^{254}Es β^- decay (39.3 h) 1973Ah04,1962Un01,1971Po20

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 156, 1 (2019)	31-Jan-2019

Parent: ^{254}Es: E=84.2 *25*; J$^\pi$=2$^+$; T$_{1/2}$=39.3 h *2*; Q(β^-)=1088 *3*; %β^- decay=98 *2*

^{254}Es-J$^\pi$,T$_{1/2}$: From ^{254}Es Adopted Levels.

^{254}Es-Q(β^-): From 2017Wa10.

^{254}Es-%β^- decay: %β^-=98 *2*.

1973Ah04: mass-separated sources of ^{254m}Es, measured Eα, Iα, Eγ, Iγ, x-ray energies and intensities, $\alpha\gamma$-, α(ce)-, and α(L x ray)-coin using Argonne magnetic α-spectrometer and Au-Si surface-barrier detectors for α detection, and Ge(Li) detectors for γ and x rays. This paper is mainly about the level scheme for ^{250}Bk from α decay of 39.3-hour ^{254}Es.

1962Un01: measured Eβ^-, ce, Eγ, Iγ, x rays, (β^-)γ-coin, $\gamma\gamma$-coin using double-lens beta-ray spectrometer for β^- and conversion electrons and NaI(Tl) detector for γ rays.

1971Po20: precise atomic-electron binding energies in fermium were deduced from precise measured energies of 40-, 45-, and 104-keV transitions in ce data. Also 1975FrZZ (priv. comm. from one of the authors of 1971Po20) provided additional details of internal conversion data. This communication mentioned a forthcoming paper on the decay of 39.3-h decay of ^{254}Es, but no paper seems to have appeared according to the search of the NSR database.

1963Ho07: measurement of transition energies from ce data.

^{254}Fm Levels

E(level)†	J$^\pi$‡	T$_{1/2}$‡
0.0#	0$^+$	3.240 h *2*
44.992# *10*	2$^+$	
149.349# *16*	4$^+$	
693.66@ *4*	2$^+$	
733.54@ *4*	3$^+$	

† From least-squares fit to Eγ data.
‡ From Adopted Levels.
\# Band(A): Ground-state band.
@ Band(B): K^π=2$^+$ γ-vibrational band.

β^- radiations

E(decay)	E(level)	Iβ^-‡	Log *ft*	Comments
(439 *4*)	733.54	16† *4*	7.3 *1*	av Eβ=125.1 *13*
(479 *4*)	693.66	56† *4*	6.9 *1*	av Eβ=137.7 *13* Iβ^-: Ib-: E(decay): 475 *5* measured by 1962Un01 (Kurie plot), which may contain contribution from β transition with Eβ(end-point)=440 feeding the 734 level. From β spectra, measured Iβ(475β)/Iβ(1127β)=3.0 *5* (1962Un01).
1127 *2*	44.992	25.0 *36*	8.5 *1*	av Eβ=361.1 *15* E(decay): measured by 1962Un01 (Kurie plot). The shape of the β spectrum showed that any contribution from a L=2 component was insignificant. Contribution from second-forbidden β branch to the 0$^+$ g.s. is assumed negligible. Iβ^-: deduced by evaluator from 98 2-(transition intensity of 693γ)- (summed transition intensity of γ rays feeding the 45 level), assuming no β feeding to the g.s. that involves 2$^+$ to 0$^+$ β transition.

Continued on next page (footnotes at end of table)

^{254}Es β^- decay (39.3 h) 1973Ah04,1962Un01,1971Po20 (continued)

β^- radiations (continued)

† Note that the quoted feeding does not include transition intensity of the 39.8-keV transition. This transition is expected to be weak as mentioned in priv. comm. 1975FrZZ.

‡ Absolute intensity per 100 decays.

γ(^{254}Fm)

Iγ normalization: The γ intensities are per 100 decays of ^{254}Es.

A γ with Eγ=989 *7*, Iγ=0.7 and Ice(K)=0.011 *4* was reported by 1962Un01, but no such γ reported by 1973Ah04.

The measured total intensity of I(K x ray)=1.72 *10* (1973Ah04) is in good agreement with the total I(K x ray)=1.63 *7*, deduced by evaluator from Iγ and α(K) data.

Energies and intensities of Fm x-ray) (1973Ah04)

E(x-ray)	I(x-ray)	Fm x-ray
115.280 *15*	0.51 *5*	Kα_2
121.065 *15*	0.77 *7*	Kα_1
135.18 *4*		Kβ_3
	0.33 *4*	Kβ_3+Kβ_1
136.55 *4*		Kβ_1
140.49 *4*		Kβ_2+Kβ_4
	0.110 *15*	Kβ_2+Kβ_4+O
141.72 *5*		

I(x-ray) values are per 100 decays of 39-h ^{254}Es

Other measurements:

I(L x-rays):I(K x-rays):I(649γ)=90 *15*:6 *1*:100 (1962Un01).

Note that the measured L/K and L/(I(649γ)) disagree with those expected from the decay scheme

E$_\gamma$[†]	I$_\gamma$[‡@]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[#]	α[&]	I$_{(\gamma+ce)}$[@]	Comments
39.881 *10*		733.54	3$^+$	693.66	2$^+$	(E2)	2.10×10^3		α(L)=1507 *22*; α(M)=434 *6*; α(N)=123 *2*; α(O)=31.1 *5*; α(P)=4.84 *7*; α(Q)=0.01054 *15* E$_\gamma$: deduced from precise ce data for 688.5 and 648.7 γ rays, and 584.2 and 544.3 γ rays (1971Po20). Mult.,δ: E2(+M1) with δ>1.75 suggested by 1975FrZZ from measured L2/L3 and M2/M3 values, but the numerical values of these subshell ratios were not listed in the communication. Also in an e-mail communication of April 4, 2017, I. Ahmad (ANL), first author of 1973Ah04 and a collaborator of author of 1975FrZZ, suggested that δ(E2/M1) cannot be deduced since values for M1 multipolarity are very small. Evaluator assigns this transition mainly as E2 based on estimate by 1975FrZZ. Conversion electron intensity of the 39.8-keV transition is not available but expected to be weak as mentioned in 1975FrZZ priv. comm.
44.992 *10*	0.062 *4*	44.992	2$^+$	0.0	0$^+$	E2	1172	72.3 *43*	α(L)=841 *12*; α(M)=242 *4* α(N)=68.8 *10*; α(O)=17.33 *25*; α(P)=2.71 *4*; α(Q)=0.00630 *9*

γ(^{254}Fm) (continued)

E_γ[†]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[&]	Comments
									E_γ: weighted average of 45.000 *15* (1973Ah04) and 44.988 *10* (1971Po20), deduced from precise ce data for 693.7 and 648.7 gamma rays). Mult.: α(L)exp>200 (1962Un01). $I_{(\gamma+ce)}$: deduced by evaluator from summed transition intensity of γ rays feeding the 45 level + I(β) to 45 level. I_γ: deduced by evaluator from Iγ+ce(45γ) and total conversion coefficient for 45γ. Other: measured value of 0.049 *5* in 1973Ah04 seems to have been underestimated, possibly due to detection efficiency issues for low-energy γ rays.
104.356 *12*	0.180 *17*	149.349	4$^+$	44.992	2$^+$	E2		21.7	α(L)=15.60 *22*; α(M)=4.49 *7* α(N)=1.277 *18*; α(O)=0.323 *5*; α(P)=0.0515 *8*; α(Q)=0.000203 *3* I_γ: other: 0.20 *2* (1975FrZZ). E_γ: weighted average of 104.350 *15* (1973Ah04) and 104.360 *12* (1971Po20, deduced from precise ce data for 648.7 and 544.3 γ rays, and 688.5 and 584.2 γ rays). Mult.: α(exp)=20 *5* (1962Un01); L1/L2=0.066 *2* (1975FrZZ,1971Po20). Ice(L):Ice(M+N+O)=3.0 *4*:1.0 *2* (1962Un01).
544.28 *10*	0.90 *8*	693.66	2$^+$	149.349	4$^+$	E2		0.0612	α(K)=0.0335 *5*; α(L)=0.0202 *3*; α(M)=0.00547 *8* α(N)=0.001542 *22*; α(O)=0.000397 *6*; α(P)=7.02$\times10^{-5}$ *10*; α(Q)=1.776$\times10^{-6}$ *25* I_γ: other: 0.98 *7* (1975FrZZ). Mult.: α(K)exp=0.00256 *40* (1975FrZZ), 0.03 *1* (1962Un01). Ice(K)=0.027 *8* (1962Un01).
584.18 *10*	2.9 *2*	733.54	3$^+$	149.349	4$^+$	E2(+M1)	>9	0.0538 *17*	α(K)=0.038 *9*; α(L)=0.0177 *15*; α(M)=0.0047 *4* α(N)=0.00133 *10*; α(O)=0.00034 *3*; α(P)=6.2$\times10^{-5}$ *6*; α(Q)=1.9$\times10^{-6}$ *4* E_γ: 583.26 *40* (1963Ho07) from ce data. I_γ: other: 3.2 *2* (1975FrZZ). Mult.,δ: from α(K)exp=0.0296 *15*, K/L1=4.43 *22*, L1/L2=0.86 *5* (1975FrZZ). Others: α(K)exp=0.042 *5* (1962Un01), using ce intensity from 1962Un01 and Iγ from 1973Ah04, evaluator also obtains α(K)exp=0.042 *5*. Ice(K)=0.123 *13* (1962Un01).
648.69 *7*	29 *2*	693.66	2$^+$	44.992	2$^+$	E2(+M1)	>9	0.0427 *13*	α(K)=0.0262 *10*; α(L)=0.0121 *2*; α(M)=0.00321 *4* α(N)=0.00090 *2*; α(O)=0.000234 *3*; α(P)=4.20$\times10^{-5}$ *7*; α(Q)=1.27$\times10^{-6}$ *4* E_γ: 648.12 *40* (1963Ho07) from ce data. I_γ: other: 31.6 *22* (1975FrZZ). Mult.,δ: from α(K)exp=0.0255 *7*, K/L1=4.91 *15*, L1/L2=0.97 *3*, L1/L3=5.32 *25* (1975FrZZ). Others: α(K)exp=0.023 *3* (1962Un01). Using ce intensities from 1962Un01 and Iγ from 1973Ah04, evaluator obtains α(K)exp=0.0269 *20*, α(L)exp=0.0128 *14* and α(M+...)exp=0.0045 *15*. δ: deduced by the evaluator from ce data in 1975FrZZ. Ice(K):Ice(L):Ice(M+N+O)=0.78 *2*:0.37 *3*:0.13 *4* (1962Un01).
688.52 *7*	12.5 *9*	733.54	3$^+$	44.992	2$^+$	E2(+M1)	>8	0.0378 *13*	α(K)=0.0239 *11*; α(L)=0.0102 *2*; α(M)=0.00270 *5*

From ENSDF

$^{254}_{100}Fm_{154}$-4

γ(^{254}Fm) (continued)

E_γ †	I_γ ‡@	E_i(level)	J^π_i	E_f	J^π_f	Mult.#	α&	Comments
								α(N)=0.000760 *12*; α(O)=0.000196 *4*; α(P)=3.55×10^{-5} *7*; α(Q)=1.13×10^{-6} *6* E_γ: 688.20 *40* (1963Ho07) from ce data. I_γ: other: 13.6 *10* (1975FrZZ). Ice(K)=0.27 *5*, Ice(L)=0.14 *4* deduced by the evaluator, see comment for 693.67γ. Mult.,δ: from α(K)exp=0.0240 *7*, K/L1=5.17 *15*, L1/L2=1.03 *3* (1975FrZZ). Other: α(K)exp=0.022 *4*, α(L)exp=0.011 *3* and K/L=1.9 *6* (deduced by evaluator from ce data given above).
693.67 *7*	24.8 *17*	693.66	2^+	0.0	0^+	E2	0.0359	α(K)=0.0225 *4*; α(L)=0.00981 *14*; α(M)=0.00260 *4* α(N)=0.000731 *11*; α(O)=0.000189 *3*; α(P)=3.41×10^{-5} *5*; α(Q)=1.074×10^{-6} *15* E_γ: 693.05 *40* (1963Ho07) from ce data. I_γ: other: 27.0 *19* (1975FrZZ). Mult.: from K/L1=4.90 *15*, L1/L2=1.03 *3*, L1/L3=6.06 *25* (1975FrZZ). Other: α(K)exp=0.021 *3* (1962Un01). Ice(K):Ice(L):Ice(M+N+O)=0.83 *3*:0.38 *4*:0.15 *4* (1962Un01) for 694+689 doublet. Evaluator deduces Ice(K)=0.56 *4* and Ice(L)=0.243 *17* for 693.67γ using its Iγ value from 1973Ah04, α(K)(theory)=0.0225 *4*, and α(L)(theory)=0.00981 *14* from BrIcc; the remaining Ice(K)=0.27 *5* Ice(L)=0.14 *4* is assigned to the 688.5γ from 734 level.

† Measurements by 1973Ah04. Others: 1962Un01, 1963Ho07.

‡ Per 100 β^- decays, obtained by 1973Ah04 from α-count rate of ^{254}Fm which was in equilibrium with 39-h ^{254}Es.

Multipolarities are from ce data of 1962Un01. The electron intensities from 1962Un01 listed here are per 100 β decays (these were measured relative to the total β spectrum). Other measurement: 1963Ho07.

@ Absolute intensity per 100 decays.

& 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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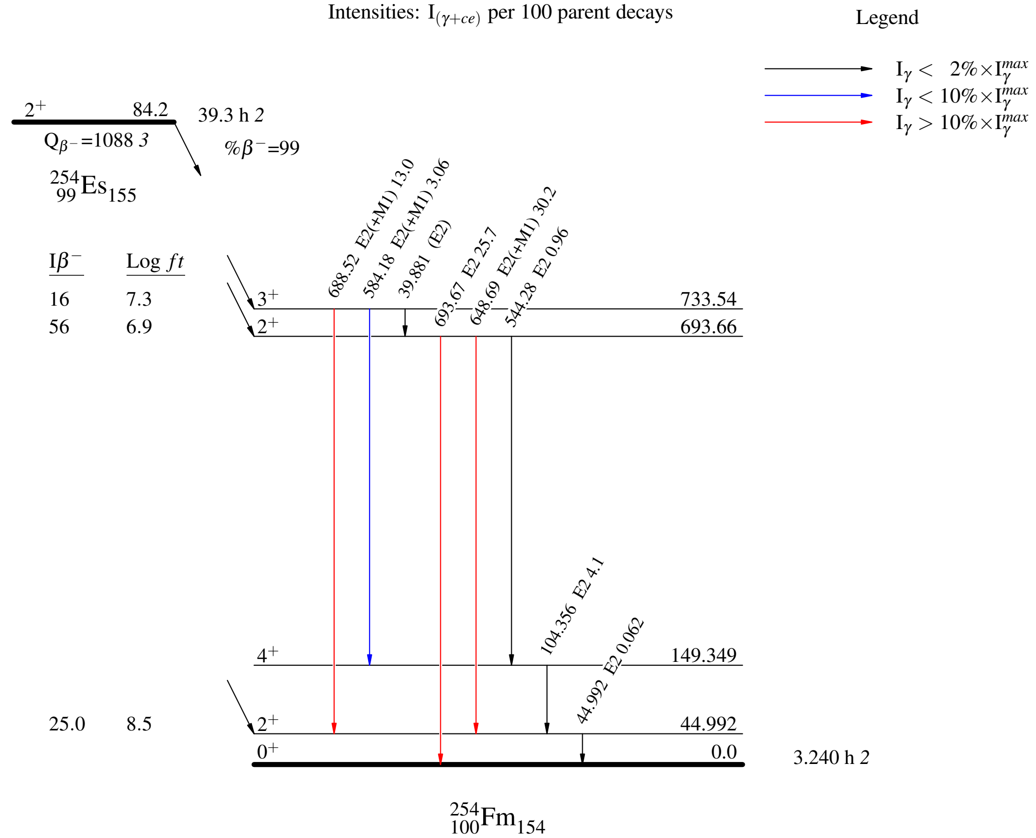
Decay Scheme

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



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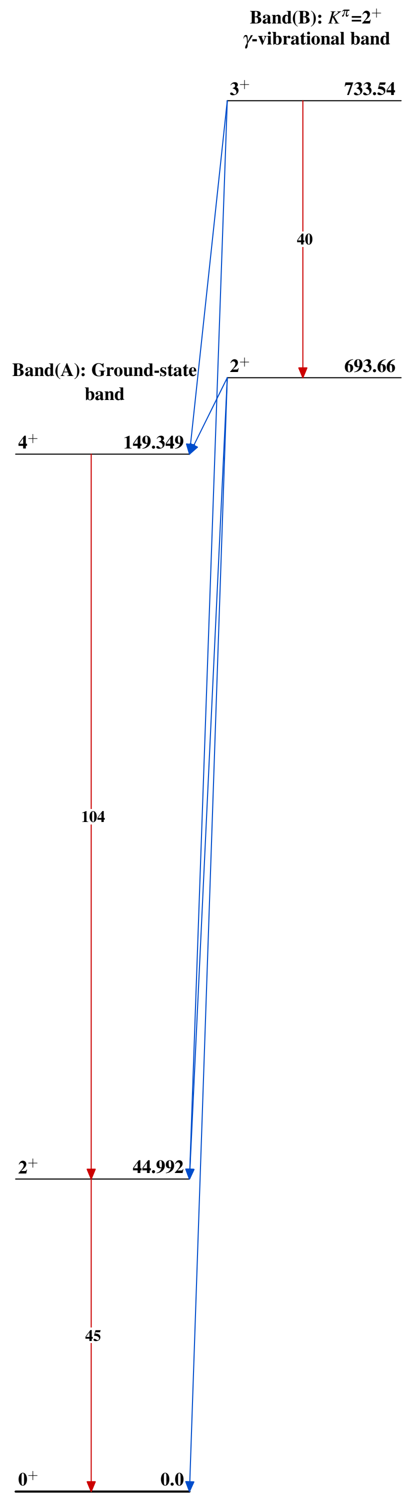

$^{254}_{100}Fm_{154}$