^{250}Es ε decay (2.22 h)

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Y. Akovali	NDS 94,131 (2001)	1-Aug-2001

Parent: ^{250}Es: E=0.0+x; J$^{\pi}$=1$^{(-)}$; $T_{1/2}$=2.22 h *5*; Q(ε)=2100 *SY*; %ε+%β^+ decay≤100.0

^{250}Es-%ε+%β^+ decay: Additional information 1.

Q+=2100 *100* is recommended by 1995Au04 for ε decay of ^{250}Es ground state. The excitation energy of the parent 2.22-H ^{250}Es isomeric state has not been determined experimentally. By assuming that the energy difference between the 1$^-$,(p 7/2[633],n 9/2[734]) configuration (2.22-H state)and the 6$^+$,(p 3/2[521],n 9/2[734]) ground state of ^{250}Es is less than the ΔQ(ε) value of 100 keV, calculations are carried here by taking Q+(2.22-H ^{250}Es)=2150 *150*.

^{250}Cf Levels

E(level)	J$^{\pi}$†	E(level)	J$^{\pi}$†	E(level)	J$^{\pi}$†	E(level)	J$^{\pi}$†
0.0	0$^+$	905.89 *2*	3$^-$	1154.24 *10*	0$^+$	1244.50 *8*	(2$^+$)
42.721 *5*	2$^+$	951.98 *2*	4$^-$	1175.52 *3*	1$^-$	1266.6 *2*	0$^+$
141.875 *10*	4$^+$	1031.852 *21*	2$^+$	1189.39 *3*	2$^+$	1296.60 *4*	2$^+$
871.57 *3*	2$^-$	1071.37 *2*	3$^+$	1209.97 *4*	(2)$^-$	1658.00 *4*	2$^+$

† ADOPTED values.

ε,β^+ radiations

E(decay)	E(level)	Iβ^+ #	Iε†‡#	Log *ft*	I($\varepsilon+\beta^+$)#	Comments
(442 *SY*)	1658.00		4.8 *3*	6.5 *5*	4.8 *3*	εK=0.66 *8*; εL=0.24 *6*; εM+=0.094 *25*
(803 *SY*)	1296.60		0.28 *3*	8.29 *20*	0.28 *3*	εK=0.717 *15*; εL=0.206 *11*; εM+=0.077 *5*
(833 *SY*)	1266.6		0.95 *5*	7.80 *19*	0.95 *5*	εK=0.720 *14*; εL=0.204 *10*; εM+=0.076 *5*
(855 *SY*)	1244.50		1.71 *10*	7.57 *19*	1.71 *10*	εK=0.721 *13*; εL=0.203 *9*; εM+=0.075 *4*
(890 *SY*)	1209.97		3.01 *20*	7.36 *18*	3.01 *20*	εK=0.723 *12*; εL=0.202 *8*; εM+=0.075 *4*
(910 *SY*)	1189.39		0.32 *5*	8.35 *19*	0.32 *5*	εK=0.725 *11*; εL=0.201 *8*; εM+=0.074 *4*
(924 *SY*)	1175.52		2.31 *13*	7.51 *17*	2.31 *13*	εK=0.725 *11*; εL=0.200 *8*; εM+=0.074 *4*
(945 *SY*)	1154.24		0.38 *5*	8.31 *17*	0.38 *5*	εK=0.727 *10*; εL=0.200 *7*; εM+=0.074 *3*
(1068 *SY*)	1031.852		23.7 *13*	6.63 *15*	23.7 *13*	εK=0.733 *8*; εL=0.196 *6*; εM+=0.0719 *23*
(1228 *SY*)	871.57		5.6 *9*	7.38 *14*	5.6 *9*	εK=0.738 *6*; εL=0.192 *4*; εM+=0.0701 *17*
(2057 *SY*)	42.721	0.032 *19*	8.1 *18*	7.69 *12*	8.5 *18*	av Eβ=514 *66*; εK=0.7502; εL=0.1806 *15*; εM+=0.0653 *7*
(2100 *SY*)	0.0	0.23 *12*	51 *5*	6.91 *8*	51 *5*	av Eβ=533 *66*; εK=0.7502; εL=0.1802 *15*; εM+=0.0651 *6*

† The intensities are given per 100 b+ decay.

‡ Relative decay branches to excited levels are deduced from intensity balances; the ε+β^+ decay branch to the ground state is obtained from I(K x-ray; measured)=I(K x-ray; calculated). The K x-ray intensity calculated by using theoretical εK/(ε+β^+) ratios for each level and α(K) conversion coefficients for all gammas. Fluorescence yield of 0.973 *4* (1979Ah01) is used.

For absolute intensity per 100 decays, multiply by ≤0.98.

