^{231}Fr β^- decay (17.6 s) 2001Fr05

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Jagdish K. Tuli, and Edgardo Browne	NDS 185, 560 (2022)	31-Aug-2022

Parent: ^{231}Fr: E=0.0; J$^\pi$=(1/2$^+$); $T_{1/2}$=17.6 s *6*; Q(β^-)=3864 *14*; %β^- decay=100.0

^{231}Fr-J$^\pi$,$T_{1/2}$: From ^{231}Fr Adopted Levels.

^{231}Fr-Q(β^-): From 2021Wa16.

2001Fr05: ^{231}Fr was produced by spallation of 1 GeV proton beam on uranium targets. The activity was mass-separated at CERN ISOLDE on-line separator, deposited on a magnetic tape, and then radiations counted at two stations. Measured Eγ, Iγ, ce, $\beta\gamma$-, $\gamma\gamma$- and (ce)γ-coin, using HPGe detector for γ rays, plastic scintillators for β^- particles, and a cooled Si(Li) detector with a magnetic mini-orange filter for conversion electrons. Additional measurements were done with the OSIRIS fission product separator in Sweden. See also 2001Bo34 from the same lab and group.

1985Hi02: ^{231}Fr produced in spallation reaction of ^{238}U induced by 600 MeV protons from the CERN synchrocyclotron, followed by mass-separation using the ISOLDE II online separator. Measured Eγ, Iγ, x rays, $T_{1/2}$ of ^{231}Fr decay. Three γ rays in ^{231}Ra were reported, which are listed in comments in this dataset.

The decay scheme proposed by 2001Fr05 is essentially based on analogy with the structure of N=143 isotone ^{233}Th. Evaluators consider the decay scheme to be incomplete in many ways: 1. many γ rays, carrying, significant transition intensities, are unplaced; 2. multipolarities of some of the low-energy transitions, with expected high internal conversion, are not known precisely; 3. with Q value of 3864 keV, the highest proposed level in ^{231}Ra is at 1774 keV, which leaves the possibility of either unobserved or unplaced transitions in the decay scheme; 4. several transitions are multiply placed with undivided intensities; 5. the $\gamma\gamma$-coin results are available only in a few cases. In this scenario, all the β feedings and log *ft* values should be treated as tentative.

^{231}Ra Levels

E(level)†	J$^\pi$‡	$T_{1/2}$#	Comments
0.0	(5/2$^+$)	103.9 s *14*	$T_{1/2}$: from Adopted Levels. J$^\pi$: Nilsson assignment ν5/2[622] to this bandhead is based on the energy of the ν5/2[622] orbital in ^{233}Th. Also on the retardation of the 66-keV E2 γ ray from the 1/2$^+$, ν1/2[631] state (at 66 keV) to the 5/2$^+$, ν5/2[622] (ground state).
46.23 *11*	(7/2$^+$)		E(level): level (2001Fr05) in comparison to a low-energy level in N=143 isotone ^{233}Th, and from 49.3-keV transition from the 95.5-keV level. Configuration: 7/2$^+$ member of configuration=ν5/2[622].
66.21 *9*	(1/2$^+$)	≈53 μs	J$^\pi$: Nilsson orbital assignment ν1/2[631] to this level is based on the expected energy of this orbital, and on the systematics of the B(E1) ratios between γ rays from the 1/2, 1/2[501] state to the 1/2$^+$ and 3/2$^+$ members of the 1/2[631] rotational band in several odd-A nuclei near ^{231}Ra. $T_{1/2}$: from 66.2γ(t) and $K_{\alpha2}$ x-ray(t). 2001Fr05 mention that the half-life is an estimate only, and has significant systematic and statistical uncertainties.
87.64 *13*	(3/2$^+$)		Configuration: 3/2$^+$ member of ν1/2[631].
95.50 *9*	(5/2$^-$)	4.72 ns *6*	J$^\pi$: Nilsson orbital assignment ν5/2[572] to this level is based on the expected energy of this orbital, and on the similarity of B(E1) ratios between γ rays from the 5/2[752] to the 5/2$^+$ and 7/2$^+$ members of the 5/2[622] rotational band in ^{231}Th and ^{229}Ra. $T_{1/2}$: from $\beta\gamma$(t). Other: 4.35 ns *44* from $\beta\gamma\gamma$(t).
285.62 *16*	(5/2$^+$)		J$^\pi$: Nilsson orbital assignment ν5/2[633] to this level is based on the expected energy of this orbital, and on the similarity of B(M1) ratios between γ rays from the 5/2[633] to the 5/2$^+$ and 7/2$^+$ members of the 5/2[622] rotational band in ^{233}Th.
397.33 *13*	(3/2$^+$)		J$^\pi$: Nilsson orbital assignment ν3/2[631] to this level is based on the expected energy of this orbital, and on the similarity of B(M1) ratios between γ rays to members of the 1/2[631] and 5/2[622] rotational bands.
455.0 *4*	(1/2$^-$ to 9/2$^-$)		
458.95 *16*	(1/2$^-$,3/2$^-$)	≤15 ps	$T_{1/2}$: from $\beta\gamma\gamma$(t).
503.33 *21*	(1/2,3/2,5/2$^+$)		
511.36 *15*	(1/2$^+$,3/2$^+$)		

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^{231}Fr β^- decay (17.6 s) 2001Fr05 (continued)

^{231}Ra Levels (continued)

E(level)†	J$^\pi$‡	$T_{1/2}$#	Comments
520.29 *14*	(1/2$^-$)	92 ps *5*	J$^\pi$: Nilsson orbital assignment ν1/2[501] to this level is based on the characteristic β^- decay pattern between the 1/2[400] (ground state in ^{231}Fr) and 1/2[501] orbitals in several odd-A nuclei near ^{231}Ra. See also arguments for Nilsson orbital assignment to ^{231}Fr ground state. $T_{1/2}$: from $\beta\gamma\gamma$(t).
605.4 *3*	(1/2$^-$,3/2,5/2$^+$)		
620.59 *24*	(3/2,5/2,7/2)	≤12.5 ps	$T_{1/2}$: from $\beta\gamma\gamma$(t).
646.6 *4*	(1/2$^-$ to 7/2)		
740.72 *18*	(3/2$^+$,5/2$^+$)		
750.86 *18*	(1/2,3/2,5/2$^+$)		
760.5 *4*	(1/2,3/2,5/2$^+$)		
772.80 *15*	(1/2$^+$,3/2)		
796.2 *3*	(1/2,3/2,5/2$^+$)		
834.63 *18*	(1/2$^+$,3/2,5/2$^-$)		
929.2 *4*	(1/2,3/2,5/2$^+$)		
931.9 *3*	(1/2,3/2,5/2)		
944.31 *22*	(1/2$^+$,3/2,5/2$^+$)		
971.1 *6*	(1/2,3/2,5/2$^+$)		
1138.79 *24*	(1/2,3/2,5/2$^+$)		
1634.1 *4*	(1/2,3/2,5/2$^+$)		
1693.3 *3*	(1/2$^+$,3/2,5/2$^+$)		
1718.2 *3*	(1/2,3/2,5/2$^+$)		
1730.1 *4*	(1/2,3/2,5/2$^+$)		
1773.90 *25*	(1/2,3/2,5/2$^+$)		

† Deduced from a least-squares fit to γ-ray energies. The gamma rays with uncertain placements are included in the fitting procedure.
‡ From the Adopted Levels.
# From $\beta\gamma$(t) or $\beta\gamma\gamma$(t) for excited states above 80 keV, using Advanced Time Delayed system (2001Fr05, also 2001Bo34).

β^- radiations

E(decay)	E(level)	Iβ^-†#	Log *ft*‡	Comments
(2090 *14*)	1773.90	2.4 *4*	6.3	av Eβ=757.2 *58*
(2134 *14*)	1730.1	1.4 *2*	6.5	av Eβ=775.3 *58*
(2146 *14*)	1718.2	0.9 *1*	6.7	av Eβ=780.2 *58*
(2171 *14*)	1693.3	2.0 *2*	6.4	av Eβ=790.5 *58*
(2230 *14*)	1634.1	1.0 *2*	6.8	av Eβ=814.9 *58*
(2725 *14*)	1138.79	0.7 *2*	7.3	av Eβ=1021.9 *59*
(2893 *14*)	971.1	0.28 *5*	7.8	av Eβ=1092.5 *59*
(2920 *14*)	944.31	0.9 *1*	7.3	av Eβ=1103.8 *59*
(2932 *14*)	931.9	0.4 *1*	7.6	av Eβ=1109.0 *59*
(2935 *14*)	929.2	0.2 *1*	7.9	av Eβ=1110.1 *59*
(3029 *14*)	834.63	1.1 *2*	7.2	av Eβ=1150.0 *60*
(3068 *14*)	796.2	1.0 *2*	7.3	av Eβ=1166.3 *60*
(3091 *14*)	772.80	1.9 *3*	7.0	av Eβ=1176.2 *60*
(3104 *14*)	760.5	0.5 *2*	7.6	av Eβ=1181.4 *60*
(3113 *14*)	750.86	2.4 *2*	6.9	av Eβ=1185.4 *60*
(3123 *14*)	740.72	1.7 *3*	7.1	av Eβ=1189.7 *60*
(3217@ *14*)	646.6	0.10 *9*	8.4	av Eβ=1229.6 *60*
(3243 *14*)	620.59	1.6 *2*	7.2	av Eβ=1240.6 *60*

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^{231}Fr β^- decay (17.6 s) 2001Fr05 (continued)

β^- radiations (continued)

E(decay)	E(level)	Iβ^- [†#]	Log *ft* [‡]	Comments
(3259 *14*)	605.4	1.4 *3*	7.3	av Eβ=1247.0 *60*
(3344 *14*)	520.29	45 *3*	5.8	av Eβ=1283.1 *60*
(3353 *14*)	511.36	1.0 *2*	7.5	av Eβ=1286.8 *60*
(3361 *14*)	503.33	0.8 *1*	7.6	av Eβ=1290.2 *60*
(3405 *14*)	458.95	1.2 *2*	7.4	av Eβ=1309.1 *60*
(3409 *14*)	455.0	0.13 *3*	8.4	av Eβ=1310.7 *60*
(3467 *14*)	397.33	3.3 *4*	7.0	av Eβ=1335.2 *60*
(3578[@] *14*)	285.62	2.8 *3*	7.1	av Eβ=1382.6 *60* Iβ^-: β feeding of 2.8% is unrealistic for ΔJ=2, $\Delta\pi$=no.
(3769[@] *14*)	95.50	<0.6	>9.4^{1u}	av Eβ=1420.3 *60* Iβ=0.1 *5*.
(3798 *14*)	66.21	31 *15*	6.2	av Eβ=1475.8 *60* Iβ^-: combined feeding to 66- and 87-keV levels.

