Nuclear Data Sheets for $A = 247^*$

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Abstract: Available information pertaining to the nuclear structure of all nuclei with mass numbers $A=247$ is presented. Various decay and reaction data are evaluated and compared. Adopted data, levels, spin, parity and configuration assignments are given. When there are insufficient data, expected values from systematics of nuclear properties or/and theoretical calculations are quoted. Unexpected or discrepant experimental results are also noted. A summary and compilation of the discovery of various isotopes in this mass region is given in 2013Fr02 (^{247}Pu , ^{247}Am , ^{247}Cm , ^{243}Bk , ^{247}Cf), 2011Me01 (^{247}Es), and 2013Th02 (^{247}Fm , ^{247}Md)

General Policies and Organization of Material: see <http://www.nndc.bnl.gov/nds/NDSPolicies.pdf>.

General Comments: This work supersedes the 2004 evaluation by Y.A. Akovali (2004Ak17).

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NUCLEAR DATA SHEETS

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Ground-State and Isomeric-Level Properties for A=247

Nuclide	Level	$J\pi$	$T_{1/2}$	Decay Modes
²⁴⁷ Pu	0.0	(1/2+)	2.27 d 23	% β^- =100
²⁴⁷ Am	0.0	(5/2)	23.0 min 13	% β^- =100
²⁴⁷ Cm	0.0	9/2-	1.56×10 ⁷ y 5	% α =100
²⁴⁷ Bk	0.0	3/2-	1380 y 250	% α ≤100
²⁴⁷ Cf	0.0	(7/2+)	3.11 h 3	% ϵ =99.965 5; % α =0.035 5
²⁴⁷ Es	0.0	(3/2-)		
	0+x	(7/2+)	4.55 min 26	% α =7; % ϵ +% β^+ =93
²⁴⁷ Fm	0.0	(7/2+)	31 s 1	% α =64
	45	(1/2+)	5.1 s 2	%IT=12 2; % α =88 2
²⁴⁷ Md	0.0	(7/2-)	1.2 s 1	% α >99.9; %SF<0.1
	0+x	(1/2-)	0.25 s 4	%IT=79 5; %SF=21 5
²⁵¹ Cf	0.0	1/2+	898 y 44	% α =100
²⁵¹ Es	0.0	3/2-	33 h 1	% α =0.5 2; ...
²⁵¹ Fm	0.0	(9/2-)	5.30 h 8	% α =1.80 13; ...
²⁵¹ Md	0.0	(7/2-)	4.27 min 26	% α =10 1; ...
²⁵¹ No	0.0	(7/2+)	0.80 s 1	% α =84 16; ...
	106	(1/2+)	1.02 s 3	% α =100
	106	(1/2+)	1.02 s 3	% α =100

Adopted Levels

$Q(\beta^-)=1950$ SY; $S(n)=4360$ SY; $Q(\alpha)=4280$ SY 2012Wa38.

$\Delta Q(\beta^-)=220$, $\Delta S(n)=200$, $\Delta Q(\alpha)=450$ (syst, 2012Wa38).

Identification:

1983Po16,1983Po14: Pu irradiated with neutron followed by chemical extraction and measured by semiconductor γ spectrometry.

Theoretical studies:

2002Du16: Calculated partial half-lives for α and cluster decays.

2005Pa73: Calculated neutron one-quasiparticle states of heaviest nuclei within a macroscopic-microscopic approach.

1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.

1995Mo29: Calculated ground-state masses and nuclear ground-state deformations.

1981Mo24: Calculated ground-state electric multipole moments Q_2 , Q_4 and masses.

1980Ho32: Calculated mass excess, $S(n)$, $S(p)$, $Q(\beta)$, $Q(\alpha)$, fission-barrier heights, deformation and energy at saddle-point.

Systematic studies:

2011Ad15: Behavior of low-lying one-quasiparticle states studied in the isotonic chain $N=147$, 149, 151, 153, and 155 within the microscopic-macroscopic TCSM and self-consistent SHFB approaches. Comparison of calculated low-lying one-quasineutron states in ^{247}Pu with available experimental data of ^{249}Cm shows a rather good agreement.

