^{167}Ho β^- decay (2.98 h) 1968Fu09

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 191,1 (2023)	22-Aug-2023

Parent: ^{167}Ho: E=0.0; J$^\pi$=7/2$^-$; T$_{1/2}$=2.98 h *3*; Q(β^-)=1010 *5*; %β^- decay=100

^{167}Ho-J$^\pi$,T$_{1/2}$: From Adopted Levels of ^{167}Ho.

^{167}Ho-Q(β^-): From 2021Wa16.

1968Fu09: ^{167}Ho from ^{168}Er(γ,p),Eγ=30−MeV and ^{164}Dy(α,p), Eα=27 MeV. Measured Eβ, Iβ, Eγ, Iγ, prompt and delayed $\beta\gamma$- and $\gamma\gamma$-coin using Ge(Li) and scintillation detectors for γ rays and a magnetic spectrometer for β radiation.

1962Ha24: measured ce using a magnetic spectrometer.

1955Ha45: ^{167}Ho from bombardment of Er_2O_3 with 22.4 MeV protons at the ORNL 86-inch cyclotron. Measured half-life of ^{167}Ho decay, Eβ, Eγ.

Theory for log *ft* values: 1994Dz03, 1975Fe13, 1974Bo49.

^{167}Er Levels

E(level)†	J$^\pi$‡	T$_{1/2}$	Comments
0.0	7/2$^+$	stable	
79.3219 *13*	(9/2)$^+$		
207.801 *5*	1/2$^-$	2.269 s *6*	T$_{1/2}$: from the Adopted Levels.
264.874 *5*	3/2$^-$		
281.574 *6*	5/2$^-$		
346.547 *15*	5/2$^-$	1.0 ns *1*	T$_{1/2}$: from $\gamma\gamma$(t), $\beta\gamma$(t) (1968Fu09); adopted in Adopted Levels.
413.272 *7*	(7/2)$^-$		
430.020 *15*	(7/2)$^-$		
441.9? *10*	(9/2)$^-$		
531.5 *3*	3/2$^+$		
535.81 *10*	(9/2$^-$)		
667.890 *20*	(5/2)$^-$		
744.94 *18*	(7/2)$^-$		

† From a least-squares fit to Eγ data.

‡ From the Adopted Levels.

β^- radiations

E(decay)	E(level)	Iβ^-†#	Log *ft*	Comments
(265 *5*)	744.94	2.9 *7*	5.49 *11*	av Eβ=73.1 *15*
(342 *5*)	667.890	42 *9*	4.68 *10*	av Eβ=97.1 *16* Measured Eβ=315 *20*, Iβ=45 (1968Fu09).
(580@ *5*)	430.020	2.5 *23*	6.7 *+11−3*	av Eβ=177.4 *18*
(664 *5*)	346.547	21 *5*	5.94 *10*	av Eβ=207.2 *18* Measured Eβ=610, Iβ=25 (1968Fu09).
(931 *5*)	79.3219	15‡ *15*	>6.2	av Eβ=308.5 *20*
(1010 *5*)	0.0	15‡ *15*	>6.3	av Eβ=339.5 *20* Measured Eβ=970 *20*, I$\beta\approx$30 (1968Fu09).

† β^- feedings to E(level)>79 are from intensity imbalance at each level.

‡ ≈30% for β^- branch to the (0.0+79.3) levels combined (1968Fu09). Evaluators assumed 50% uncertainty in this intensity in order to obtain γ normalization.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

γ(^{167}Er)

Iγ normalization: If total I(γ+ce) to (g.s.+79.3 level) minus I(γ+ce)(79.3γ) is 70% *15* (1968Fu09 report Iβ≈30% for β group populating the (0.0+79.3) levels; evaluators assigns 50% uncertainty to this intensity).

