^{170}Ho β^- decay (2.76 min) 1978Ka16,1978Tu04,1974Ka21

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	C. M. Baglin[1], E. A. Mccutchan[2], S. Basunia[1]	NDS 153, 1 (2018)	1-Oct-2018

Parent: ^{170}Ho: E=0; J$^\pi$=(6$^+$); T$_{1/2}$=2.76 min *5*; Q(β^-)=3870 *50*; %β^- decay=100.0

Typically, sources have been produced by ^{170}Er(n,p), E(n)=14 MeV.

1978Ka16: measured Eβ, Eβ, Iγ, $\gamma\gamma$ coin, $\beta\gamma$ coin, α(K)exp.

1974Ka21: measured Eγ, Iγ, $\gamma\gamma$ coin, Eβ, $\beta\gamma$ coin.

1969Sc01: measured Eβ, Eγ, Iγ, $\beta\gamma$ coin.

Measured Q(β^-)=3870 keV *50* (1978Tu04) is the same as that recommended in 2017Wa10.

The adopted decay scheme is that of 1978Ka16; it differs significantly from that of 1974Ka21. The 1147.8 *10* γ, Iγ=1.4 *8*, placed from the 2159 level by 1974Ka21, is absent in 1978Ka16; consequently, it has been omitted here. Eγ and Iγ from 1978Ka16 and 1974Ka21 are in satisfactory agreement; however, 1978Ka16 observe many more transitions than 1974Ka21 and report Eγ with higher precision.

^{170}Er Levels

E(level)†	J$^\pi$‡	Comments
0.0	0$^+$	
78.65 *8*	2$^+$	
260.22 *11*	4$^+$	
540.63 *15*	6$^+$	
934.06? *17*	2$^+$	
1010.64 *14*	(3$^+$)	
1103.47 *14*	4$^+$	
1127.29 *15*	4$^+$	
1217.48 *13*	3$^{(+)}$	
1236.7 *4*	(5$^+$)	
1268.80 *13*	(4$^-$)	
1304.60 *14*	(4$^+$)	
1372.31 *14*	(5$^-$)	
1413.14 *19*	(5$^+$)	
1496.24 *15*	(6$^-$)	
1590.94 *15*	(6$^-$)	
1746.03? *20*	(4$^-$)	Order of 413γ and 477γ unknown; alternative E(level)=1681.8 *2*. However, a 1746 level is known from (n,n′γ).
2159.06 *16*	(5$^+$)	

† From a least-squares fit to Eγ, by evaluators.

‡ From the Adopted Levels.

β^- radiations

E(decay)†	E(level)	Iβ^-‡#	Log *ft*	Comments
(1.71×10^3 *5*)	2159.06	64 *9*	5.08 *8*	av Eβ=632 *22* E(decay): others: 1710 *50* (1978Tu04), 1650 *200* (1978Ka16), 1500 (1969Sc01). Additional information 1.
(2.28×10^3 *5*)	1590.94	11.7 *19*	6.31 *8*	av Eβ=880 *23* E(decay): others: 2300 *200* (1978Ka16), 2000 (1969Sc01).
(2.46×10^3 *5*)	1413.14	0.8 *4*	7.60 *22*	av Eβ=959 *23*
(2.50×10^3 *5*)	1372.31	4.3 *24*	6.90 *25*	av Eβ=977 *23*
(2.57×10^3 *5*)	1304.60	4.5 *19*	6.93 *19*	av Eβ=1007 *23* Iβ may imply additional, as yet unobserved, γ feeding to 1305 level; log *ft* is low

Continued on next page (footnotes at end of table)

^{170}Ho β^- decay (2.76 min) 1978Ka16,1978Tu04,1974Ka21 (continued)

β^- radiations (continued)

E(decay)†	E(level)	Iβ^{-}‡#	Log *ft*	Comments
				for 6^+ to 4^+ transition.
(2.63×10^3 *5*)	1236.7	2.9 *5*	7.17 *9*	av Eβ=1038 *23*
(3.33×10^3 *5*)	540.63	1.8 *6*	7.79 *15*	av Eβ=1352 *23*

† Other data: 1969Sc01, 1974Ka21, 1978Ka16. The Eβ=3000 *300* endpoint reported by 1974Ka21 is attributed to ^{28}Al in 1978Ka16.
‡ From intensity balance, assigning 0.5Iγ±0.5Iγ whenever γ placement is uncertain.
# Absolute intensity per 100 decays.