 ^{247}Pu Levels

E(level)	$J\pi$	$T_{1/2}$	Comments
0.0	(1/2+)	2.27 d 23	$\% \beta^- = 100$. β^- decay has been inferred through ^{247}Am activity. Direct β^- decay scheme of ^{247}Pu to ^{247}Am was not studied. $T_{1/2}$: Measured by 1983Po14 (see also 1983Po16) from the increase in the intensity of the 226- and 285-keV γ 's in ^{247}Am β^- decay. $J\pi$: In analogy to ^{249}Cm , ^{251}Cf and ^{253}Fm isotones, $J\pi(\text{g.s.})$ is probably 1/2+ of the 1/2[620] orbital.

Adopted Levels

$Q(\beta^-)=1620$ SY; $S(n)=5910$ SY; $S(p)=5530$ SY; $Q(\alpha)=4850$ SY 2012Wa38.

$\Delta Q(\beta^-)=100$, $\Delta S(n)=100$, $\Delta S(p)=100$, $\Delta Q(\alpha)=110$ (syst, 2012Wa38).

Identification:

1983Po14: Pu irradiated with neutron followed by chemical extraction and measured by semiconductor γ spectrometry.

1967Or02,1968Fi03: ²⁴⁴Pu irradiated with α , followed by chemical extraction and measured γ -rays with Ge(Li) detector.

Experimental work:

1987We01: Measured ²⁴⁸Cm(¹²⁹Xe,X) and ²⁴⁸Cm(¹³²Xe,X) production cross-sections.

1974Ba73: Measured ²⁴⁸Cm(t, α F) at E=16 MeV.

Measured α singles and α -fission product coincidence spectra. α measured with ΔE -E counter telescope with energy resolution of 145 keV and the fission fragments were measured with fission detector. By using a statistical model, heights and curvatures for the peaks of double-humped fission barrier were deduced.

1968Fi03: Measured ²⁴⁴Pu(α ,p) at E(α)=42 MeV from Argonne 60-inch cyclotron. 227- and 285-keV γ -rays assigned to ²⁴⁷Am.

1967Or02: Measured ²⁴⁴Pu(α ,p) at E(α)=24 MeV. Measured $T_{1/2}$ from the decay of the 226- and 285-keV γ 's.

Theoretical studies:

2004Pa40: Calculated deformation parameters and the proton one quasiparticle states of heaviest nuclei using the macroscopic-microscopic approach.

2002Du16: Calculated partial half-lives for α and cluster decays.

2001YaZU: Calculated fission barrier with semimicroscopic model with account of possible dependence on excitation energy.

1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.

1995Mo29: Calculated ground-state masses and nuclear ground-state deformations.

1988Po04: Estimated nuclear mass excess using a semiempirical method.

1981Mo24: Calculated ground-state electric multipole moments Q_2 , Q_4 and masses.

1985Lo17: Ground-state spin and parity predicted on the basis on the calculated Nilsson potential parameters.

1984Ku05, : Calculated fission barrier with statistical approach and the two hump fission barrier model.

1981Mo24: Calculated ground-state electric multipole moments Q_2 , Q_4 and masses.

1980Ku14: Quantitative description of the main characteristics of the fission probability using a simple phenomenological model.

1980Ho32: Calculated mass excess, S(n), S(p), Q(β), Q(α), fission-barrier heights, deformation and energy at saddle-point.

²⁴⁷Am Levels

E(level)	J π	T _{1/2}	Comments
0.0	(5/2)	23.0 min 13	β^- =100. $J\pi$: From systematics of Nilsson orbitals (1977Ch27) suggesting 5/2+[642] in ²⁴⁵ Am or 5/2-[523] in analogy to ²⁴³ Am, ²⁴¹ Am and ²³⁹ Am. $T_{1/2}$: From measurement of 1983Po14. Others: 20 min 4 (1968Fi03), 24 min 3 (1967Or02).

Adopted Levels, Gammas

Q(β⁻)=44 7; S(n)=5155 4; S(p)=6750 SY; Q(α)=5354 3 2012Wa38.
ΔS(p)=18, ΔQ(α)=450 (syst, 2012Wa38).

Identification:

1954St33: ²⁴⁷Cm produced by irradiating Pu samples with neutrons followed by chemical purification and mass separation. Half-life determined by 1971Fi01, 1968Fi03, 1963Fi08.

Theoretical studies:

- 2012Ni16: α decay T_{1/2} for transitions from ground-state to favored rotational bands using Multichannel Cluster Model.
2011Ad15: Studied one-quasiparticle levels using the microscopic-macroscopic modified TCSM, QPM and the self-consistent SHFB approaches.
2011Zh36: Systematics and calculated partial half-life of α decay to members of favored band. Accurate expressions are proposed for the evaluation of partial half-lives of these transitions based on microscopic quantum tunneling theory.
2002Du16: Calculated half-lives and Q-values of spontaneous nuclear decay processes in the framework of the effective liquid drop model (ELDM).
1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.
1995Mo29: Calculated ground-state mass and deformations.
1993Bu09: Calculated partial α decay half-life, α branching, and nuclear radius using the cluster model predictions.
1981Mo24: Calculated electric multipole moments, Q2 and Q4 using macroscopic-microscopic model.
1980Ho32: Calculated ground-state mass excess using macroscopic-microscopic model. Fission-barrier heights, deformation and energy at saddle-point were also calculated.
1971Ga20: Calculated fission barriers, ground-state masses and particle separation energies.

Systematic studies:

- 2013Af01: Systematic study of pairing and rotational properties of actinides using the covariant density functional theory (CDFT) and the density functional theory framework, respectively.
2012Zh01: Comparison of the low lying one-quasineutron band for N=151 isotones between the experimental values and calculated values using the cranked shell model (CSM) with pairing correlations.
2011As03: Calculated ground-state deformation and energies of neutron one-quasiparticle states in the N=151 isotones using a macroscopic-microscopic model. Energy systematics discussed in terms of evolution of nuclear deformation.
2007Ma82: Comparison with experimental results of ²⁴⁵Pu and systematics of neutron single-particle levels in N=151 isotones (²⁴⁷Cm, ²⁴⁹Cf, ²⁵¹Fm and ²⁵³No).
2006Sh19: Calculated energy levels of ground-state rotational band in N=151 isotones.
2005Pa73: Calculated neutron one quasi-particle states of heaviest nuclei within a macroscopic-microscopic approach.
1977Ch27, 1976Ch22: Extracted neutron single particle states with constant pairing elements.

²⁴⁷Cm Levels

Cross Reference (XREF) Flags

- A ²⁵¹Cf α Decay
B ²⁴⁷Am β⁻ Decay
C ²⁴⁶Cm(d,p), ²⁴⁸Cm(d,t)
D ²⁴⁸Cm(²⁰⁹Bi, ²¹⁰Biγ)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
0.0 [§]	9/2-	ABCD	1.56×10 ⁷ y 5	%α=100. μ=0.36 7 (1973Ab03, 2011StZZ). μ: From electron paramagnetic resonance measurement (1973Ab03). Compiled by 2011StZZ. Jπ: Spin measured by 1973Ab03 (electron paramagnetic resonance) and parity determined from the measured magnetic dipole moment and Nilsson diagram. T _{1/2} : Measured by 1971Fi01. This half-life is recommended by 1989Ho24. Earlier measurement: 1.64×10 ⁷ y 24 (1963Fi08). XREF: B(?).
61.67 [§] 4	11/2-	ABCD		
134.66 [§] 6	13/2-	A CD		
219.02 [§] 7	15/2-	A CD		
227.38 [#] 19	5/2+	ABC	26.3 μs 3	T _{1/2} : From ²⁵¹ Cf α decay (2003Ah07). Other: 25 μs 3 (1968Ch03).
265.86 [#] 4	(7/2+)	A		
285.41 [@] 5	(7/2+)	ABC		
309 3		C		
314.7 [§] 9	17/2-	D		

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Adopted Levels, Gammas (continued) ^{247}Cm Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF	T _{1/2}	Comments
318.31 [#] 5	9/2+	A C		
336 5		C		
345.89 [@] 6	(9/2+)	A C		
370? 5		C		
381 [#] 5	(11/2+)	C		
398 4		C		J π : 11/2+,7/2[624] state was tentatively suggested by 1971Br27 from (d,t) data.
404.90 ^{&} 3	1/2+	A C	100.6 ns 6	J π ,T _{1/2} : From ^{251}Cf α decay (2003Ah07).
417? 6		C		J π : 3/2+,1/2[620] state was tentatively assigned by 1971Br27 from (d,t) data. This state was observed at 433 keV in ^{251}Cf α decay.
421.0 [§] 9	19/2-	D		
433 ^{&} 2	(3/2+)	A		
439 3		C		J π : 9/2+,7/2[613] assignment was tentatively suggested by 1971Br27.
448 ^{&} 2	(5/2+)	A C		
506 ^a 3	(1/2+)	C		
516.68 ^{&} 11	(7/2+)	A C		
518.59 ^a 7	(3/2+)	A C		
539.8 [§] 12	21/2-	D		
550 ^{&} 2	(9/2+)	C		
581.67 ^a 8	(5/2+)	A C		
592 2		C		
604 ^a 3	(7/2+)	C		
667.9 [§] 12	23/2-	D		
668 5	(3/2+)	C		
687 5	(11/2+)	C		
699 ^a 2	(9/2+)	C		Level was assumed doublet in the (d,p),(d,t) reactions, and the other member was assigned to the 5/2+,3/2[622] state by 1971Br27.
749 5	(7/2+)	C		
784 4	(3/2-)	C		
803 5		C		
807.9 [§] 12	25/2-	D		
819 4	(7/2-)	C		
819 4	(9/2+)	C		
856 5		C		
897 5	(11/2-)	C		
947 2		C		
957 ^b 2	(1/2-)	C		
957.9 [§] 13	27/2-	D		
988 5		C		
1001 ^b 2	(3/2-,5/2-)	C		
1044 3		C		
1064 3		C		
1079 3	(5/2+)	C		
1091 3		C		
1118.9 [§] 14	29/2-	D		
1159 3		C		
1182 3	(9/2+)	C		
1199? 4		C		
1239 5		C		
1247 5		C		
1271 3		C		
1283 3	(5/2-)	C		
1287.9 [§] 15	31/2-	D		
1317 3		C		
1356? 3		C		
1364 4		C		
1372 4		C		
1467.9 [§] 16	33/2-	D		
1512 6		C		
1655.9 [§] 16	35/2-	D		
1853.9 [§] 17	37/2-	D		
2056.9 [§] 19	39/2-	D		
2271.9 [§] 20	41/2-	D		

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Adopted Levels, Gammas (continued) ^{247}Cm Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF
2487.9 § 22	43/2-	D
2717.9 § 22	45/2-	D
2945.9 § 24	47/2-	D
3187.9 § 24	49/2-	D
3427 § 3	51/2-	D

[†] From ^{251}Cf α decay, (d,p), (d,t) and $^{248}\text{Cm}(^{209}\text{B},^{210}\text{Bi})\gamma$ data.

[‡] From band assignments. Spin and parities for some of the bandheads are explained in comments for those levels. Arguments for band members are given with each band assignment. Nilsson state and band assignments were tentatively proposed to some levels above 600 keV by 1971Br27 from (d,p) and (d,t) data.

§ (A): 9/2[734] band. A=5.6. Band assignment from alpha hindrance factors, γ decays, and (d,p), (d,t) data.

(B): 5/2[622] band. A=5.7. Band assignment from (d,p), (d,t) data and alpha hindrance factors.

@ (C): 7/2[624] band. Band assignment from (d,p), (d,t) data and alpha hindrance factors.

& (D): 1/2[620] band. A=7.1. Band assignment from (d,p), (d,t) data and alpha hindrance factors.

a (E): 1/2[631] band. A=7.0. Band assignment from (d,t), (d,p) data.

b (F): 1/2[501] band. Band assignment from (d,t), (d,p) data.

 $\gamma(^{247}\text{Cm})$

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\ddagger}$	Mult.§	$\delta^{\S}$	α	Comments
61.67	61.67 5		M1+E2	0.25 3	37.5 23	
134.66	73.00 8	35 8	[M1+E2]	0.7 3	39 13	
	134.65 8	100 13	[E2]		4.94	
219.02	84.35 8	100 13	[M1+E2]		26 15	
	157.35 8	50 10	[E2]		2.56	
227.38	165.70 5	1.76 15	E3		30.4	B(E3)(W.u.)=5.5 6.
	227.38 2	100 4	M2+E3	0.52 +9-8	10.3 4	B(M2)(W.u.)=0.0033 4; B(E3)(W.u.)=7.3 21.
265.86	38.48 5	8.8 14	(M1+E2)	0.21 5	180 40	
	265.86 8	100 7	[E1]		0.0565	
285.41	58.03 5	2.1 4	(M1+E2)	0.53 11	80 16	
	285.41 8	100 8	[E1]		0.0484	
314.7	180 1					
318.31	52.45 5	37 4	(M1+E2)	0.27 6	70 11	
	256.65 8	100 8	[E1]		0.0611	
	318.3 1	38 4	[E1]		0.0384	
345.89	60.5 1	8.3 25	(M1+E2)	0.48 16	62 18	
	284.2 1	100 8	[E1]		0.0489	
	345.9 1	36 3	[E1]		0.0322	
404.90	177.52 2		E2		1.567	B(E2)(W.u.)=0.1350 14.
421.0	202 1					
516.68	289.3 1		[M1+E2]		0.9 7	
518.59	113.7 1	8.0 17	[M1+E2]		8 3	
	291.20 8	100 10	[M1+E2]		0.9 7	
539.8	225 1					
581.67	315.8 1	100 13	[M1+E2]		0.7 6	
	354.3 1	54 8	[M1+E2]		0.5 4	
667.9	247 1					
807.9	140 1					
	268 1					
957.9	150					
	290					
1118.9	161					
	311					
1287.9	169					
	330					
1467.9	180 [#]					
	349					
1655.9	188					
	368					
1853.9	198					
	386					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

 $\gamma(^{247}\text{Cm})$ (continued)

<u>E(level)</u>	<u>$E_{\gamma}^{\dagger}$</u>
2056.9	401
2271.9	418
2487.9	431
2717.9	446
2945.9	458
3187.9	470
3427	481

[†] From ^{251}Cf α decay and $^{248}\text{Cm}(^{209}\text{B}, ^{210}\text{Bi}\gamma)$ data.

[‡] Relative photon intensities de-exciting each level, adopted from ^{251}Cf α decay.

[§] Determined in ^{251}Cf α decay and ^{247}Am β^- decay. The multipolarities in square brackets are from the level scheme; they have not been determined experimentally.

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

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

(E) 1/2[631] band.

(F) 1/2[501] band.

(3/2-, 5/2-)	1001
(1/2-)	957

(9/2+)	699
(7/2+)	604
(5/2+)	581.67
(3/2+)	518.59
(1/2+)	506
(D)1/2+	
(B)(7/2+)	
(B)5/2+	

^{247}Am β^- Decay 1967Or02,1968Fi03

Parent ^{247}Am : $E=0.0$; $J\pi=(5/2)$; $T_{1/2}=23.0$ min 13; $Q(\text{g.s.})=1620$ syst; $\%\beta^-$ decay=100.

$^{247}\text{Am}-T_{1/2}$: From Adopted levels of ^{247}Am .

$^{247}\text{Am}-Q(\beta^-)$: 1620 100 (syst, 2012Wa38).

1991Po17: Gamma emission of actinides isotopes.

1968Fi03: ^{247}Am produced by 42-MeV α on ^{244}Pu at the Argonne 60-inch cyclotron. Chemical purification was followed by evaporation on a quartz plate. Gammas were then measured with a Ge(Li) detector through a thick copper detector to reduce β -particle background.

1967Or02: ^{247}Am produced by 28-MeV α on ^{244}Pu at the Los Alamos variable-energy cyclotron. Chemical purification was followed by evaporation on teflon film. Following β decay of ^{247}Am , γ 's were measured with a Ge(Li) detector and the electron spectrum was measured with a Si(Li) detector.

