^{228}Th α decay (1.9125 y) 1977Ku15,1984Ge07

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Sukhjeet Singh	ENSDF	08-Mar-2022

Parent: ^{228}Th: E=0; J$^\pi$=0$^+$; $T_{1/2}$=1.9125 y *9*; Q(α)=5520.15 *22*; %α decay=100

^{228}Th-Q(α): From 2021Wa16.

^{228}Th-$T_{1/2}$: 698.53 d *32* or 1.9125 y *9* (using 1 tropical year=365.2422 d). This value is the weighted average of 698.4 d *4* (from Erratum in Applied Rad. Isot. 159, 108976 (2020) to 2014Un01 which was revision of their previous values reported in 2002Un02 and 1992Un01); 698.77 d *32* (1971Jo14, also 1964Ei01), 697.8 d *7* (1956Ki16). Others: 1964Ei01 give $T_{1/2}$=1.91313 y *44*, a value also quoted in 1971Jo14 with an internal uncertainty of 0.00044 y but with a final uncertainty of 0.00088 y; 1956Ki16, 1964Ei03 and 1971Jo14 are from the same laboratory; 696.9 d *15*, 703 d *7* (1962Ma57), 695.8 d *70* (1918Me01, uncertainty of 1% mentioned by 1956Ki16).

^{228}Th-Additional information 1.

^{228}Th-%α decay: %α=100. Cluster decay: measured %^{20}O=1.13×10^{-11} *22* (1993Bo20).

1977Ku15 (also 1977Ku25): measured Eγ, Iγ, $\gamma\gamma$-coin using Ge(Li) detectors. Deduced levels, J, π, half-life, α hindrance factors.

1984Ge07: measured Iγ, absolute Iγ using 4$\pi\alpha$-γ counting system. Precise Eγ values were not measured in this work.

1970Ba20: measured Eα, Iα using a magnetic spectrograph. Deduced levels, J, π. See also 1976BaZZ.

1989Po19: measured $\gamma\gamma$-coin, $\alpha\gamma(\theta)$, ce, total-conversion coefficients from $\alpha\gamma$-coin data.

Others:

1973He13: measured g factor of first 2$^+$ state.

1970SpZW: measured subshell ratios.

1968Du06, 1966Co40: measured total-conversion coefficient from $\alpha\gamma$-coin data.

α measurements: 1971Gr17, 1953As31, 1949Ro02. Evaluation: 1991Ry01.

γ ray measurements: 1982Sa36, 1974HeYW, 1973Ta25, 1972DaYV, 1957St92, 1954Ne01, 1953Ri23, 1953Bo45.

$\alpha\gamma(\theta)$ measurements: 1954St02, 1953Ba07, 1951Be42.

1982Sa36: measured Iγ for four γ rays. The values are systematically lower than in 1977Ku15 and 1984Ge07, thus not used here.

The decay scheme is from 1977Ku15.

^{224}Ra Levels

E(level)†	J$^\pi$‡	$T_{1/2}$‡	Comments
0	0$^+$	3.6319 d *23*	
84.373 *3*	2$^+$	0.748 ns *19*	g=+0.46 *11* (1973He13) g: $\alpha\gamma(\theta$,H) (1973He13). $T_{1/2}$: weighted average of (α)(ce)(t) values: 0.748 ns *20* (1970To08), 0.744 ns *19* (1965Ne03), 0.76 ns *3* (1960Be25).
215.985 *4*	1$^-$		
250.783 *5*	4$^+$	0.181 ns *9*	J$^\pi$: 4$^+$ from $\alpha\gamma(\theta)$ from 0$^+$ parent (1989Po19). $T_{1/2}$: (α)(ce)(t) (1965Ne03).
290.32 *5*	3$^-$		
432.89 *19*	(5)$^-$		
479.28 *20*	(6$^+$)		
916.39 *19*	0$^+$		
992.50 *10*	(2$^+$)		

† From least-squares fit to Eγ data.
‡ From Adopted Levels.