$\gamma(^{250}Cf)$

Californium x-rays (1980Ah03):

E(x-ray)	I(x-ray) (same Units As Iγ's)	
109.8 1	22.2 16	$K\alpha_2$ x ray
115.0 1	34.7 24	$K\alpha_1$ x ray
129.7 2	13.1 9	$K\beta_1'$ x ray
133.7 2	4.7 4	$K\beta_2'$ x ray

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[#]	α[a]	Comments
(34.325 *5*)	[@]	905.89	3^-	871.57	2^-	M1+E2	0.42 *5*	7.4×10^2 *11*	
42.721 *5*	0.028 *2*	42.721	2^+	0.0	0^+	E2		1293	α(L)=939; α(M)=266 E_γ: adopted from 8.6-H ^{250}Es ε decay. Eγ=42.7 *2* was obtained by 1980Ah03 from the electron lines. I_γ: calculated from Ice(M)=7.5 *4* (1980Ah03) and α(M)=266 only the Ce(M) and Ce(N) lines of this transition were observed. Mult.: adopted from 8.6-H ^{250}Es ε decay.
(46.093 *5*)	[@]	951.98	4^-	905.89	3^-	M1+E2	0.40 *2*	200 *10*	
(80.412 *10*)	[@]	951.98	4^-	871.57	2^-	E2		63.3	
(99.160 *10*)	0.034 *5*	141.875	4^+	42.721	2^+	E2		23.8	α(L)=17.0; α(M)=4.84; α(N+..)=1.934 γ was not observed; its energy is from 8.6-H ^{250}Es ε decay; Iγ is calculated from intensity balance At the 141.88 level.
(119.4 *3*)	0.000034 *15*	1071.37	3^+	951.98	4^-	[E1]		0.0956	α(L)=0.0714; α(M)=0.01769; α(N+..)=0.00656 E_γ: γ was not observed In 2.22-H ^{250}Es ε decay. Energy is from ^{250}Bk β^- decay. I_γ: calculated from Iγ(119γ)/Iγ(1028γ)=0.0015 *5*/10.9 *3*, measured In ^{250}Bk β^- decay.
(126.01 *3*)	0.00190 *17*	1031.852	2^+	905.89	3^-	[E1]		0.0834	α(L)=0.0622; α(M)=0.01541; α(N+..)=0.00573 E_γ: transition was not observed In 2.22-H ^{250}Es ε decay. Its energy was measured In ^{250}Bk β^- decay. I_γ: photon intensity is calculated from the ratio measured In ^{250}Bk β^- decay: Iγ(126γ)/Iγ(989γ)=0.0140 *12*/100.
(160.26 *4*)	0.0086 *6*	1031.852	2^+	871.57	2^-	[E1]		0.1859	α(K)= 0.1403; α(L)=0.0340; α(M)=0.00840; α(N+..)=0.00313 E_γ: transition was not observed In 2.22-H ^{250}Es ε decay. Its energy was measured In ^{250}Bk β^- decay. I_γ: photon intensity is calculated from the ratio measured In ^{250}Bk β^- decay: Iγ(160γ)/Iγ(989γ)=0.0633 *44*/100.
(165.44 *15*)	0.00007 *3*	1071.37	3^+	905.89	3^-	[E1]		0.1726	α(K)=0.1305; α(L)=0.0315; α(M)=0.00776; α(N+..)=0.00289 E_γ: γ was not observed In 2.22-H ^{250}Es ε decay. Energy is from