† Deduced by evaluators from γ-ray transition intensity balance. These values should be considered as only approximate as the decay scheme is considered incomplete by the evaluators for reasons mentioned in the header comments.

‡ All the values should be considered as only approximate since the decay scheme is considered by the evaluators as incomplete.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

$\gamma(^{231}$Ra)

Iγ normalization: Deduced by evaluators, assuming no β^- feeding to g.s. and 46-keV level, and using summed I(γ+ce)=100% to these levels. Note that significant I(γ+ce) intensity is unplaced in the decay scheme. In addition there may be levels above 1775 keV from which transitions are either not observed or not assigned.
Measured I(K x rays)=39 *4* (1985Hi02) relative to 100 for 432.6-keV γ ray.

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	α[b]	Comments
(21.4)	≤0.8	87.64	(3/2+)	66.21	(1/2+)	[M1]	286 *4*	α(L)=216 *3*; α(M)=52.4 *8* α(N)=13.82 *20*; α(O)=3.15 *5*; α(P)=0.550 *8*; α(Q)=0.0433 *6* E_γ: γ ray was not observed.
46.3[d] *2*	0.27 *5*	46.23	(7/2+)	0.0	(5/2+)	[M1]	29.5 *6*	α(L)=22.3 *5*; α(M)=5.34 *11* α(N)=1.41 *3*; α(O)=0.322 *7*; α(P)=0.0561 *11*; α(Q)=0.00441 *9*
49.3 *1*	0.71 *4*	95.50	(5/2−)	46.23	(7/2+)	E1	0.727 *10*	B(E1)↓=3.2×10^{-5} *3* (2001Fr05) α(L1)exp+α(L2)exp≤9 α(L)=0.549 *9*; α(M)=0.1345 *21* α(N)=0.0347 *6*; α(O)=0.00734 *11*; α(P)=0.001061 *16*; α(Q)=4.16×10^{-5} *6* δ(M2/E1)<0.11. Possible coin. with 85.4-keV x ray.
66.2 *1*	5.2 *2*	66.21	(1/2+)	0.0	(5/2+)	E2	67.4 *10*	B(E2)↓=0.12 *5* (2001Fr05) α(L1)exp+α(L2)exp=28 *4*; α(L3)exp=20 *3*; α(M)exp=14 *2*; α(N)exp=4.0 *8* α(L)=49.5 *8*; α(M)=13.45 *22* α(N)=3.55 *6*; α(O)=0.753 *12*; α(P)=0.1083 *17*; α(Q)=0.000263 *4* δ(E2/M1)>2 or 12.9 *12*; ΔJ$^\pi$ consistent with pure E2.
x77.1 *3*	0.7 *3*					E1	0.220 *4*	α(L1)exp+α(L2)exp≤2.8 α(L)=0.167 *3*; α(M)=0.0404 *7* α(N)=0.01047 *19*; α(O)=0.00226 *4*; α(P)=0.000345 *6*; α(Q)=1.58×10^{-5} *3* δ(M2/E1)<0.18.
x82.5 *1*	1.36 *6*							
x83.3 *1*	2.47 *9*							
x86.2 *1*	4.1[@] *3*							
95.5 *1*	14.0 *10*	95.50	(5/2−)	0.0	(5/2+)	E1	0.1247 *18*	B(E1)↓=8.7×10^{-5} *13* (2001Fr05) α(L1)exp+α(L2)exp≤0.5; α(L3)exp≤0.15 α(L)=0.0945 *14*; α(M)=0.0228 *4* α(N)=0.00592 *9*; α(O)=0.001289 *19*; α(P)=0.000201 *3*; α(Q)=9.85×10^{-6} *14* Eγ=95.6 *4*, Iγ=17 *3* (1985Hi02), relative to 100 for 432.6γ. δ(M2/E1)<0.11.
x96.8 *3*	0.37 *8*							
x97.5 *2*	0.70[@] *12*					M1	3.35 *5*	α(L1)exp+α(L2)exp=2.3 *9*; α(L2)exp≤0.82 α(L)=2.54 *4*; α(M)=0.607 *10* α(N)=0.1600 *25*; α(O)=0.0365 *6*; α(P)=0.00636 *10*; α(Q)=0.000500 *8* δ(E2/M1)<0.4.
123.1 *2*	0.70 *10*	520.29	(1/2−)	397.33	(3/2+)	E1	0.291 *4*	B(E1)↓=9.8×10^{-6} *16* (2001Fr05)

From ENSDF

$\gamma(^{231}$Ra) (continued)