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α radiations

Eα[†]	E(level)	Iα[‡@]	HF[#]	Comments
4430	992.50	≈4.6×10^{-6}	≈7.1	
4507	916.39	1.7×10^{-5} *3*	7 *1*	
4944	479.28	2.4×10^{-5} *5*	4.6×10^{3} *10*	
4990	432.89	1.0×10^{-5} *3*	2.1×10^{4} *7*	
5138	290.32	0.036 *6*	44 *8*	Eα: 5136.1 (1970Ba20). Iα: ≈0.05 (1970Ba20).
5173	250.783	0.218 *8*	12.5 *5*	Eα: 5171.5 (1970Ba20). Eα: other: 5173 (1953As31). Iα: 0.2 (1953As31), 0.18 (1970Ba20).
5211	215.985	0.408 *14*	10.7 *4*	Eα: 5208.9 (1970Ba20). Eα: other: 5208 (1953As31). Iα: 0.4 (1953As31), 0.36 (1970Ba20).
5340.36 *15*	84.373	26.0 *10*	0.96 *4*	Eα: measured values: 5339.2 *10* (1976BaZZ), 5340.54 *15* (1971Gr17), 5338.6 (1970Ba20), 5338.5 *10* (1953As31), 5338 (1949Ro02). Iα: 26.7 *2* (1969Pe17), 26.7 (1970Ba20), 28 (1953As31), 28 (1949Ro02). 1976BaZZ and 1970Ba20 are from the same lab.
5423.15 *22*	0	73.4 *5*	1.0	Iα: from DDEP evaluation (published in 2013BeZP); based on measurements by 1976BaZZ and 1993Ba72. Eα: measured values: 5420.6 *10* (1976BaZZ), 5423.33 *22* (1971Gr17), 5420.0 (1970Ba20), 5421 *1* (1953As31), 5423 (1949Ro02). Iα: others: 74.0 *6* (1993Ba72), 72.4 *10* (1976BaZZ), 72.7 (1970Ba20) 71 (1953As31), 72 (1949Ro02).

† Data for the ground-state and 84-level branches are from 1991Ry01 evaluation. Others are from 1970Ba20, but increased by 2 keV by the evaluators to account for changes in calibration as deduced from a comparison of authors′ values for the two strong branches with those of 1991Ry01 evaluation.
‡ From I(γ+ce) imbalance at each level, unless stated otherwise.
\# HF(5423.15α)=1.0 yields $r_0(^{224}Ra)$=1.53389 fm *32*, same r_0 in 2020Si16 evaluation.
@ Absolute intensity per 100 decays.

$\gamma(^{224}Ra)$

Iγ normalization: From absolute Iα=73.4 *5* (2013BeZP evaluation based on measured values in 1976BaZZ and 1993Ba72), and summed γ transition intensity to g.s.=100-73.4 *5*. Others: measured values: 0.0121 *6*(1969Pe17), 0.01248 *29* (1984Ge07), 0.019 *1* (1982Sa36, this value is discrepant). Evaluation: 0.0122 *2* (1991BaZS and 1986LoZT).

Eγ[†]	Iγ[#&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	α[a]	Comments
74.4 *1*	0.033 *12*	290.32	3$^-$	215.985	1$^-$	[E2]	38.5	α(L)=28.3 *5*; α(M)=7.70 *12* α(N)=2.03 *4*; α(O)=0.431 *7*; α(P)=0.0621 *10*; α(Q)=0.0001645 *25*
84.373[‡] *3*	100.0 *16*	84.373	2$^+$	0	0$^+$	E2	21.2	α(L)=15.57 *22*; α(M)=4.24 *6* α(N)=1.119 *16*; α(O)=0.238 *4*; α(P)=0.0343 *5*; α(Q)=0.0001015 *15* Eγ=84.371 *3* (1977Ku25). Mult.: L1:L2:L3=5.19 *21*:134.3 *10*:100; M1:M2:M3=5.7 *6*:121.9 *9*:100 (1970SpZW); theory(E2): L1:L2:L3=4.8:129.7:100. From αγ: α(exp)=21.4 *9* (1969Pe17), 19.6 *14* (1968Du06), 18 *4* (1966Co40).
131.613[‡] *4*	10.70 *15*	215.985	1$^-$	84.373	2$^+$	E1[@]	0.247	α(K)=0.194 *3*; α(L)=0.0406 *6*; α(M)=0.00977 *14* α(N)=0.00254 *4*; α(O)=0.000559 *8*;

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^{228}Th α decay (1.9125 y) 1977Ku15,1984Ge07 (continued)

γ(^{224}Ra) (continued)

E_γ[†]	I_γ[#&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	α[a]	Comments
								α(P)=8.92×10^{-5} *13*; α(Q)=4.80×10^{-6} *7* Eγ=131.610 *4* (1977Ku25).
142.0 *5*	0.00011 *4*	432.89	(5)$^-$	290.32	3$^-$	[E2]	2.18 *5*	α(K)=0.280 *4*; α(L)=1.40 *3*; α(M)=0.380 *8* α(N)=0.1004 *22*; α(O)=0.0214 *5*; α(P)=0.00313 *7*; α(Q)=1.86×10^{-5} *4* I_γ: Ig(142.0)/Iγ(182.2)=0.26 *10* is in disagreement with 0.56 *13* from Adopted Gammas.
166.410[‡] *4*	8.49 *12*	250.783	4$^+$	84.373	2$^+$	E2	1.164	α(K)=0.225 *4*; α(L)=0.691 *10*; α(M)=0.187 *3* α(N)=0.0495 *7*; α(O)=0.01056 *15*; α(P)=0.001553 *22*; α(Q)=1.200×10^{-5} *17* αγ(θ): A_2=+0.55 *6*, A_4=−0.48 *18* (1989Po19). Eγ=166.407 *4* (1977Ku25). Mult.: from I(γ+ce)(161γ)=Iα(5173)=0.18 (1970Ba20), α(exp)(166γ)=0.73.
182.2 *2*	0.00043 *15*	432.89	(5)$^-$	250.783	4$^+$	[E1]	0.1127	α(K)=0.0895 *13*; α(L)=0.0176 *3*; α(M)=0.00421 *6* α(N)=0.001100 *16*; α(O)=0.000244 *4*; α(P)=3.97×10^{-5} *6*; α(Q)=2.31×10^{-6} *4* I_γ: see comment for 142.0γ.
205.93 *5*	1.61 *5*	290.32	3$^-$	84.373	2$^+$	E1	0.0842	α(K)=0.0671 *10*; α(L)=0.01293 *19*; α(M)=0.00309 *5* α(N)=0.000807 *12*; α(O)=0.000179 *3*; α(P)=2.94×10^{-5} *5*; α(Q)=1.763×10^{-6} *25* Mult.: α(K)exp<0.19, α(L)exp<0.05, α(M)exp<0.014 (1989Po19).
215.983[‡] *5*	20.78 *25*	215.985	1$^-$	0	0$^+$	E1[@]	0.0752	α(K)=0.0600 *9*; α(L)=0.01148 *16*; α(M)=0.00274 *4* α(N)=0.000717 *10*; α(O)=0.0001593 *23*; α(P)=2.62×10^{-5} *4*; α(Q)=1.587×10^{-6} *23* I_γ: absolute Iγ/100 decays=0.261 *3* (1984Ge07). Eγ=215.979 *5* (1977Ku25).
228.5 *2*	0.0015 *3*	479.28	(6$^+$)	250.783	4$^+$	[E2]	0.366	α(K)=0.1243 *18*; α(L)=0.178 *3*; α(M)=0.0478 *7* α(N)=0.01264 *19*; α(O)=0.00272 *4*; α(P)=0.000406 *6*; α(Q)=5.36×10^{-6} *8*
700.5 *5*	≈0.00025	916.39	0$^+$	215.985	1$^-$	[E1]	0.00611	α(K)=0.00501 *7*; α(L)=0.000833 *12*; α(M)=0.000196 *3* α(N)=5.15×10^{-5} *8*; α(O)=1.165×10^{-5} *17*; α(P)=2.00×10^{-6} *3*; α(Q)=1.472×10^{-7} *21*
742.2 *5*	0.00012 *4*	992.50	(2$^+$)	250.783	4$^+$	[E2]	0.01624	α(K)=0.01195 *17*; α(L)=0.00322 *5*; α(M)=0.000802 *12* α(N)=0.000211 *3*; α(O)=4.71×10^{-5} *7*; α(P)=7.76×10^{-6} *11*; α(Q)=4.18×10^{-7} *6*
832.0 *2*	0.0012 *2*	916.39	0$^+$	84.373	2$^+$	[E2]	0.01289	α(K)=0.00970 *14*; α(L)=0.00240 *4*; α(M)=0.000594 *9* α(N)=0.0001565 *22*; α(O)=3.50×10^{-5} *5*; α(P)=5.81×10^{-6} *9*; α(Q)=3.35×10^{-7} *5*
908.10 *10*	≈0.00014	992.50	(2$^+$)	84.373	2$^+$	[M1,E2]	0.024 *13*	α(K)=0.019 *11*; α(L)=0.0036 *17*; α(M)=0.0009 *4*

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^{228}Th α decay (1.9125 y) 1977Ku15,1984Ge07 (continued)

γ(^{224}Ra) (continued)

E_γ [†]	I_γ [#&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	α [a]	Comments
								α(N)=0.00023 *11*; α(O)=5.2×10^{-5} *24*; α(P)=9.E−6 *5*; α(Q)=7.E−7 *4* E_γ,I_γ: from Iγ/I(742γ)=1.14 *26* in ^{224}Fr β^- decay in later work of these authors (1981Ku02). Spectrum in present work shows 911.2γ labeled as a background peak.
992.9 *10*	≈0.00012	992.50	(2$^+$)	0	0$^+$	[E2]	0.00913	α(K)=0.00705 *10*; α(L)=0.001568 *23*; α(M)=0.000383 *6* α(N)=0.0001010 *15*; α(O)=2.27×10^{-5} *4*; α(P)=3.81×10^{-6} *6*; α(Q)=2.40×10^{-7} *4*

[†] From 1977Ku15 unless otherwise noted.

[‡] The value in 1977Ku25 has been adjusted by the evaluators for change in calibration of ^{198}Au line from 411.794 keV *7* (used by 1977Ku25) to 411.80205 keV *17* recommended by 2000He14.

[#] Relative to 100 for the 84γ. Values for the strong lines (>1) are from 1984Ge07. Others are from 1977Ku15.

[@] From an intensity balance at the 216 level, using Iα(5211α)=0.36 (1970Ba20), both the 131γ and 216γ must be E1.

[&] For absolute intensity per 100 decays, multiply by 0.01188 *34*.

[a] 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.

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Decay Scheme