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γ(^{250}Cf) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[a]	Comments
								^{250}Bk β^- decay. I_γ: calculated from Iγ(165γ)/Iγ(1028γ)=0.0030 *4*/10.9 *3*, measured In ^{250}Bk β^- decay.
(199.72 *20*)	0.000055 *17*	1071.37	3^+	871.57	2^-	[E1]	0.1127	α(K)=0.0861; α(L)=0.01986; α(M)=0.00488; α(N+..)=0.00182 E_γ: γ was not observed In 2.22-H ^{250}Es ε decay. Energy is from ^{250}Bk β^- decay. I_γ: calculated from Iγ(199γ)/Iγ(1028γ)=0.0024 *3*/10.9 *3*, measured In ^{250}Bk β^- decay.
(303.95 *20*)	0.083 *14*	1175.52	1^-	871.57	2^-	[M1,E2]	1.0 *8*	E_γ: energy is from ^{250}Bk β^- decay. This transition was not observed In ^{250}Es ε decays. I_γ: calculated from Iγ(303γ)/Iγ(1133γ)=0.51 *5*/4.30 *22*, measured In ^{250}Bk β^- decay.
586.6 *2*	0.40 *10*	1658.00	2^+	1071.37	3^+	M1(+E2)	0.24 *1*	α(K)exp= 0.18 *5*; α(L)= 0.4
626.1 *2*	1.2 *1*	1658.00	2^+	1031.852	2^+	M1(+E2)	0.24 *1*	α(K)exp= 0.18 *3*; α(L)exp=0.044 *9*
[x]659.7 *3*	0.48 *9*							α(K)exp= 0.25 *6*, α(L)exp= 0.058 *19* (1980Ah03).
(764.2 *1*)	@	905.89	3^-	141.875	4^+	E1	0.00758	
(786.26 *14*)	0.19 *4*	1658.00	2^+	871.57	2^-	[E1]	0.00721	α(K)=0.00579; α(L)=0.00107 E_γ: this γ was not observed In 2.22-H ^{250}Es ε decay; its energy is from ^{250}Bk β^- decay. I_γ: calculated from adopted branching ratios.
[x]802.9 *2*	0.44 *9*					(M1+E2)		α(K)exp= 0.066 *20* (1980Ah03). α(K)(M1)=0.100, α(K)(E2)=0.0164.
(810.2 *1*)	@	951.98	4^-	141.875	4^+	E1	0.00684	
828.9 *1*	5.6 *9*	871.57	2^-	42.721	2^+	E1	0.00658	α(K)=0.00528; α(L)= 0.00097
(863.2 *1*)	@	905.89	3^-	42.721	2^+	E1	0.00613	
889.9 *2*	0.45 *7*	1031.852	2^+	141.875	4^+	[E2]	0.01961	α(K)=0.01376; α(L)=0.00439
929.4 *3*	0.10 *7*	1071.37	3^+	141.875	4^+	[E2]	0.0180	α(K)=0.0128; α(L)=0.00394
989.1 *1*	13.6 *9*	1031.852	2^+	42.721	2^+	E2	0.01603	α(K)=0.01153; α(L)=0.00338
1028.5 *3*	0.25 *7*	1071.37	3^+	42.721	2^+	(E2)	0.0149	α(K)=0.01079; α(L)=0.00308 Mult.: determined In ^{250}Bk β^- decay.
1031.9 *1*	10.8 *8*	1031.852	2^+	0.0	0^+	E2	0.01480	α(K)=0.01074; α(L)=0.00306
1047.8 *5*	≈0.1	1189.39	2^+	141.875	4^+	[E2]	0.0144	α(K)=0.0105; α(L)=0.00295
[x]1068.2 *5*	≈0.1							1980Ah03 suggested that the 1068.2γ decays from the 1,3$^-$ collective state seen In (d,d′) At 1210 keV, to the 4^+ state of the g.s. band. The authors pointed out that the expected 1167.4-keV transition from this 3^- state to the 2^+ of g.s. band would Be obscured by the 1167.3γ which is placed to deexcite the 1210-keV 2^-,(N 9/2[734], N 5/2[622]) state, identified In (d,p) reaction, to the 4^+ g.s. band. On their level scheme, the 1068.2γ is shown however, to decay from the 2^- state to the 4^+ of g.s. band, competing with an E1 transition. if the 1068.2 were to decay from the 3^- state, an ε decay with≈0.1% intensity (deduced from intensity balance, excluding any contribution from possible

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^{250}Es ε decay (2.22 h) (continued)

γ(^{250}Cf) (continued)