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	δ[&]	α[b]	Comments
									α(L1)exp+α(L2)exp≤0.38 α(K)=0.227 4; α(L)=0.0484 7; α(M)=0.01165 17 α(N)=0.00303 5; α(O)=0.000665 10; α(P)=0.0001056 16; α(Q)=5.58×10^{-6} 8 δ(M2/E1)<0.17.
[x]225.4 2	0.69[@] 13					M1		1.565 22	α(K)exp=1.5 5 α(K)=1.259 18; α(L)=0.232 4; α(M)=0.0555 8 α(N)=0.01463 21; α(O)=0.00334 5; α(P)=0.000582 9; α(Q)=4.56×10^{-5} 7 α(K) exp gives δ(E2/M1)<0.5.
239.4[cd] 3	1.1[c@] 2	285.62	(5/2$^+$)	46.23	(7/2$^+$)	(M1)		1.324 19	α(K)exp=1.2 3 α(K)=1.065 16; α(L)=0.196 3; α(M)=0.0469 7 α(N)=0.01236 18; α(O)=0.00282 4; α(P)=0.000491 7; α(Q)=3.85×10^{-5} 6 α(K)exp for a doubly-placed γ ray. δ(E2/M1)<0.45 for a doubly placed γ ray.
239.4[cd] 3	1.1[c] 2	750.86	(1/2,3/2,5/2$^+$)	511.36	(1/2$^+$,3/2$^+$)	(M1)			Mult.: same assignment of (M1) is given for the doublet.
252.5 2	0.77 15	772.80	(1/2$^+$,3/2)	520.29	(1/2$^-$)				
261.6 3	0.58[@] 11	772.80	(1/2$^+$,3/2)	511.36	(1/2$^+$,3/2$^+$)				
[x]273.7 2	1.0 2								
285.7[d] 2	5.8 5	285.62	(5/2$^+$)	0.0	(5/2$^+$)	M1		0.811 12	α(K)exp=0.71 12; α(L1)exp+α(L2)exp=0.10 5 α(K)=0.653 10; α(L)=0.1199 17; α(M)=0.0286 4 α(N)=0.00755 11; α(O)=0.001722 25; α(P)=0.000300 5; α(Q)=2.35×10^{-5} 4 δ(E2/M1)<0.4.
309.9 2	5.1 5	397.33	(3/2$^+$)	87.64	(3/2$^+$)	M1		0.648 9	α(K)exp=0.58 11 α(K)=0.522 8; α(L)=0.0958 14; α(M)=0.0229 4 α(N)=0.00603 9; α(O)=0.001375 20; α(P)=0.000240 4; α(Q)=1.88×10^{-5} 3 δ(E2/M1)<0.35.
314.4 3	0.47 15	834.63	(1/2$^+$,3/2,5/2$^-$)	520.29	(1/2$^-$)				
331.2 2	4.5 6	397.33	(3/2$^+$)	66.21	(1/2$^+$)	M1		0.540 8	α(K)exp=0.50 15 α(K)=0.435 7; α(L)=0.0797 12; α(M)=0.0190 3 α(N)=0.00502 7; α(O)=0.001144 17; α(P)=0.000200 3; α(Q)=1.564×10^{-5} 22 δ(E2/M1)<0.55.
[x]346.5 3	1.2[@] 3								α(K)exp≤0.27
353.6 3	0.8 3	750.86	(1/2,3/2,5/2$^+$)	397.33	(3/2$^+$)				
359.5 3	0.51[@] 10	455.0	(1/2$^-$ to 9/2$^-$)	95.50	(5/2$^-$)				
363.4 2	4.2 4	458.95	(1/2$^-$,3/2$^-$)	95.50	(5/2$^-$)	M1(+E2)	0.7 7	0.31 11	B(M1)↓≥0.032 (2001Fr05) α(K)exp=0.24 10

$^{231}_{88}$Ra$_{143}$-5

γ(^{231}Ra) (continued)

E_γ	I_γ[a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[&]	δ[&]	α[b]	Comments
									α(K)=0.243 97; α(L)=0.051 11; α(M)=0.0124 24 α(N)=0.0033 7; α(O)=0.00074 15; α(P)=0.00013 3; α(Q)=8.7×10^{-6} 35
375.7[c] 3	0.8[c] 2	772.80	(1/2$^+$,3/2)	397.33	(3/2$^+$)				
375.7[c] 3	0.8[c] 2	834.63	(1/2$^+$,3/2,5/2$^-$)	458.95	(1/2$^-$,3/2$^-$)				
387.7 3	0.55[@] 11	1138.79	(1/2,3/2,5/2$^+$)	750.86	(1/2,3/2,5/2$^+$)				
392.8[‡d] 3	1.1 4	458.95	(1/2$^-$,3/2$^-$)	66.21	(1/2$^+$)				B(E1)↓≥7.2×10^{-5} (2001Fr05)
397.3 3	1.9[@] 2	397.33	(3/2$^+$)	0.0	(5/2$^+$)	(E2(+M1))	>0.7	0.24 18	α(K)exp≤0.18 α(K)=0.19 15; α(L)=0.040 18; α(M)=0.010 4 α(N)=0.0025 11; α(O)=0.00057 25; α(P)=0.00010 5; α(Q)=7×10^{-6} 6 α(K)exp gives E2(+M1) with δ(E2/M1)>0.7 or E1, ΔJ^π favors E2(+M1).
^{x}400.5[‡] 3	0.5 2								
415.6 3	2.6 3	503.33	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)				
423.8[†] 2	0.7 2	511.36	(1/2$^+$,3/2$^+$)	87.64	(3/2$^+$)				
428.8[d] 3	0.5[@] 2	931.9	(1/2,3/2,5/2)	503.33	(1/2,3/2,5/2$^+$)				
432.6 2	100.0 50	520.29	(1/2$^-$)	87.64	(3/2$^+$)	E1		0.01588 22	B(E1)↓=3.22×10^{-5} 21 (2001Fr05) α(K)exp≤0.022 α(K)=0.01291 19; α(L)=0.00226 4; α(M)=0.000535 8 α(N)=0.0001401 20; α(O)=3.15×10^{-5} 5; α(P)=5.33×10^{-6} 8; α(Q)=3.68×10^{-7} 6 Eγ=432.6 2, Iγ=100 3 (1985Hi02).
437.4[c] 3	1.12[c] 15	503.33	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)				
437.4[c] 3	1.12[c] 15	834.63	(1/2$^+$,3/2,5/2$^-$)	397.33	(3/2$^+$)				
445.1 2	4.0 4	511.36	(1/2$^+$,3/2$^+$)	66.21	(1/2$^+$)	M1+E2	0.45 30	0.21 4	α(K)exp=0.17 4 α(K)=0.17 4; α(L)=0.032 4; α(M)=0.0077 9 α(N)=0.00203 24; α(O)=0.00046 6; α(P)=8.0×10^{-5} 11; α(Q)=6.0×10^{-6} 12 Possible coin. with 88.2-keV x ray.
^{x}448.1 3	1.7 3								α(K)exp≤0.17 Possible coin. with 88.2-keV x ray.
454.0 2	78.1 48	520.29	(1/2$^-$)	66.21	(1/2$^+$)	E1		0.01437 20	B(E1)↓=2.18×10^{-5} 15 (2001Fr05) α(K)exp≤0.024 α(K)=0.01169 17; α(L)=0.00203 3; α(M)=0.000482 7 α(N)=0.0001261 18; α(O)=2.84×10^{-5} 4;

$^{231}_{88}$Ra$_{143}$-6

γ(^{231}Ra) (continued)

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π	Comments
						α(P)=4.81×10^{-6} 7; α(Q)=3.34×10^{-7} 5 Eγ=454.1 2, Iγ=80 4 (1985Hi02), relative to 100 for 432.6γ.
472.8 5	1.2[@] 3	931.9	(1/2,3/2,5/2)	458.95	(1/2$^-$,3/2$^-$)	
[x]477.9 4	2.4[@] 2					α(K)exp≤0.089 Possible coin. with 85.0 and 88.4-keV x ray.
[x]492.9 4	2.2 2					Possible coin. with 88.6-keV x ray.
[x]505.4 4	2.0 2					
510.3 5	1.4 3	605.4	(1/2$^-$,3/2,5/2$^+$)	95.50	(5/2$^-$)	E$_\gamma$,I$_\gamma$: from $\gamma\gamma$-coin measurement.
[x]513.6[‡†] 3	0.73[@] 11					
525.2 3	6.8 7	620.59	(3/2,5/2,7/2)	95.50	(5/2$^-$)	B(M1)↓≥0.016 (2001Fr05)
539.1 3	4.3 9	605.4	(1/2$^-$,3/2,5/2$^+$)	66.21	(1/2$^+$)	Possible coin. with 88.2- and 85.4-keV x rays.
[x]542.1[†] 4	0.37[@] 11					
551.3 4	1.3[@] 3	646.6	(1/2$^-$ to 7/2)	95.50	(5/2$^-$)	
[x]572.7 4	1.5 4					
[x]617.2 5	3.1[@] 3					
620.2[d] 5	1.12[@] 15	620.59	(3/2,5/2,7/2)	0.0	(5/2$^+$)	B(E1)↓≥1.8×10^{-5} (2001Fr05)
645.2 3	1.0 5	740.72	(3/2$^+$,5/2$^+$)	95.50	(5/2$^-$)	
653.2 3	1.1 3	740.72	(3/2$^+$,5/2$^+$)	87.64	(3/2$^+$)	
659.0[d] 5	1.0 2	944.31	(1/2$^+$,3/2,5/2$^+$)	285.62	(5/2$^+$)	
663.1 3	6.0 6	750.86	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)	Possible coin. with 88.6-keV x ray.
672.8[‡] 5	0.8 2	760.5	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)	
674.6[‡] 5	3.0 3	740.72	(3/2$^+$,5/2$^+$)	66.21	(1/2$^+$)	
684.6[c‡] 5	2.7[c] 2	750.86	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)	
684.6[c] 5	2.7[c] 2	772.80	(1/2$^+$,3/2)	87.64	(3/2$^+$)	
694.4[c] 4	1.3[c] 7	740.72	(3/2$^+$,5/2$^+$)	46.23	(7/2$^+$)	
694.4[c] 4	1.3[c] 7	760.5	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)	
704.8[#] 5	1.5 2	1634.1	(1/2,3/2,5/2$^+$)	929.2	(1/2,3/2,5/2$^+$)	
706.5[#] 5	2.0 2	772.80	(1/2$^+$,3/2)	66.21	(1/2$^+$)	Possible coin. with 88.2-keV x ray.
708.6[#] 5	1.13 15	796.2	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)	
[x]719.6[‡] 5	1.1 4					
730.0[‡] 3	2.7 5	796.2	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)	
[x]735.7 4	1.9 5					
740.5 5	0.52 14	740.72	(3/2$^+$,5/2$^+$)	0.0	(5/2$^+$)	
746.9 4	2.0 4	834.63	(1/2$^+$,3/2,5/2$^-$)	87.64	(3/2$^+$)	
[x]756.2 5	0.6 2					
[x]770.5[‡] 3	2.5 3					
772.8[‡] 3	1.8 2	772.80	(1/2$^+$,3/2)	0.0	(5/2$^+$)	
[x]805.7 6	0.67 14					
[x]818.8[‡†] 3	1.0 4					

γ(^{231}Ra) (continued)

E_γ	I_γ[a]	E_i(level)	J^π_i	E_f	J^π_f
834.5 6	1.3[@] 2	834.63	(1/2$^+$,3/2,5/2$^-$)	0.0	(5/2$^+$)
841.4[c‡] 6	0.9[c@] 2	929.2	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
841.4[c] 6	0.9[c] 2	1773.90	(1/2,3/2,5/2$^+$)	931.9	(1/2,3/2,5/2)
843.5[‡] 5	0.8[@] 2	931.9	(1/2,3/2,5/2)	87.64	(3/2$^+$)
862.9 6	1.4[@] 2	929.2	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
877.9 4	0.7 3	944.31	(1/2$^+$,3/2,5/2$^+$)	66.21	(1/2$^+$)
883.6[c] 6	0.56[c@] 14	971.1	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
883.6[c] 6	0.56[c] 14	1634.1	(1/2,3/2,5/2$^+$)	750.86	(1/2,3/2,5/2$^+$)
883.6[c] 6	0.56[c] 14	1718.2	(1/2,3/2,5/2$^+$)	834.63	(1/2$^+$,3/2,5/2$^-$)
904.6 10	0.55[@] 14	971.1	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
[x]910.9 6	0.57[@] 14				
939.8 7	0.74[@] 14	1773.90	(1/2,3/2,5/2$^+$)	834.63	(1/2$^+$,3/2,5/2$^-$)
944.3 3	1.9 3	944.31	(1/2$^+$,3/2,5/2$^+$)	0.0	(5/2$^+$)
[x]947.1 5	1.0 2				
[x]982.2 6	0.9[@] 2				
[x]991.7 6	1.0 2				
1001.7 6	1.2 10	1773.90	(1/2,3/2,5/2$^+$)	772.80	(1/2$^+$,3/2)
[x]1021.2[‡] 5	1.9 4				
1051.4 3	1.3 3	1138.79	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
1072.5[c] 6	1.0[c] 4	1138.79	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
1072.5[c] 6	1.0[c] 4	1693.3	(1/2$^+$,3/2,5/2$^+$)	620.59	(3/2,5/2,7/2)
[x]1079.8[‡] 5	1.4 5				
1097.8 6	0.7 2	1718.2	(1/2,3/2,5/2$^+$)	620.59	(3/2,5/2,7/2)
[x]1126.1[‡] 5	0.83 15				
1127.5[‡] 5	0.9 2	1773.90	(1/2,3/2,5/2$^+$)	646.6	(1/2$^-$ to 7/2)
[x]1201.8 5	0.9 5				
[x]1207.8 5	1.1 3				
[x]1268.1 5	1.2[@] 2				
[x]1297.1 6	0.7 2				
[x]1316.7 6	1.1 2				
[x]1325.8[†] 4	0.9 4				
1376.1 6	0.9 2	1773.90	(1/2,3/2,5/2$^+$)	397.33	(3/2$^+$)
1408.0[‡d] 6	1.0[@] 2	1693.3	(1/2$^+$,3/2,5/2$^+$)	285.62	(5/2$^+$)
[x]1468.6 6	2.5 6				
1546.4 6	1.1 4	1634.1	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
[x]1558.3 7	0.7 3				
1567.8 6	0.8 3	1634.1	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
[x]1583.1 5	5.8 5				
1605.5 4	3.3 4	1693.3	(1/2$^+$,3/2,5/2$^+$)	87.64	(3/2$^+$)

$^{231}_{88}Ra_{143}$-8

^{231}Fr β^- decay (17.6 s) 2001Fr05 (continued)

γ(^{231}Ra) (continued)

E_γ	I_γ[a]	E_i(level)	J_i^π	E_f	J_f^π
[x]1609.4 4	0.7 3				
1627.2 6	1.1 3	1693.3	(1/2$^+$,3/2,5/2$^+$)	66.21	(1/2$^+$)
1630.6 5	1.9 3	1718.2	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
1642.5 5	3.9 4	1730.1	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
1651.9[‡] 6	0.5 2	1718.2	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
[x]1653.6[‡] 6	0.7 2				
1663.8 5	1.6 3	1730.1	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
[x]1682.8[#] 6	2.9 5				
1686.1[‡] 5	3.8 5	1773.90	(1/2,3/2,5/2$^+$)	87.64	(3/2$^+$)
1693.7 8	1.7 5	1693.3	(1/2$^+$,3/2,5/2$^+$)	0.0	(5/2$^+$)
[x]1703.6 7	1.5 5				
1707.6 7	1.0 4	1773.90	(1/2,3/2,5/2$^+$)	66.21	(1/2$^+$)
[x]1720.7 6	1.1 3				
[x]1762.3 4	1.2 3				
[x]1781.9 5	0.9 4				
[x]1785.9 6	0.6 2				
[x]1800.7[‡] 6	0.9 2				
[x]1802.6 6	1.2 2				

E_γ	I_γ[a]	E_i(level)
[x]1828.1 5	0.6 2	
[x]1839.1 7	1.1 2	
[x]1856.2 7	0.9 4	
[x]1870.0 6	1.3 2	
[x]1876.4 6	1.8 3	
[x]1965.8 5	0.6 3	
[x]1973.8[†] 8	0.4 3	
[x]1983.2 11	0.7 2	
[x]2000.9 7	0.5 2	
[x]2008.1 6	1.4 2	
[x]2053.4[†] 8	0.46 14	
[x]2114.8 8	0.49 13	
[x]2129.3[†] 8	0.6 2	
[x]2133.5 7	0.7 3	
[x]2206.4 11	0.49[@] 15	
[x]2289.0 8	0.35 13	
[x]2457.9[†] 8	0.15 5	
[x]2621.3[†] 8	0.13 3	

[†] Tentatively assigned to ^{231}Ra.

[‡] Possible doublet.

[#] Possible multiplet.

[@] Contribution from impurities was removed.

[&] From ce data in 2001Fr05. Only the dominant multipolarity is assigned. Possible admixtures with upper limits are given under comments. The same assignments are given in the Adopted dataset.

[a] For absolute intensity per 100 decays, multiply by ≈0.25.

[b] 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.

[c] Multiply placed with undivided intensity.

[d] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

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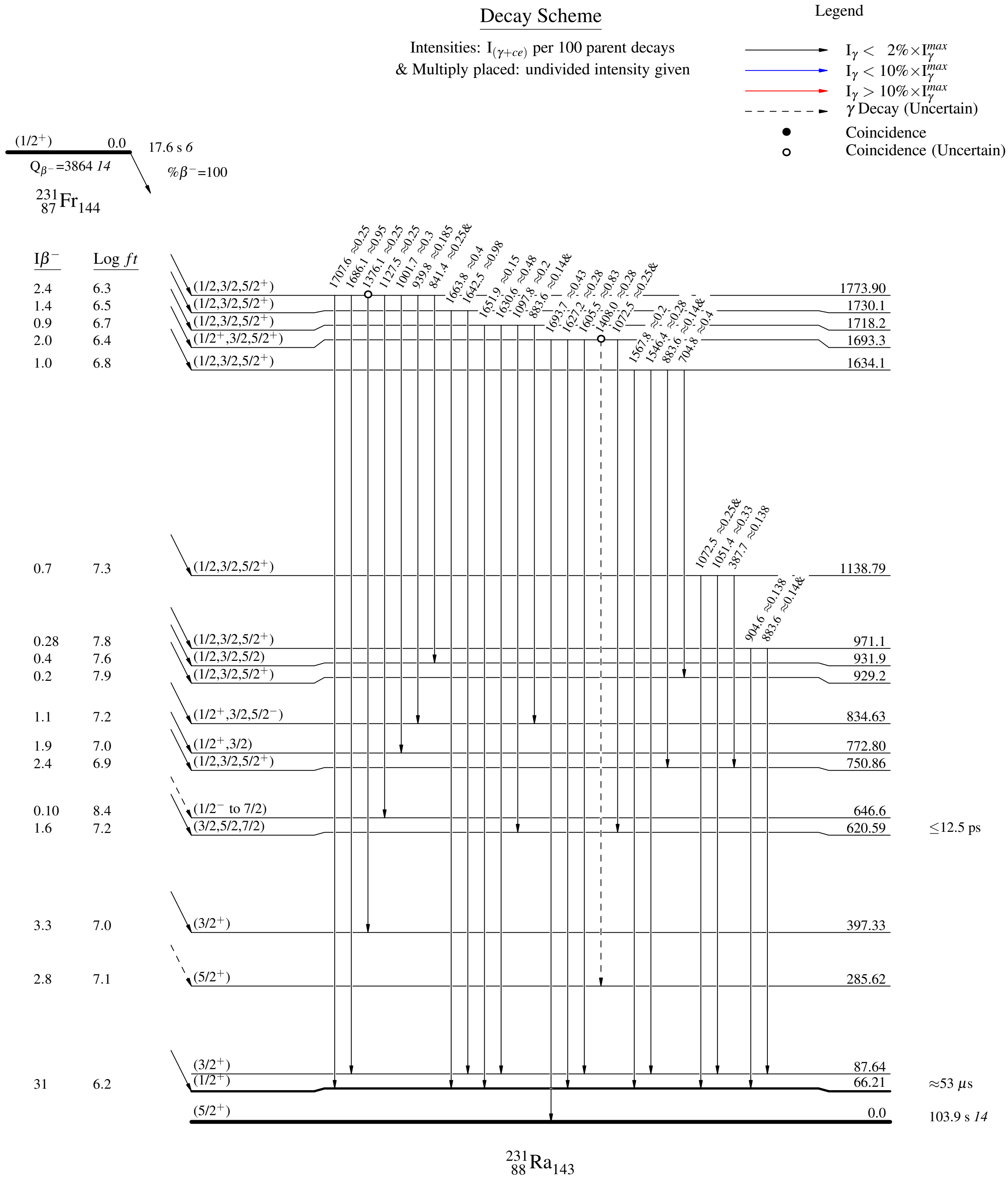
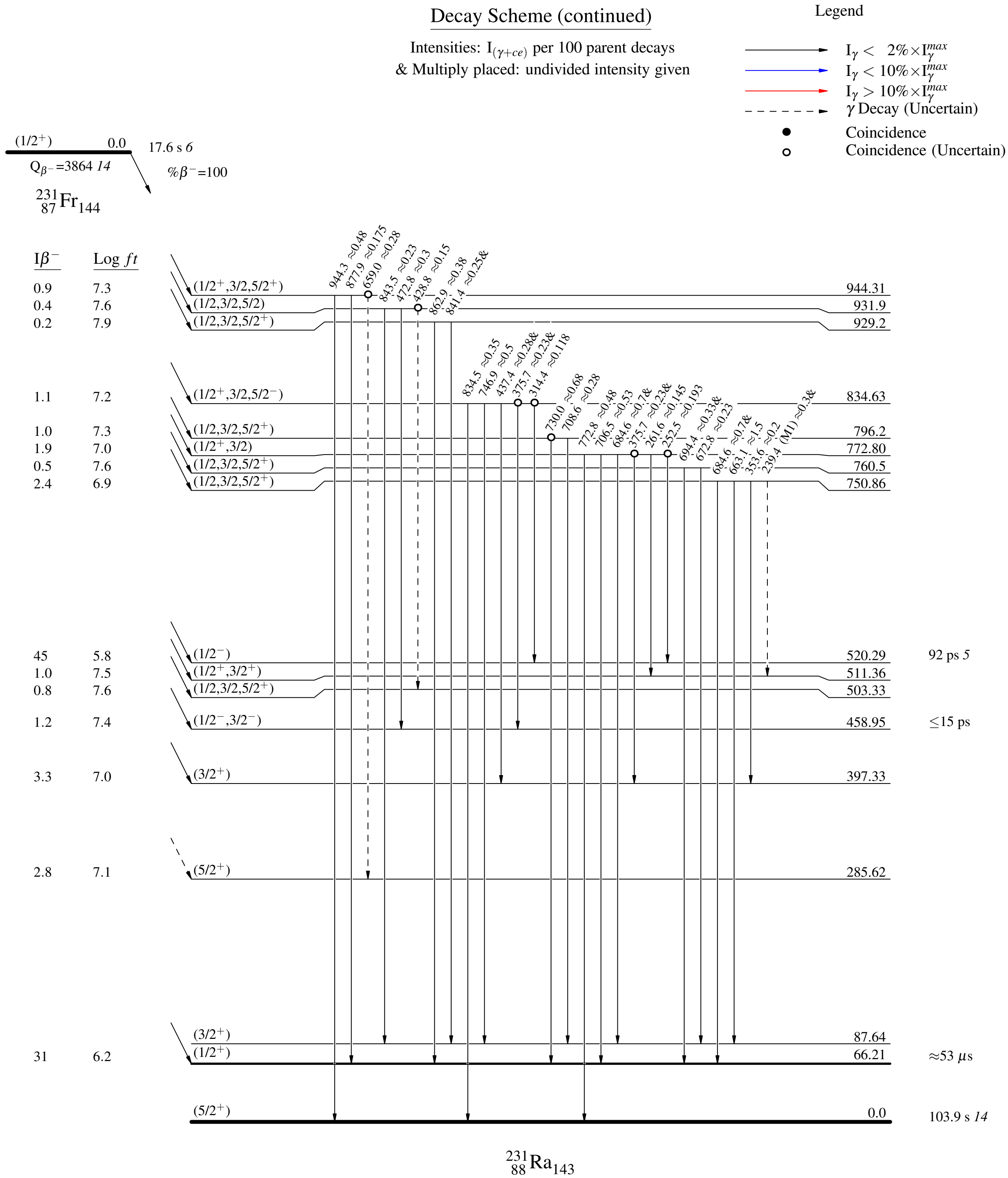
^{231}Fr β^- decay (17.6 s) 2001Fr05



^{231}Fr β^- decay (17.6 s) 2001Fr05

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays
& Multiply placed: undivided intensity given



^{231}Fr β^- decay (17.6 s) 2001Fr05

Decay Scheme (continued)

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays
& Multiply placed: undivided intensity given

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)
- Coincidence
- Coincidence (Uncertain)