E_γ[†]	I_γ[†a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ	α[b]	$I_{(\gamma+ce)}$[a]	Comments
(16.700[#] *9*)	≈0.022	281.574	5/2$^-$	264.874	3/2$^-$	[M1]		89.0 *13*	≈2.0	%Iγ≈0.012 ce(L)/(γ+ce)=0.771 *7*; ce(M)/(γ+ce)=0.1715 *31* ce(N)/(γ+ce)=0.0400 *8*; ce(O)/(γ+ce)=0.00576 *11*; ce(P)/(γ+ce)=0.000315 *6* α(L)=69.4 *10*; α(M)=15.43 *22* α(N)=3.59 *5*; α(O)=0.518 *7*; α(P)=0.0283 *4* Unobserved, but expected from decay scheme; Eγ deduced from energy difference between 281.6 and 264.9 levels. I(γ+ce) deduced from intensity balance at 264.9 level. I$_\gamma$: deduced from I(γ+ce) and α(theory) for M1.
57.0723[&] *12*	1.4 *6*	264.874	3/2$^-$	207.801	1/2$^-$	M1+E2	0.352 *16*	5.02 *23*		α(N)=0.208 *10*; α(O)=0.0264 *11*; α(P)=0.000684 *11* %Iγ=0.8 *4* α(L)=3.88 *18*; α(M)=0.91 *4* I$_\gamma$: deduced from intensity balance at 207.8 level. E$_\gamma$,Mult.,δ: from the Adopted Gammas, based on subshell ratios.
73.775[#] *4*	0.8 *3*	281.574	5/2$^-$	207.801	1/2$^-$	E2		9.66 *14*		%Iγ=0.45 *20* α(K)=1.898 *27*; α(L)=5.94 *8*; α(M)=1.448 *20* α(N)=0.327 *5*; α(O)=0.0380 *5*; α(P)=8.80×10^{-5} *12* Eγ=73.8 *2* (1968Fu09). Mult.: from L1:L2:L3=(very weak):20:20 (1962Ha24).
79.3219[#] *13*	3.8 *9*	79.3219	(9/2)$^+$	0.0	7/2$^+$	M1+E2	−0.32 *3*	5.70 *8*		%Iγ=2.1 *7* α(K)exp≈3.0 (1962Ha24) α(K)=4.37 *8*; α(L)=1.03 *6*; α(M)=0.236 *15* α(N)=0.0544 *33*; α(O)=0.0073 *4*; α(P)=0.000268 *5* Eγ=79.3 *2* (1968Fu09). K:L1=≈250:50 (1962Ha24). L2 is weak (1962Ha24). Mult.,δ: from the Adopted Gammas; α(K)exp in ^{167}Ho β^- decay gives M1+E2 with δ≈1.2.
83.4733[#] *25*	2.7[@] *6*	430.020	(7/2)$^-$	346.547	5/2$^-$	M1+E2	0.40 *+50−13*	4.94 *35*		%Iγ=1.5 *5* α(K)exp≈2.6 (1962Ha24) α(K)=3.7 *8*; α(L)=1.0 *8*; α(M)=0.23 *21*

γ(^{167}Er) (continued)

E_γ [†]	I_γ [†a]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [‡]	α [b]	Comments
								α(N)=0.05 *5*; α(O)=0.007 *5*; α(P)=2.2×10^{-4} *6* Eγ=83.5 *2* (1968Fu09). K:L1:L2=≈150:30:≈15 (1962Ha24). δ: from α(K)exp and K, L1, L2 ratios using BrIccMixing code, assuming 50% uncertainty in α(K)exp, K and L2 intensities and 20% in L1.
105.75[#] *10*	0.16 *7*	535.81	(9/2$^-$)	430.020	(7/2)$^-$	[M1,E2]	2.40 *4*	%Iγ=0.09 *4* α(K)=1.5 *5*; α(L)=0.7 *4*; α(M)=0.17 *10* α(N)=0.038 *23*; α(O)=0.0047 *24*; α(P)=8.E−5 *4* Eγ=106 *1* (1968Fu09).
131[c] *1*	≈0.08	667.890	(5/2)$^-$	535.81	(9/2$^-$)	[E2]	1.088 *34*	α(K)=0.540 *14*; α(L)=0.421 *16*; α(M)=0.102 *4* %Iγ≈0.045 α(N)=0.0231 *9*; α(O)=0.00275 *10*; α(P)=2.31×10^{-5} *6* Observed in coincidence spectrum only. I$_\gamma$: deduced from intensity balance at 536.3 level; Iγ(131γ+131.7γ)=0.2 *1*.
131.700[#] *4*	≈0.12	413.272	(7/2)$^-$	281.574	5/2$^-$	[M1,E2]	1.18 *12*	%Iγ≈0.0674 α(K)=0.81 *28*; α(L)=0.29 *12*; α(M)=0.068 *32* α(N)=0.015 *7*; α(O)=0.0020 *7*; α(P)=4.5×10^{-5} *22* Eγ=131.7 *3* (1968Fu09). I$_\gamma$: see comment with 131γ from 668 level; remaining intensity is attributed to 131.7γ.
148.394[#] *6*	0.2 *1*	413.272	(7/2)$^-$	264.874	3/2$^-$	[E2]	0.699 *10*	%Iγ=0.11 *6* α(K)=0.382 *5*; α(L)=0.2434 *34*; α(M)=0.0586 *8* α(N)=0.01331 *19*; α(O)=0.001601 *22*; α(P)=1.677×10^{-5} *23* Eγ=148.3 *4* (1968Fu09).
207.801[#] *5*	8.8 *6*	207.801	1/2$^-$	0.0	7/2$^+$	E3	1.380 *19*	%Iγ=4.9 *11* α(K)=0.476 *7*; α(L)=0.689 *10*; α(M)=0.1718 *24* α(N)=0.0392 *5*; α(O)=0.00466 *7*; α(P)=2.75×10^{-5} *4* Eγ=207.8 *2* (1968Fu09). Mult.: from the Adopted Gammas, based on ce subshell ratios and α(K)exp.
208.7 *4*	0.30 *15*	744.94	(7/2)$^-$	535.81	(9/2$^-$)	[M1,E2]	0.29 *7*	%Iγ=0.17 *9* α(K)=0.22 *8*; α(L)=0.051 *7*; α(M)=0.0118 *20* α(N)=0.0027 *4*; α(O)=0.000361 *29*; α(P)=1.3×10^{-5} *6* Observed in coincidence spectrum only.
237.873[#] *15*	9.0 *6*	667.890	(5/2)$^-$	430.020	(7/2)$^-$	M1	0.2498 *35*	%Iγ=5.1 *11* α(K)exp=0.31; K/L1=6.0 (1962Ha24) α(K)=0.2100 *29*; α(L)=0.0310 *4*; α(M)=0.00688 *10* α(N)=0.001604 *22*; α(O)=0.0002322 *33*; α(P)=1.286×10^{-5} *18* Eγ=237.9 *2* (1968Fu09).
250.2[#] *5*	[@]	531.5	3/2$^+$	281.574	5/2$^-$	[E1]	0.0292 *4*	α(K)=0.0246 *4*; α(L)=0.00359 *5*; α(M)=0.000793 *12* α(N)=0.0001831 *27*; α(O)=2.56×10^{-5} *4*; α(P)=1.249×10^{-6} *19*

γ(^{167}Er) (continued)

E_γ [†]	I_γ [†a]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [‡]	δ	α [b]	Comments
254.7 *2*	0.37 *10*	667.890	(5/2)$^-$	413.272	(7/2)$^-$	[M1,E2]		0.16 *5*	%Iγ=0.21 *7* α(K)=0.13 *5*; α(L)=0.0261 *5*; α(M)=0.00596 *27* α(N)=0.00138 *5*; α(O)=0.000186 *7*; α(P)=7.3×10^{-6} *33*
266.5[#] *5*	[@]	531.5	3/2$^+$	264.874	3/2$^-$	E1[#]		0.0249 *4*	α(K)=0.02099 *31*; α(L)=0.00305 *5*; α(M)=0.000673 *10* α(N)=0.0001556 *23*; α(O)=2.178×10^{-5} *32*; α(P)=1.072×10^{-6} *16*
303[c] *1*	≤0.06	744.94	(7/2)$^-$	441.9?	(9/2)$^-$	[M1,E2]		0.098 *31*	%Iγ<0.0337 α(K)=0.079 *30*; α(L)=0.0149 *12*; α(M)=0.00339 *18* α(N)=0.00078 *5*; α(O)=0.000107 *13*; α(P)=4.6×10^{-6} *21*
315.0 *5*	1.3 *3*	744.94	(7/2)$^-$	430.020	(7/2)$^-$	[M1,E2]		0.088 *29*	%Iγ=0.73 *23* α(K)=0.071 *27*; α(L)=0.0132 *13*; α(M)=0.00300 *21* α(N)=0.00069 *5*; α(O)=9.5×10^{-5} *13*; α(P)=4.1×10^{-6} *19*
321.336[#] *25*	42.0 *15*	667.890	(5/2)$^-$	346.547	5/2$^-$	M1(+E2)	<0.8	0.100 *11*	%Iγ=24 *5* α(K)exp=0.087; K:L1=80:15 (1962Ha24) α(K)=0.083 *10*; α(L)=0.0132 *5*; α(M)=0.00295 *9* α(N)=0.000685 *24*; α(O)=9.8×10^{-5} *5*; α(P)=5.0×10^{-6} *7* Eγ=321.3 *2* (1968Fu09). δ: from combined fit to α(K)exp and K/L1 ratio, assuming 20% uncertainty in each value.
323.7[#] *5*	[@]	531.5	3/2$^+$	207.801	1/2$^-$	E1[#]		0.01538 *22*	α(K)=0.01299 *19*; α(L)=0.001866 *27*; α(M)=0.000411 *6* α(N)=9.51×10^{-5} *14*; α(O)=1.340×10^{-5} *19*; α(P)=6.75×10^{-7} *10*
332 *1*	0.30 *15*	744.94	(7/2)$^-$	413.272	(7/2)$^-$	[M1,E2]		0.076 *25*	α(N)=0.00059 *6*; α(O)=8.1×10^{-5} *13*; α(P)=3.6×10^{-6} *16* %Iγ=0.17 *9* α(K)=0.062 *24*; α(L)=0.0112 *13*; α(M)=0.00254 *24*
346.547[#] *15*	100	346.547	5/2$^-$	0.0	7/2$^+$	E1		0.01304 *18*	%Iγ=56 *12* α(K)exp=0.016; K:L1=35:6 (1962Ha24) α(K)=0.01102 *15*; α(L)=0.001576 *22*; α(M)=0.000347 *5* α(N)=8.04×10^{-5} *11*; α(O)=1.134×10^{-5} *16*; α(P)=5.76×10^{-7} *8* Eγ=346.5 *2* (1968Fu09).
(351.31 *25*)	1.4 *11*	430.020	(7/2)$^-$	79.3219	(9/2)$^+$	[E1]		0.01261 *18*	%Iγ=0.8 *6* α(K)=0.01067 *15*; α(L)=0.001524 *22*; α(M)=0.000336 *5* α(N)=7.77×10^{-5} *11*; α(O)=1.097×10^{-5} *15*; α(P)=5.58×10^{-7} *8* E_γ: from the Adopted Gammas; transition probably not resolved from 346.5γ in ^{167}Ho β^- decay (1968Fu09). I_γ: deduced from Iγ(83.5γ) and adopted γ branching ratio for 430.0 level.
386.2 *2*	6.0 *3*	667.890	(5/2)$^-$	281.574	5/2$^-$	M1		0.0682 *10*	α(K)exp=0.12 (1962Ha24) α(N)=0.000432 *6*; α(O)=6.27×10^{-5} *9*; α(P)=3.49×10^{-6} *5* %Iγ=3.4 *8* α(K)=0.0575 *8*; α(L)=0.00838 *12*; α(M)=0.001855 *26*

$^{167}_{68}$Er$_{99}$-4

^{167}Ho β^- decay (2.98 h) 1968Fu09 (continued)

γ(^{167}Er) (continued)

E_γ[†]	I_γ[†a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α[b]	Comments
398.6 *3*	1.6 *3*	744.94	(7/2)$^-$	346.547	5/2$^-$	[M1,E2]	0.046 *16*	α(K)=0.038 *15*; α(L)=0.0065 *12*; α(M)=0.00147 *24* %Iγ=0.9 *3* α(N)=0.00034 *6*; α(O)=4.7×10^{-5} *10*; α(P)=2.2×10^{-6} *10*
403.0 *2*	5.8 *3*	667.890	(5/2)$^-$	264.874	3/2$^-$	[M1,E2]	0.045 *16*	%Iγ=3.3 *7* α(K)=0.037 *14*; α(L)=0.0063 *12*; α(M)=0.00142 *24* α(N)=0.00033 *6*; α(O)=4.6×10^{-5} *10*; α(P)=2.2×10^{-6} *9*
430.0 *5*	0.22 *6*	430.020	(7/2)$^-$	0.0	7/2$^+$	[E1]	0.00785 *11*	%Iγ=0.12 *4* α(K)=0.00665 *9*; α(L)=0.000939 *13*; α(M)=0.0002066 *29* α(N)=4.79×10^{-5} *7*; α(O)=6.79×10^{-6} *10*; α(P)=3.53×10^{-7} *5*
460.0 *2*	3.7 *4*	667.890	(5/2)$^-$	207.801	1/2$^-$	[E2]	0.02045 *29*	α(K)=0.01612 *23*; α(L)=0.00336 *5*; α(M)=0.000769 *11* %Iγ=2.1 *5* α(N)=0.0001772 *25*; α(O)=2.378×10^{-5} *33*; α(P)=8.84×10^{-7} *12*
463 *1*	0.8 *3*	744.94	(7/2)$^-$	281.574	5/2$^-$	[M1,E2]	0.031 *11*	%Iγ=0.45 *20* α(K)=0.026 *10*; α(L)=0.0042 *10*; α(M)=0.00095 *20* α(N)=0.00022 *5*; α(O)=3.1×10^{-5} *8*; α(P)=1.5×10^{-6} *7*
480.0 *5*	0.26 *5*	744.94	(7/2)$^-$	264.874	3/2$^-$	[E2]	0.01828 *26*	%Iγ=0.15 *4* α(K)=0.01449 *21*; α(L)=0.00294 *4*; α(M)=0.000673 *10* α(N)=0.0001552 *22*; α(O)=2.091×10^{-5} *30*; α(P)=7.98×10^{-7} *11*
531.5[&] *8*	<0.03	531.5	3/2$^+$	0.0	7/2$^+$	E2[#]	0.01408 *20*	α(N)=0.0001140 *17*; α(O)=1.551×10^{-5} *23*; α(P)=6.27×10^{-7} *9* %Iγ<0.017 α(K)=0.01128 *16*; α(L)=0.002171 *32*; α(M)=0.000494 *7*
668.0 *5*	0.4 *2*	667.890	(5/2)$^-$	0.0	7/2$^+$	[E1]	0.00301 *4*	%Iγ=0.23 *12* α(K)=0.00256 *4*; α(L)=0.000352 *5*; α(M)=7.73×10^{-5} *11* α(N)=1.795×10^{-5} *25*; α(O)=2.57×10^{-6} *4*; α(P)=1.388×10^{-7} *20* I_γ: 0.4 +*1*−*2* in 1968Fu09.
745.0 *5*	0.3 *1*	744.94	(7/2)$^-$	0.0	7/2$^+$	[E1]	2.41×10^{-3} *3*	%Iγ=0.17 *7* α(K)=0.002053 *29*; α(L)=0.000281 *4*; α(M)=6.16×10^{-5} *9* α(N)=1.432×10^{-5} *20*; α(O)=2.056×10^{-6} *29*; α(P)=1.117×10^{-7} *16*

[†] From 1968Fu09, except where noted.

[‡] From α(K)exp, unless otherwise specified; the Iγ (adopted here) and ce intensity (1962Ha24) scales are normalized through α(K)=0.469 (E3 theory) for 207.8γ. The same values are adopted in Adopted Gammas.

[#] From the Adopted Gammas.

[@] Negligible relative to Iγ(531.5γ) (from adopted branching).

[&] From ce data (1962Ha24).

[a] For absolute intensity per 100 decays, multiply by 0.56 *12*.

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

$^{167}_{68}Er_{99}$-5

^{167}Ho β^- decay (2.98 h) 1968Fu09

Decay Scheme

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