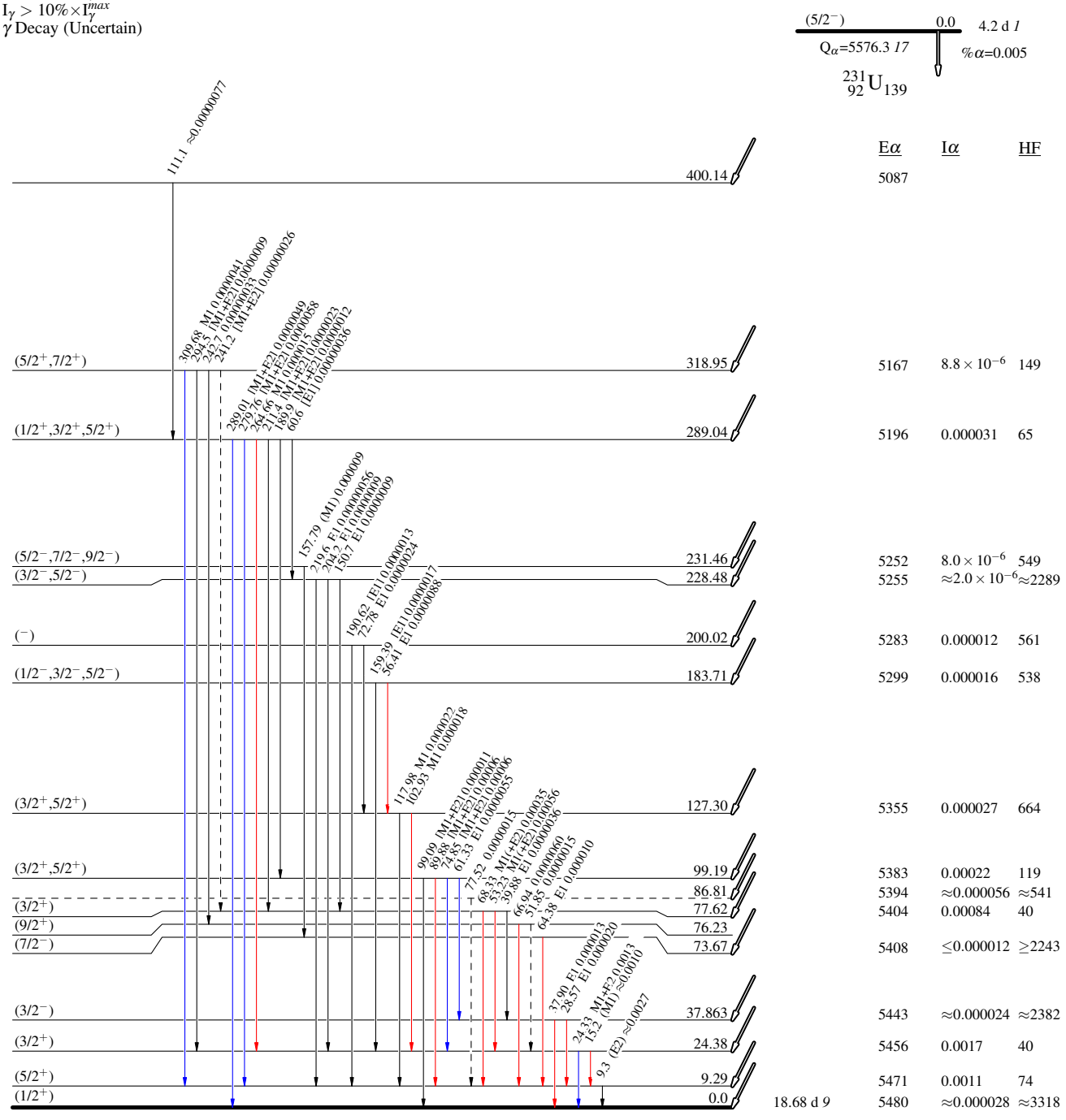
$^{227}_{90}$Th$_{137}$-6

^{231}U α decay (4.2 d) 1997Mu08

Decay Scheme

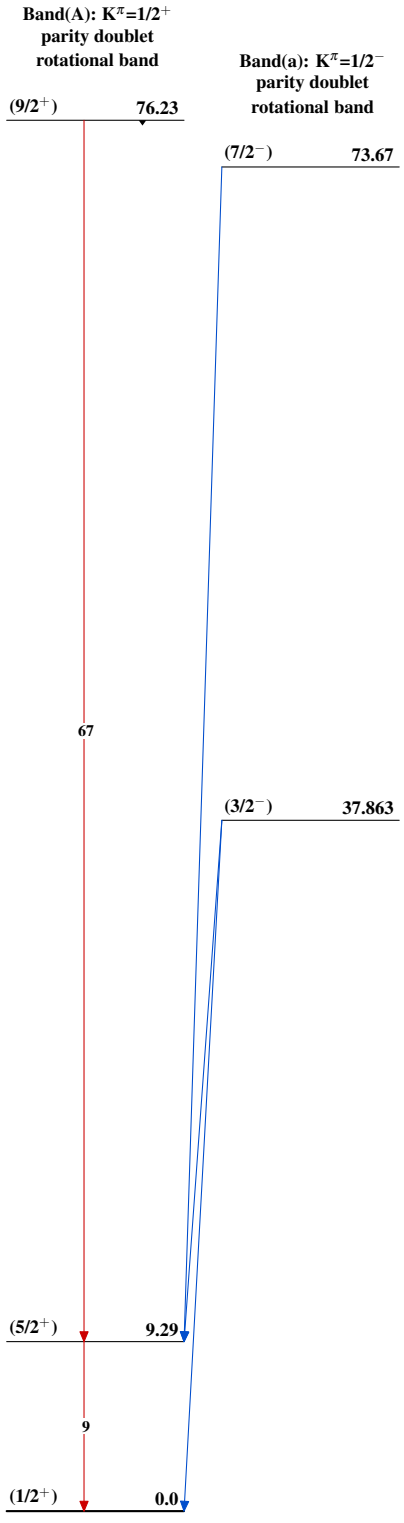
Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

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)



$^{227}_{90}Th_{137}$

^{231}U α decay (4.2 d) 1997Mu08



$^{227}_{90}Th_{137}$