$E_γ$[†]	$I_γ$[‡&]	E_i(level)	$J^π_i$	E_f	$J^π_f$	Mult.[#]	α[a]	$I_{(γ+ce)}$[&]	Comments
									1167.4γ to the 4⁺ state) would have log ft≈8.8, which is quite small for a second-forbidden β transition from the 1⁻ parent. IT is possible that the 1068.2γ is a doublet, decaying from both the 3⁻ and 2⁻ states At 1210 keV. Because of problems mentioned above, this γ is not placed on the decay scheme here.
1103.0 *3*	0.09 *3*	1244.50	(2⁺)	141.875	4⁺	[E2]	0.01306		α(K)=0.00960; α(L)=0.00261
1111.5 *3*	0.27 *4*	1154.24	0⁺	42.721	2⁺	[E2]	0.0129		α(K)=0.00947; α(L)=0.00256
1133.0 *3*	0.70 *9*	1175.52	1⁻	42.721	2⁺	[E1]	0.00385		α(K)=0.00311; α(L)=0.00056
1146.7 *3*	0.20 *3*	1189.39	2⁺	42.721	2⁺	E0+E2		0.22 *4*	α(K)exp= 0.075 *20* the expected ce intensities from E2 component are Ice(K)=0.00180, Ice(L)=0.00048. The measured Ice(K)=0.015 *3* is then mostly due to the E0 component: Ice(K;E0)=0.013 *3*. The unobserved higher-shell electron intensity, Ice(LMN), can Be estimated As 0.0046 by assuming the same ratio observed for the 1154.3 keV E0 transition.
1154.3 *2*		1154.24	0⁺	0.0	0⁺	E0			K/Total ce=0.74 *6*, L/Total ce=0.14 *4*, M/Total ce=0.08 *3* $ N/Total ce≈0.04.
1154.9 *3*	0.10 *2*	1296.60	2⁺	141.875	4⁺	[E2]	0.0120		α(K)=0.00888; α(L)=0.00235
1167.3 *2*	3.0 *2*	1209.97	(2)⁻	42.721	2⁺	E1	0.00366		α(K)=0.00296; α(L)=0.00053
1175.5 *2*	1.60 *9*	1175.52	1⁻	0.0	0⁺	E1	0.00362		α(K)=0.00292; α(L)=0.00052
1201.7 *2*	1.25 *9*	1244.50	(2⁺)	42.721	2⁺	[E2,M1]	0.027 *16*		α(K)=0.00212 *13*; α(L)=0.0046 *25*
1223.8 *2*	0.33 *3*	1266.6	0⁺	42.721	2⁺	[E2]	0.01078		α(K)=0.00804; α(L)=0.00206
1244.4 *2*	0.35 *3*	1244.50	(2⁺)	0.0	0⁺	[E2]	0.01045		α(K)=0.00781; α(L)=0.00198
1254.0 *2*	≈0.05	1296.60	2⁺	42.721	2⁺	E0+E2		0.177 *23*	K/Total ce=0.56, L/Total ce=0.11, M/Total ce=0.040.
1266.6 *2*		1266.6	0⁺	0.0	0⁺	E0			K/Total ce=0.79 *6*, L/Total ce=0.153 *14*, M/Total ce=0.042 *6*.
(1296.54 *13*)	0.0094 *13*	1296.60	2⁺	0.0	0⁺	[E2]	0.00969		$E_γ$,$I_γ$: transition was not observed In 2.22-H ^{250}Es ε decay. Its energy was measured by 1979Re01 In ^{250}Bk β⁻ decay. The intensity, Iγ=0.0094 *13*, is calculated from Iγ(1296γ)/Iγ(1154γ)=15 *2*/159 *8*, also measured by 1979Re01.
(1516.22 *7*)	0.048 *6*	1658.00	2⁺	141.875	4⁺		0.00727		α(K)=0.00556; α(L)=0.00129 $E_γ$: 1516.22γ was not observed In 2.22-H ^{250}Es ε decay; its energy is from ^{250}Bk β⁻ decay. $I_γ$: calculated from adopted branching ratios.
1615.3 *3*	1.80 *17*	1658.00	2⁺	42.721	2⁺	E2	0.00498		α(K)exp=0.0039 *17*
1658.1 *3*	1.05 *9*	1658.00	2⁺	0.0	0⁺	E2			α(K)exp=0.0048 *20*

† Measurements of 1980Ah03. See also 1979Ah02. Earlier measurements: 1970Ah01, 1976Ya02.

‡ Relative photon intensity, measured by 1980Ah03. Intensities per 100 ε decay is obtained by normalizing the sum of all ε decay branches to 100. The x-ray intensities are utilized to deduce the ε decay to the g.s. the same procedure was applied by 1980Ah03; however, Q+(^{250}Es)=2070 was used by 1980Ah03 for εK/ε calculations which yielded slightly higher normalization factor than the one given here: the listed Iγ′s and Ice′s were given As intensities per 100 ε decays

$\gamma(^{250}$Cf) (continued)

by 1980Ah03; these intensities correspond to per 102 *5* ε decays here.

[#] Deduced from ce work of 1980Ah03, except where noted. The electron intensities were normalized At Ice(K 989.2γ)=0.156 to yield α(K)=0.115 (E2 theory). Multipolarities In square brackets are deduced from level scheme.

[@] Intensity balance At the 905.89-, 951.46-keV levels, and the adopted γ branchings from these levels yield Iγ(34.325)=2.6$\times10^{-6}$ *7*, Iγ(46.098γ)=1.1$\times10^{-6}$ *5*, Iγ(80.4γ)=1.6$\times10^{-6}$ *8*, Iγ(764.2γ)=1.6$\times10^{-4}$ *4*, Iγ(810.2γ)=5.1$\times10^{-5}$ *23*, Iγ(863.2γ)=2.0$\times10^{-4}$ *5*.

[&] For absolute intensity per 100 decays, multiply by 0.98 *5*.

[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.

[x] γ ray not placed in level scheme.

^{250}Es ε decay (2.22 h)

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch