^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 75,199 (1995)	31-May-1995

Parent: ^{172}Hf: E=0.0; $J^\pi=0^+$; $T_{1/2}$=1.87 y *3*; Q(ε)=350 *50*; %ε decay=100.0
1979To18: ^{172}Hf activity produced by ^{175}Lu(p,4n) E=40 MeV. Measured γ, γγ, I(K x ray).
1966Ha23: ^{172}Hf activity produced by ^{172}Yb(α,4n) E≈80 MeV. Measured ce.
1962Va07: ce data.
Others:
γ: 1993He18. Precise energies of five γ rays determined from differences of closely spaced peaks.
γ, γγ: 1970SeZT, 1967Ja10, 1965Br26, 1962Br40, 1961Br43, 1960Na04.
$T_{1/2}$(^{172}Hf g.s.): 1971Ch57. Others: 1973Or02, 1960Na11, 1951Wi08.
g factor measurement: 1976Kr04.

^{172}Lu Levels

The following levels proposed by 1970SeZT and/or 1966Ha23 are omitted due to lack of coincidence data to support these: 133.3, 135.9, 147.6 and 264.

E(level)‡	J^π#	$T_{1/2}$	Comments
0.0	4^-		g factor=0.565 *25* (1976Kr04, using g factor for ^{177}Lu g.s. as standard).
41.86 *4*	1^-		
65.79† *4*	$(1)^+$	0.332 μs *20*	$T_{1/2}$: from γγ(t) 1965Br26.
109.41 *10*	$(1)^+$	440 μs *12*	$T_{1/2}$: weighted average of 430 μs *50* (1965Bj01), 450 μs *20* (1966Gr22) and 434 μs *15* (1967Co26). 1979To18 assign $K^\pi=1^+$ with Configuration=((ν 1/2(521))(π 1/2(541))) but bandhead of this configuration is calculated at≈66 keV (1976El11).
109.85† *4*	$(2)^+$	2.30 ns *12*	$T_{1/2}$: from (K x ray+82γ)(ce(L)(44γ))(t) (1967Ja10).
179.85 *10*	$(1)^+$		Probable Configuration=((π 5/2(402))(ν 7/2(633))).
191.60† *4*	$(1)^+$	≤0.5 ns	$T_{1/2}$: from (K x ray+82γ)(ce(L) 126)(t), (K x ray)(126γ)(t) (1967Ja10).
196.58? *11*	$(0,1,2)^-$		
204.00? *21*	$(0^+,1^+,2^+)$		
232.33 *10*	$(1)^+$		
237.32 *14*	$(0^-,1^-)$		
252.2? *3*	$(0^+,1^+)$		

† Band(A): $K^\pi=0^+$ band. Configuration=((π 7/2(404))(ν 7/2(633))) (1979To18 1966Ha23). For the 65.79 and 191.60 level these assignments disagree with those from (^{3}He,d) and (α,t). See Adopted Levels for detailed arguments.
‡ From least-squares fit to Eγ's.
# From Adopted Levels.

ε radiations

E(decay)	E(level)	Iε†	Log *ft*	Comments
(1.0×10^2‡ *5*)	252.2?	≈5.0	≈7.6	εK=0.4 *5*; εL=0.4 *3*; εM+=0.15 *16*
(1.1×10^2 *5*)	237.32	1.7 *5*	8.3 *9*	εK=0.5 *6*; εL=0.3 *4*; εM+=0.12 *17*
(1.2×10^2 *5*)	232.33	6.4 *10*	7.8 *9*	εK=0.6 *6*; εL=0.3 *4*; εM+=0.12 *17*
(1.5×10^2‡ *5*)	204.00?	≈2.1	≈8.6	εK=0.65 *24*; εL=0.26 *17*; εM+=0.09 *7*
(1.5×10^2‡ *5*)	196.58?	0.31 *6*	9.5 *6*	εK=0.66 *19*; εL=0.25 *14*; εM+=0.09 *6*
(1.6×10^2 *5*)	191.60	58 *5*	7.2 *6*	εK=0.67 *17*; εL=0.25 *12*; εM+=0.08 *5*

Continued on next page (footnotes at end of table)

^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07 (continued)

ϵ radiations (continued)

E(decay)	E(level)	Iε†	Log *ft*	Comments
(1.7×10^2 *5*)	179.85	19 *2*	7.8 *5*	εK=0.69 *12*; εL=0.23 *9*; εM+=0.08 *4*
(2.4×10^2 *5*)	109.41	5.9 *13*	8.7 *3*	εK=0.75 *4*; εL=0.19 *3*; εM+=0.062 *10*
(2.8×10^2‡ *5*)	65.79	<15	>8.5	εK=0.763 *21*; εL=0.179 *16*; εM+=0.058 *6*

† Absolute intensity per 100 decays.
‡ Existence of this branch is questionable.

^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07 (continued)

γ(^{172}Lu)

Iγ normalization: Ti(γ's to 41.86 level)=100. Comparison of Ti(41.86γ)≈675 (deduced from ce data of 1966Ha23) with Ti(transitions to the 41.86)=880 *50* suggests that there is no direct ε feeding of the 41.86 level.
I(K x ray)=950 *50* (1979To18) (relative to 100 for 126γ). Others: 1965Br26, 1962Va07, 1961Br43, 1960Na04.
The following γ rays with Eγ(Iγ) reported by 1970SeZT only are omitted: 45.10 (2.5), 65.67 (1.51), 76.83 (2.3), 77.80 (2.6).

E_γ †	I_γ †[b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	α[c]	$I_{(\gamma+ce)}$[b]	Comments
11.8#[d]	<0.4	191.60	(1)$^+$	179.85	(1)$^+$	[M1]		79	24 *8*	$I_{(\gamma+ce)}$: α(K)=79 and Iγ<0.4 gives I(γ+ce)<32. Normalized ce(M)>12.5 gives I(γ+ce)>16. ce(M)>50 (relative to 650 for ce(K)(126γ)) (1966Ha23).
12.41[d] *20*	≈0.1	204.00?	(0$^+$,1$^+$,2$^+$)	191.60	(1)$^+$	[M1]		256		Weak ce(M) and ce(N) lines (1966Ha23).
x19.94 *10*	0.4 *2*									E_γ: from 1979To18.
x23.4#										Weak L1 and L3 lines (1966Ha23). Suggested placement: 133-110 (1966Ha23).
23.9331[a] *2*	180 *10*	65.79	(1)$^+$	41.86	1$^-$	E1		3.3		α(L)=2.53; α(M)=0.579 Mult.: from L-subshell ratios. δ(M2/E1)<0.008. L1:L2:L3:M:N=520:440:750:400:100 (1966Ha23). Additional information 2.
x34.6@	<0.1&									Weak L2, L3, M lines (1966Ha23).
41.13 *10*	2.37 *20*	232.33	(1)$^+$	191.60	(1)$^+$	M1+E2	0.14 *5*	12 *3*		α(L)=8.9 *20*; α(M)=2.1 *5* Mult.: from α(L1)exp=7.4, α(M)exp=2.1. L1:M=70:20 (1966Ha23). Weak L2 line.
41.86 *4*	0.034 *3*	41.86	1$^-$	0.0	4$^-$	M3		2.58×10^4	880 *50*	α(L)=1.85×10^4; α(M)=5.43×10^3 E_γ: from ce data (1962Va07). $I_{(\gamma+ce)}$: from Ti(of γ's to 41.86 level). I_γ: I(γ+ce)/(1+α). Mult.: from L-subshell ratios. δ(E4/M3)<0.03. L1:L2:L3:M:N=450:50:1300:665:160 (1966Ha23). Additional information 1.
44.17 *10*	2.8 *5*	109.85	(2)$^+$	65.79	(1)$^+$	E2		122		α(L)=92; α(M)=22.62 Mult.: from α(L2)exp=48. δ(E2/M1)>4. L2:L3:M:N=525:610:325:100 (1966Ha23). Additional information 3.

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^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07 (continued)

γ(^{172}Lu) (continued)

E_γ [†]	I_γ [†b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	α[c]	Comments
48.17 *20*	≈0.8	252.2?	(0$^+$,1$^+$)	204.00?	(0$^+$,1$^+$,2$^+$)	(M1+E2)	≈0.2	8.2	α(L)=6.3; α(M)=1.4 Mult.: from α(L1)exp≈4.8, α(M)exp≈1.7. L1:L2:M=15:≈5:5.5 (1966Ha23).
60.65[#]	≈10	252.2?	(0$^+$,1$^+$)	191.60	(1)$^+$	(M1)		2.7	Mult.: from α(L1)exp≈1.7. δ(E2/M1)<0.7. L1:M=68:<22 (1966Ha23). Weak L2 line. I_γ: deduced by 1979To18 from ce(L1) (1966Ha23) and α(L1) (for M1).
67.35 *10*	47 *5*	109.41	(1)$^+$	41.86	1$^-$	E1		0.99	α(K)=0.800; α(L)=0.1452; α(M)=0.0326; α(N+..)=0.00896 Mult.: from L-subshell ratios and α(L1)exp=0.124, α(M)exp=0.054. L1:L2:L3:M=23:≈10:<22:10 (1966Ha23).
68.00 *10*	6.1 *6*	109.85	(2)$^+$	41.86	1$^-$	[E1]		0.96	α(K)=0.781; α(L)=0.1414; α(M)=0.0317; α(N+..)=0.00873 E_γ: from 1979To18 only. Mult.: from absence of conversion lines.
69.99 *10*	7.4 *8*	179.85	(1)$^+$	109.85	(2)$^+$	M1+E2	0.16 *2*	10.7	α(K)=8.71; α(L)=1.542; α(M)=0.350; α(N+..)=0.1009 Mult.: from L-subshell ratios and α(L1)exp=1.8. L1:L2:L3:M=53:<45:≈6:15 (1966Ha23). Additional information 4.
[x]73.9[@]	<0.1[&]								ce(M)=2, weak L1, L2, L3 lines (1966Ha23).
81.7513[a] *5*	40 *2*	191.60	(1)$^+$	109.85	(2)$^+$	M1+E2	0.066 *15*	6.8	α(K)=5.63; α(L)=0.873; α(M)=0.1956; α(N+..)=0.0575 Mult.: from L-subshell ratios and α(K)exp=7.0. K:L1:L2:L3:M=1100:200:23:5:55 (1966Ha23). Additional information 5.
[x]91.3[#]	1.0 *4*								I_γ: from 1967Ja10. Weak K line (1966Ha23). Suggested placement: 133-42 (1966Ha23).
114.061[a] *3*	22.6 *25*	179.85	(1)$^+$	65.79	(1)$^+$	M1		2.59	α(K)=2.162; α(L)=0.333; α(M)=0.0748; α(N+..)=0.02145 Mult.: from α(K)exp=2.0, α(L1)exp=0.28. δ(E2/M1)<0.6. K:L1:M=175:25:7 (1966Ha23). ce(L3) is weak. K:L1:M=170:25:10 (1962Va07).
[x]116.1[@]	<0.3[&]								ce(K)=14, weak L1 line (1966Ha23).
[x]119.0[#]									Weak K line (1966Ha23). Suggested placement: 252-133 (1966Ha23).
122.916[a] *3*	10.1 *10*	232.33	(1)$^+$	109.41	(1)$^+$	M1+E2	2.3 *10*	1.6 *1*	α(K)=0.80 *24*; α(L)=0.64 *10*; α(M)=0.16 *2*; α(N+..)=0.043 *7* Mult.: from L-subshell ratios and α(L2)exp=0.25, α(L3)exp=0.21. K:L1:L2:L3=<45:≈3:10:8.5 (1966Ha23).
125.812[a] *3*	100 *5*	191.60	(1)$^+$	65.79	(1)$^+$	M1+E2	0.16 *2*	1.94	α(K)=1.60 *1*; α(L)=0.261 *3*; α(M)=0.0590 *7*; α(N+..)=0.0165 Mult.,δ: from L-subshell ratios. K:L1:L2:L3:M=650:100:14:4:32 (1966Ha23). Additional information 6.

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^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07 (continued)

γ(^{172}Lu) (continued)

E_γ [†]	I_γ [†b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[c]	Comments
127.91 *10*	12.9 *13*	237.32	(0⁻,1⁻)	109.41	(1)⁺	[E1]	0.185	α(K)=0.1530; α(L)=0.02468; α(M)=0.00551; α(N+..)=0.00148 Mult.: from absence of conversion lines.
[x]138.1[@]	<0.2[&]							K:L1=≈6:0.8 (1966Ha23). Suggested placement: 180-42 (1966Ha23).
[x]142.4[@]	<0.1[&]							ce(K)≈16, weak L1 line (1966Ha23). Suggested placement: 252-110 (1966Ha23).
[x]148.8[@]	<0.1[&]							Weak K line (1966Ha23).
[x]150.4[@]	<0.1[&]							ce(K)=3 (1966Ha23).
154.72[d] *10*	1.3 *2*	196.58?	(0,1,2)⁻	41.86	1⁻	M1	1.09	α(K)=0.909; α(L)=0.1401; α(M)=0.0313; α(N+..)=0.00856 Mult.: from α(K)exp=1.4, α(L1)exp=0.19. K:L1=7:1 (1966Ha23).
[x]172.2[@]	<0.1[&]							ce(K)=1.5 (1966Ha23).
[x]178.5[@]	<0.1[&]							Partially resolved ce line (1966Ha23).
[x]198.9[@]	<0.1[&]							ce(K)=2 (1966Ha23). Suggested placement: 264-66 (1966Ha23).
[x]202.5[#]								ce(K)=1.5 (1966Ha23).

[†] From 1979To18 unless otherwise stated.
[‡] Deduced from ce data (1966Ha23) and γ-ray data (1979To18). The two intensity scales are normalized with respect to 126γ mult=M1+E2, δ=0.16 *2* (from L=subshell ratios), α(K)exp=1.60.
[#] From 1966Ha23. 1979To18 report that if this transition exists, it is obscured by neighboring intense photon lines.
[@] Reported in ce data of 1966Ha23. It is treated as uncertain.
[&] Photon line not seen by 1979To18, an upper limit is given.
[a] From 1993He18 (table 2).
[b] For absolute intensity per 100 decays, multiply by 0.113 *7*.
[c] 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.
[d] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

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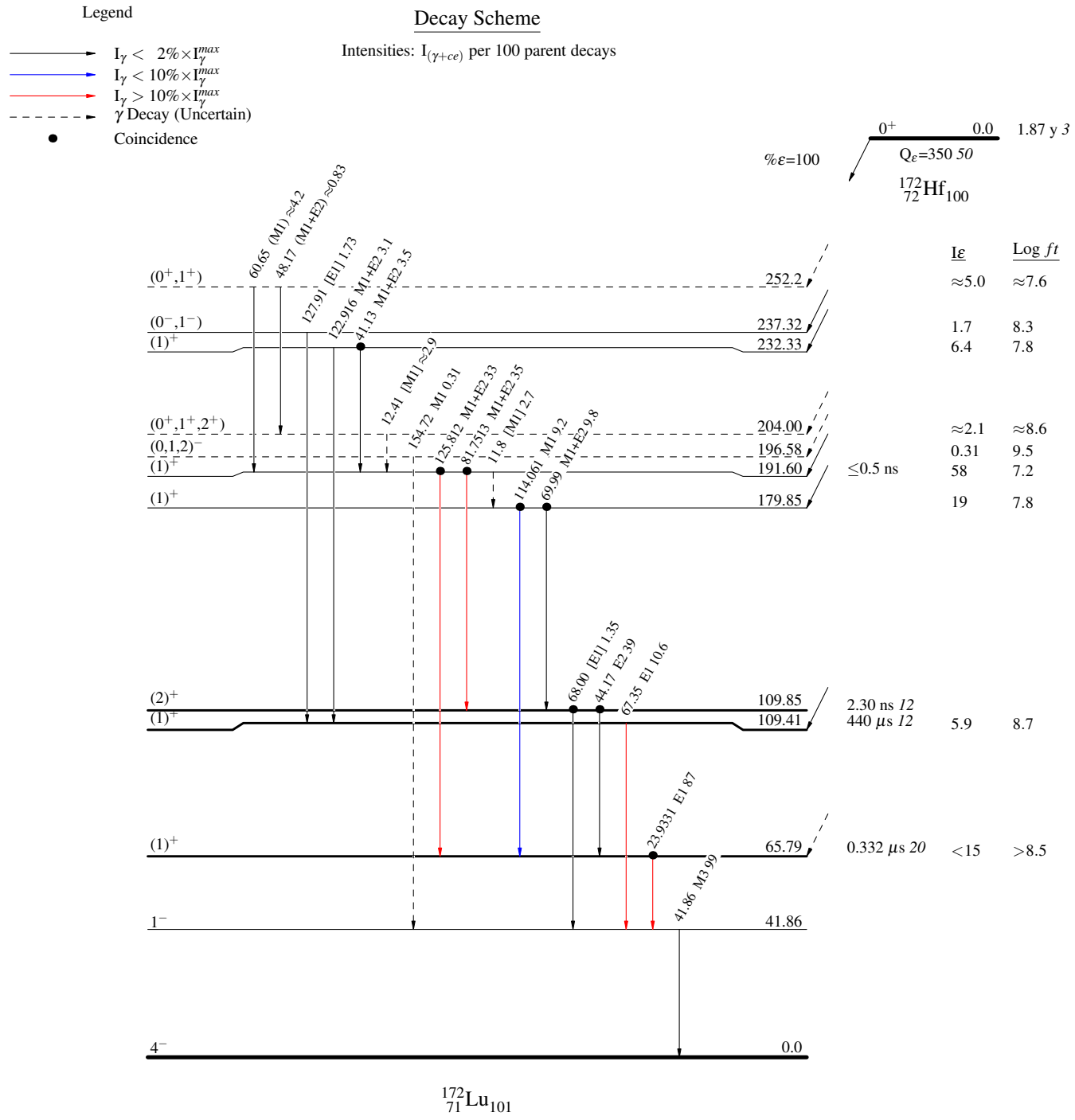
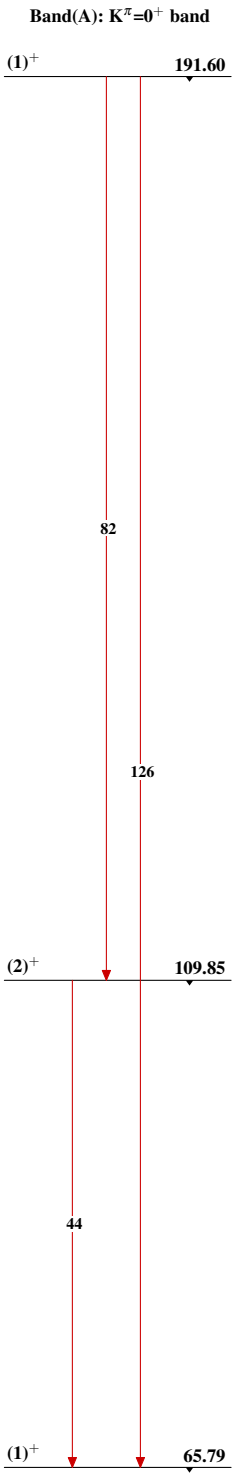


^{172}Hf ε decay (1.87 y) 1979To18,1966Ha23,1962Va07



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