γ(^{170}Er)

Iγ normalization: assuming Σ(I(γ+ce) to g.s.)=100%.
Data are from 1978Ka16, except as noted.
%Iγ have been deduced by evaluators.

E_γ	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	α[d]	Comments
51.30 *10*	11.4 *8*	1268.80	(4$^-$)	1217.48	3$^{(+)}$	E1	0.355 *6*	%Iγ=2.6 *4* α(L)=0.278 *5*; α(M)=0.0619 *10*; α(N+..)=0.01581 *24* α(N)=0.01398 *21*; α(O)=0.00177 *3*; α(P)=6.14×10^{-5} *9* α(exp)≤1.0 from intensity balance at 1217 level (1978Ka16).
^{x}69.3[@] *3*								From coin spectrum; weak.
78.65 *8*	52 *6*	78.65	2$^+$	0.0	0$^+$	E2[b]	7.47	%Iγ=11.63 *18* α(K)=1.738 *25*; α(L)=4.39 *7*; α(M)=1.069 *16*; α(N+..)=0.270 *4* α(N)=0.242 *4*; α(O)=0.0281 *5*; α(P)=7.68×10^{-5} *11* α(exp)=7.1 *12* (1978Ka16) from intensity balance.
87.16 *9*	4.8 *6*	1304.60	(4$^+$)	1217.48	3$^{(+)}$	M1	4.22	%Iγ=1.07 *19* α(K)=3.54 *5*; α(L)=0.533 *8*; α(M)=0.1182 *17*; α(N+..)=0.0318 *5* α(N)=0.0276 *4*; α(O)=0.00398 *6*; α(P)=0.000219 *4* α(K)exp=5 *3* (1978Ka16)
94.67 *8*	11.1 *9*	1590.94	(6$^-$)	1496.24	(6$^-$)	M1	3.33	%Iγ=2.5 *4* α(K)=2.79 *4*; α(L)=0.419 *6*; α(M)=0.0931 *14*; α(N+..)=0.0250 *4* α(N)=0.0217 *3*; α(O)=0.00314 *5*; α(P)=0.0001725 *25* α(K)exp=2.7 *14* (1978Ka16)
103.54 *8*	20.5 *15*	1372.31	(5$^-$)	1268.80	(4$^-$)	M1	2.58	%Iγ=4.6 *7* α(K)=2.16 *3*; α(L)=0.324 *5*; α(M)=0.0719 *11*; α(N+..)=0.0193 *3* α(N)=0.01676 *24*; α(O)=0.00242 *4*; α(P)=0.0001333 *19* α(K)exp=2.1 *8* (1978Ka16)
123.90 *14*	16 *3*	1496.24	(6$^-$)	1372.31	(5$^-$)	(M1,E2)	1.44 *11*	%Iγ=3.6 *8* α(K)=1.0 *4*; α(L)=0.37 *18*; α(M)=0.09 *5*; α(N+..)=0.022 *11* α(N)=0.020 *10*; α(O)=0.0025 *11*; α(P)=5.E−5 *3* α(K)exp=1.1 *9* (1978Ka16)
141.50 *9*	7.8 *10*	1268.80	(4$^-$)	1127.29	4$^+$	[E1]	0.1293	%Iγ=1.7 *3* α(K)=0.1082 *16*; α(L)=0.01654 *24*; α(M)=0.00366 *6*; α(N+..)=0.000960 *14* α(N)=0.000840 *12*; α(O)=0.0001146 *17*; α(P)=5.12×10^{-6} *8*
165.36 *8*	16.9 *15*	1268.80	(4$^-$)	1103.47	4$^+$	(E1)	0.0856	%Iγ=3.8 *6* α(K)=0.0718 *10*; α(L)=0.01081 *16*; α(M)=0.00239 *4*; α(N+..)=0.000629 *9* α(N)=0.000550 *8*; α(O)=7.56×10^{-5} *11*; α(P)=3.47×10^{-6} *5* α(K)exp≤0.2 (1978Ka16)
181.57 *8*	108 *10*	260.22	4$^+$	78.65	2$^+$	E2[b]	0.348	%Iγ=24 *4* α(K)=0.215 *3*; α(L)=0.1029 *15*; α(M)=0.0246 *4*; α(N+..)=0.00629 *9* α(N)=0.00560 *8*; α(O)=0.000685 *10*; α(P)=9.88×10^{-6} *14* α(exp)=0.33 *17* (1978Ka16) from intensity balance.

From ENSDF

$^{170}_{68}$Er$_{102}$-3

$\gamma(^{170}$Er) (continued)

E_γ	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ[#]	α[d]	Comments
218.69 *10*	5.2 *10*	1590.94	(6⁻)	1372.31	(5⁻)				%Iγ=1.2 *3*
227.41 *9*	16 *2*	1496.24	(6⁻)	1268.80	(4⁻)	[E2]		0.1650	%Iγ=3.6 *6* α(K)=0.1117 *16*; α(L)=0.0411 *6*; α(M)=0.00974 *14*; α(N+..)=0.00250 *4* α(N)=0.00222 *4*; α(O)=0.000277 *4*; α(P)=5.42×10^{-6} *8*
258.17 *9*	168 *10*	1268.80	(4⁻)	1010.64	(3⁺)	D+Q[b]			%Iγ=38 *5*
280.44 *11*	12 *2*	540.63	6⁺	260.22	4⁺	E2[b]		0.0849	%Iγ=2.7 *6* α(K)=0.0612 *9*; α(L)=0.0183 *3*; α(M)=0.00430 *6*; α(N+..)=0.001112 *16* α(N)=0.000984 *14*; α(O)=0.0001255 *18*; α(P)=3.11×10^{-6} *5*
283.42 *10*	12 *2*	1217.48	3$^{(+)}$	934.06?	2⁺	[M1]		0.1554	%Iγ=2.7 *6* α(K)=0.1307 *19*; α(L)=0.0192 *3*; α(M)=0.00426 *6*; α(N+..)=0.001145 *16* α(N)=0.000993 *14*; α(O)=0.0001439 *21*; α(P)=7.98×10^{-6} *12*
413.2 *2*	14.3 *9*	2159.06	(5⁺)	1746.03?	(4⁻)				%Iγ=3.2 *5* Order of 413γ and 477γ undetermined (1978Ka16).
477.4[a] *2*	15.4[a] *10*	1746.03?	(4⁻)	1268.80	(4⁻)				%Iγ=3.4 *5* Order of 413γ and 477γ undetermined (1978Ka16).
662.9[@f] *3*	5.5 *7*	2159.06	(5⁺)	1496.24	(6⁻)				%Iγ=1.23 *21*
746.0[@f] *2*	7.0 *10*	2159.06	(5⁺)	1413.14	(5⁺)				%Iγ=1.6 *3*
750.4 *2*	24.0 *13*	1010.64	(3⁺)	260.22	4⁺	(M1+E2)[b]	-1.8×10^2 *+11−46*	0.00621 *9*	%Iγ=5.4 *7* α=0.00621 *9*; α(K)=0.00512 *8*; α(L)=0.000852 *12*; α(M)=0.000191 *3*; α(N+..)=5.07×10^{-5} *8* α(N)=4.43×10^{-5} *7*; α(O)=6.18×10^{-6} *9*; α(P)=2.90×10^{-7} *4*
786.3 *5*	22 *4*	2159.06	(5⁺)	1372.31	(5⁻)				%Iγ=4.9 *11*
832.5[@f] *10*	≈3	1372.31	(5⁻)	540.63	6⁺				%Iγ=0.7 *4*
843.5 *2*	11 *3*	1103.47	4⁺	260.22	4⁺	M1+E2[b]	+2.81 *10*	0.00532 *9*	%Iγ=2.5 *8* α=0.00532 *9*; α(K)=0.00443 *7*; α(L)=0.000693 *11*; α(M)=0.0001546 *23*; α(N+..)=4.12×10^{-5} *7* α(N)=3.59×10^{-5} *6*; α(O)=5.08×10^{-6} *8*; α(P)=2.54×10^{-7} *4*
854.7[e&f] *5*	7.3[e&] *13*	934.06?	2⁺	78.65	2⁺	E2(+M1)[b]	≥14	0.00468 *7*	%Iγ=1.6 *4* α=0.00468 *7*; α(K)=0.00389 *6*; α(L)=0.000620 *9*; α(M)=0.0001386 *20*; α(N+..)=3.69×10^{-5} *6* α(N)=3.21×10^{-5} *5*; α(O)=4.52×10^{-6} *7*; α(P)=2.21×10^{-7} *4*

From ENSDF

$^{170}_{68}$Er$_{102}$-4

γ(^{170}Er) (continued)

E_γ	I_γ [†c]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [‡]	δ [#]	α [d]	Comments
854.7[e&] *5*	48[e&] *7*	2159.06	(5$^+$)	1304.60	(4$^+$)				%Iγ=10.7 *20*
867.0 *2*	9.7 *8*	1127.29	4$^+$	260.22	4$^+$	M1+E2[b]	−9.8 *+22−63*	0.00458 *7*	%Iγ=2.2 *3* α=0.00458 *7*; α(K)=0.00380 *6*; α(L)=0.000603 *9*; α(M)=0.0001346 *20*; α(N+..)=3.58×10^{-5} *6* α(N)=3.12×10^{-5} *5*; α(O)=4.40×10^{-6} *7*; α(P)=2.16×10^{-7} *4*
872.6[@f] *3*	1.7 *4*	1413.14	(5$^+$)	540.63	6$^+$	D+Q[b]			%Iγ=0.38 *10*
890.2 *2*	100	2159.06	(5$^+$)	1268.80	(4$^-$)				%Iγ=22 *3*
932.1 *2*	164 *9*	1010.64	(3$^+$)	78.65	2$^+$	(M1+E2)[b]	−1.5×10^2 *+8−50*	0.00389 *6*	%Iγ=37 *5* α=0.00389 *6*; α(K)=0.00324 *5*; α(L)=0.000505 *7*; α(M)=0.0001125 *16*; α(N+..)=3.00×10^{-5} *5* α(N)=2.61×10^{-5} *4*; α(O)=3.69×10^{-6} *6*; α(P)=1.84×10^{-7} *3*
934.10[&f] *16*	6.6[&] *CA*	934.06?	2$^+$	0.0	0$^+$	E2[b]		0.00387 *6*	%Iγ=1.5 *8* α=0.00387 *6*; α(K)=0.00323 *5*; α(L)=0.000502 *7*; α(M)=0.0001120 *16*; α(N+..)=2.98×10^{-5} *5* α(N)=2.60×10^{-5} *4*; α(O)=3.67×10^{-6} *6*; α(P)=1.84×10^{-7} *3*
941.4 *2*	94 *2*	2159.06	(5$^+$)	1217.48	3$^{(+)}$				%Iγ=21.0 *25*
957.4 *3*	17.0 *9*	1217.48	3$^{(+)}$	260.22	4$^+$	D+Q[b]			%Iγ=3.8 *5*
976.5 *3*	13.2 *8*	1236.7	(5$^+$)	260.22	4$^+$	(M1+E2)[b]		0.0050 *15*	%Iγ=3.0 *4* α=0.0050 *15*; α(K)=0.0042 *13*; α(L)=0.00062 *17*; α(M)=0.00014 *4*; α(N+..)=3.7×10^{-5} *10* α(N)=3.2×10^{-5} *9*; α(O)=4.6×10^{-6} *13*; α(P)=2.5×10^{-7} *9*
1024.7 *4*	7 *3*	1103.47	4$^+$	78.65	2$^+$	E2[b]		0.00320 *5*	%Iγ=1.6 *7* α=0.00320 *5*; α(K)=0.00267 *4*; α(L)=0.000407 *6*; α(M)=9.05×10^{-5} *13*; α(N+..)=2.41×10^{-5} *4* α(N)=2.10×10^{-5} *3*; α(O)=2.98×10^{-6} *5*; α(P)=1.523×10^{-7} *22*
1044.2 *2*	29.2 *15*	1304.60	(4$^+$)	260.22	4$^+$	(M1+E2)[b]	+6.3 *+45−18*	0.00314 *7*	%Iγ=6.5 *9* α=0.00314 *7*; α(K)=0.00263 *6*; α(L)=0.000397 *9*; α(M)=8.82×10^{-5} *19*; α(N+..)=2.35×10^{-5} *5* α(N)=2.05×10^{-5} *5*; α(O)=2.91×10^{-6} *7*; α(P)=1.50×10^{-7} *4*
1048.7 *8*	2 *1*	1127.29	4$^+$	78.65	2$^+$	E2[b]		0.00305 *5*	%Iγ=0.45 *23* α=0.00305 *5*; α(K)=0.00255 *4*; α(L)=0.000387 *6*; α(M)=8.59×10^{-5} *13*; α(N+..)=2.29×10^{-5} *4* α(N)=1.99×10^{-5} *3*; α(O)=2.84×10^{-6} *4*;

From ENSDF

$^{170}_{68}$Er$_{102}$-5

γ(^{170}Er) (continued)

E_γ	I_γ[†c]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ[#]	α[d]	Comments
									α(P)=1.455×10^{-7} *21* I_γ: note that I(1049γ)/I(867γ)=0.21 *11* here but 0.86 *9* in Adopted Gammas.
1111.8 *3*	9.4 *7*	1372.31	(5$^-$)	260.22	4$^+$				%Iγ=2.1 *3*
1138.7 *2*	93 *4*	1217.48	3$^{(+)}$	78.65	2$^+$	(M1+E2)[b]	+14 +7−4	0.00259 *4*	%Iγ=21 *3* α=0.00259 *4*; α(K)=0.00218 *4*; α(L)=0.000324 *5*; α(M)=7.18×10^{-5} *11*; α(N+..)=2.02×10^{-5} *3* α(N)=1.669×10^{-5} *24*; α(O)=2.38×10^{-6} *4*; α(P)=1.242×10^{-7} *18*; α(IPF)=1.053×10^{-6} *17*
1153.0 *3*	8.9 *8*	1413.14	(5$^+$)	260.22	4$^+$				%Iγ=2.0 *3*
1226.0 *3*	14 *2*	1304.60	(4$^+$)	78.65	2$^+$				%Iγ=3.1 *6*
[x]1306.9[@] *3*	2.0 *4*								%Iγ=0.45 *11* E_γ: A 1306.8γ is placed from a 1385, 2$^+$ level in (n,n′γ), but that level could be populated only indirectly in this decay.

[†] Relative photon intensities normalized so I(890.2γ)=100.

[‡] From α(exp) or α(K)exp (1978Ka16). Authors normalized their α(K)exp data assuming mult=E2 for 79γ and 181γ (based on α(exp) deduced by authors from intensity balance at the 79 and 260 levels).

[#] From the Adopted Gammas.

[@] Assignment uncertain (1978Ka16).

[&] If the 934γ is correctly assigned, an 855γ of comparable intensity should deexcite the 934 level also; this suggests that the observed 854.7γ (Iγ=55 *7*), placed from the 2159 level, is in fact a doublet. No β^- branch is expected to feed the 934 level (ΔJ=(4)), so intensity balance requires I(934γ+855γ)=13.9 *24* which, combined with adopted branching from 934 level, implies I(855γ)=7.3 *13* (leaving Iγ=48 *7* deexciting 2159 level) and I(934γ)=6.6 *11* (cf. observed I(934γ)=17 *4*). Possibly the observed 934γ is complex.

[a] In (n,n′γ), the 477γ is a doublet deexciting both 1488 and 1746 levels; it is accompanied by a 406γ of at least comparable strength from the 1746 level and by 251γ and 947γ from the 1488 level, none of which is reported in ^{170}Ho β^- decay. In this decay, 477γ-γ coin data strongly favor placement from the 1746 level, and intensity balance at the 1746 level limits I(477γ) from 1486 level to 1.1 *13*. The absence of a 406γ in decay is not understood.

[b] From the Adopted Gammas.

[c] For absolute intensity per 100 decays, multiply by 0.22 *3*.

[d] 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.

[e] Multiply placed with intensity suitably divided.

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

[x] γ ray not placed in level scheme.

From ENSDF

$^{170}_{68}$Er$_{102}$-6

^{170}Ho β^- decay (2.76 min) 1978Ka16,1978Tu04,1974Ka21