 ^{247}Cm Levels

E(level) [†]	$J\pi^{\dagger}$	$T_{1/2}$	Comments
0.0 (61.67 4)	9/2- 11/2-	1.56×10^7 y 5	$T_{1/2}$: From Adopted Level.
227.38 19	5/2+	26.3 μ s 3	$T_{1/2}$: From Adopted Levels. Others: 24 μ s (1967Or02), 20 μ s 4 (1968Fi03).
285.41 5	(7/2+)		

[†] From Adopted Level.

 β^- radiations

$I(\beta^-)$'s were deduced from intensity balance. Since the decay scheme is incomplete, $I(\beta^-)$'s given should be taken as approximate.

$E\beta^-$	E(level)	$I\beta^-^{\dagger}$	Log ft	Comments
(1335)	285.41	63 19	=6.22	
(1393)	227.38	31 21	=6.6	
(1620 [‡])	0.0	<6	>8.4 ^{1u}	If $J\pi(^{247}\text{Am g.s.})=5/2+$ and $\log f^{1u}t > 8.5$ for the β to g.s., $I(\beta^-)$ to g.s. <6%.

[†] Absolute intensity per 100 decays.

[‡] Existence of this branch is questionable.

 $\gamma(^{247}\text{Cm})$

$I\gamma$ normalization: The normalization factor to convert the relative photon intensities to absolute intensities is obtained as 0.25 which is an average of $NR=0.26$ assuming $I\beta$ to g.s.=0 with $[I\gamma(226)(1+\alpha)+I\gamma(285)(1+\alpha)+I\gamma(61.67)(1+\alpha)]=100\%$ and $NR \geq 0.24$ when $I\beta$ to g.s. <6 % by requiring $\log f^{1u}t > 8.5$ with $[I\gamma(226)(1+\alpha)+I\gamma(285)(1+\alpha)+I\gamma(61.67)(1+\alpha)] \geq 94\%$. The decay scheme should, however, be considered to be incomplete.

$E\gamma$	E(level)	$I\gamma^{\textcircled{a}}$	Mult. [§]	$\delta^{\S}$	α	Comments
(58.03 [#] 5)	285.41	$2.1^{\pm 5}$	(M1+E2)	0.49 19	70 30	
(61.67 5)	(61.67)	0.33 9	M1+E2	0.26 +12-16	38 10	$I\gamma$: Calculated by the evaluator from intensity balance at the 61.67-keV level.
(165.70 [#] 5)	227.38	$0.41^{\pm 4}$	E3		30.4	
226 2	227.38	$23^{\dagger} 3$	M2+E3	0.56 17	10.4 7	$I\gamma(226)$ relative to $285\gamma=25.7$ was measured by 1967Or02. $\alpha(K)\text{exp}=6.3$ estimated from comparison of ce and γ . $\alpha(K)\text{exp}=6.5$ in ^{251}Cf α decay (2003Ah07).
285 2	285.41	$100^{\dagger} 10$	[E1]		0.0486 11	From nonobservation of ce lines for 285γ , 1967Or02 suggest that 285γ is probably E1 or E2.

[†] Relative photon intensity measured by 1991Po17.

[‡] Calculated by the evaluator from adopted relative branching.

[§] From Adopted Gammas.

[#] Transition was not observed in ^{247}Am β^- decay; energy is from Adopted Gammas.

[Ⓐ] For absolute intensity per 100 decays, multiply by ≈ 0.25 .

^{247}Am β^- Decay 1967Or02,1968Fi03 (continued)

 ^{251}Cf α Decay 2003Ah07,1968Ch03,1970BrZN

Parent ^{251}Cf : $E=0.0$; $J\pi=1/2+$; $T_{1/2}=898$ y 44; $Q(\text{g.s.})=6177.0$ 9; $\% \alpha$ decay=100.

$^{251}\text{Cf}-T_{1/2}$: From Adopted Levels in ^{251}Cf .

$^{251}\text{Cf}-Q(\alpha)$: From 2012Wa38. E_α (to 404.90 level)=5679.3 16 yields $Q\alpha=6176.2$ 16.

2003Ah07: Produced ^{251}Cf from α decay of ^{255}Fm . Measured level $T_{1/2}$, γ , α , α - γ coincidence, and electron spectra with high resolution spectrometers such as the passivated, implanted, planar silicon Detector (PIPS) (FWHM=10.5 and 9.2 keV). The latter being also measured by the PIN diode.

1970BrZN: Studied alpha spectrum decay of ^{251}Cf with a Au-Si surface barrier detector (FWHM=15 keV) and ZnS-photomultiplier tube. Measured γ 's with 5 cm³ Ge(Li) detector and electrons with Si(Li) detector. Measured α -particles energies, γ energies, intensities, α - γ coincidence, and conversion electrons.

1968Ch03: α decay of ^{251}Cf along with α - γ coincidence measurements were done using Si(Au), Ge(Li) and NaI(Tl) detectors Measured E_α , I_α , E_γ , I_γ , α - γ coincidences. Deduced $J\pi$, $T_{1/2}$ and identified rotational bands.

Other measurements: 1966Rg01.

 ^{247}Cm Levels

E(level) [†]	$J\pi$	$T_{1/2}$	Comments
0.0 [‡]	9/2-	1.56×10^7 y 5	$T_{1/2}$: From Adopted Levels.
61.67 [‡] 4	11/2-		
134.66 [‡] 6	13/2-		
219.02 [‡] 7	15/2-		
227.379 [§] 19	5/2+	26.3 μs 3	$T_{1/2}$: From 2003Ah03. Others: 25 μs 3 (1968Ch03).
265.86 [§] 4	(7/2+)		
285.41 [#] 5	(7/2+)		
318.31 [§] 5	9/2+		
345.89 [#] 6	(9/2+)		
404.90 [@] 3	1/2+	100.6 ns 6	$T_{1/2}$: From 2003Ah03.
432.98 [@] 23	(3/2+)		
448.8 [@] 13	(5/2+)		
516.68 [@] 11	(7/2+)		
518.59 ^{&} 7	(3/2+)		
581.67 ^{&} 8	(5/2+)		

[†] From least-squares fit to E_γ 's.

[‡] (A): 9/2[734].

[§] (B): 5/2[622].

[#] (C): 7/2[624].

[@] (D): 1/2[620].

[&] (E): 1/2[631].

²⁵¹Cf α Decay 2003Ah07,1968Ch03,1970BrZN (continued)

α radiations

Eα [†]	E(level)	Iα [‡] #	HF [§]	Comments
5505 2	581.67	0.27 5	33 7	Iα: 0.060 17 from I(γ+ce) imbalances.
5567 2	518.59	≤1.9	≥10	Eα: From Eα(404.9 level)=5679.3 16 and the level energy difference from least-squares fit to Eγ's (recoil energy is taken into account). Eα=5568 2, measured by 2003Ah07, is assumed by the evaluator to be a doublet, feeding the 516.7- and 518.6-keV levels.
5569 2	516.68	≤1.9	≥11	Iα: 1.9 1 was measured by 2003Ah07 for the doublet. Eα: From Eα(404.9 level)=5679.3 16 and the level energy difference from least-squares fit to Eγ's (recoil energy is taken into account). Eα=5568 2, measured by 2003Ah07, is assumed by the evaluator to be a doublet, feeding the 516.7- and 518.6-keV levels.
5635 2	448.8	4.9 2	10.7 8	Iα: 1.9 1 was measured by 2003Ah07 for the doublet.
5651 2	432.98	3.3 2	19.5 17	
5679.3 16	404.90	35.4 5	2.62 16	Iα: 44.2 24 from I(γ+ce) imbalances. Eα: Recommended by 1991Ry01 from Eα=5680.3 10 measured by 1971Bb10, 5667 10 by 1968Ch03, and 5667 3 by 1970BrZN. Adjustments were applied by 1991Ry01 because of changes in calibration energies. Eα=5679 2 from 2003Ah07.
5738 2	345.89	0.8 1	248 34	
5766 2	318.31	3.6 2	78 7	
5798 2	285.41	2.5 2	170 17	
5817 2	265.86	4.0 2	136 11	
5854 2	227.379	27.6 5	31.7 19	
(5863.0 9)	219.02			From the γ's de-exciting the 219-keV level, existence of an alpha branch to the 219.0-keV level with Iα=1.2% 7 and Eα=5862 2 may be deduced from intensity balance. For Iα=1.2%, HF=800.
5946 2	134.66	0.60 6	4520 520	
6017 2	61.67	12.5 3	519 32	Iα: 9.7 16 from I(γ+ce) imbalances.
6078 2	0.0	2.6 1	5150 360	Iα: 6 5 from I(γ+ce) imbalances.

[†] Measurements by 2003Ah07, except where noted otherwise.

[‡] Measurements of 2003Ah07 are adopted.

[§] r₀(²⁴⁷Cm)=1.4924 88, unweighted average of r₀(²⁴⁶Cm)=1.4836 5 and r₀(²⁴⁸Cm)=1.5012 6 (1998Ak04), is used in calculations of HF.

[#] Absolute intensity per 100 decays.

γ(²⁴⁷Cm)

²⁵¹Cm x-rays: (2003Ah07)

E(x-ray)	I(x-ray)	Transitions
104.57 2	12.6 7	Kα ₂ x-ray
109.26 2	19.8 10	Kα ₁ x-ray
122.31 2		Kβ ₃ x-ray
	7.7 5	
	I(Kβ ₃ x-ray+Kβ ₁ x-ray)	
123.40 2		Kβ ₁ x-ray
127.01 4		Kβ ₂ x-ray+Kβ ₄ x-ray
	2.6 2	
	I(Kβ ₂ x-ray+Kβ ₄ x-ray+KO ₂₃ x-ray)	
128.00 5		KO ₂₃ x-ray

Others: 1966Rg01, 1968Ch03, 1970BrZN

Eγ [†]	E(level)	Iγ [‡] &	Mult.#	δ	α	Comments
(16 [§] 3)	448.8					
(28 [§] 2)	432.98					
38.48 5	265.86	0.038 6	(M1+E2)	0.21 [#] 5	183 [@] 32	
(44 [§] 2)	448.8					
52.45 5	318.31	0.048 5	(M1+E2)	0.27 [#] 6	70 [@] 8	

Continued on next page (footnotes at end of table)

^{251}Cf α Decay 2003Ah07,1968Ch03,1970BrZN (continued) $\gamma(^{247}\text{Cm})$ (continued)

$E_{\gamma}^{\dagger}$	E(level)	$I_{\gamma}^{\ddagger\&}$	Mult.#	δ	α	Comments
58.03 5	285.41	0.024 5	(M1+E2)	0.53 [#] 11	80 [@] 22	
60.5 1	345.89	0.010 3	(M1+E2)	0.48 [#] 16	62 [@] 21	
61.67 5	61.67	0.40 3	M1+E2	0.25 [#] 2	37.5 16	$\alpha(\text{L1+L2}): \alpha(\text{L3}): \alpha(\text{M+N}) = 23.5 \text{ } 31:3.3 \text{ } 8:11.0 \text{ } 17$ (2003Ah07). $\alpha(\text{K}): \alpha(\text{L1+L2}): \alpha(\text{L3}): \alpha(\text{M}): \alpha(\text{N}) = 0.24 \text{ } 5:1.0 \text{ } 1:0.5 \text{ } 1:0.7 \text{ } 1:$ 0.37 5 (1970BrZN).
(68 [§] 2)	516.68					
73.00 8	134.66	0.040 5	[M1+E2]	0.7 [#] +5-4	39 [@] 16	
(83.7 [§] 2)	516.68					
84.35 8	219.02	0.040 5	[M1+E2]		26 15	
113.7 1	518.59	0.024 5	[M1+E2]		8 3	
134.65 8	134.66	0.014 3	[E2]		4.94	
157.35 8	219.02	0.020 4	[E2]		2.56	
165.70 5	227.379	0.12 1	E3		30.4	Ice(L1+L2):Ice(L3)=15 3:6.7 26 (2003Ah07).
177.52 2	404.90	17.3 9	E2		1.567 22	Ice(K):Ice(L1+L2):Ice(L3):Ice(M+N)=0.19 3:0.71 8:0.31 3: 0.41 5 (2003Ah07). Ice(K):Ice(L1+L2):Ice(L3):Ice(M):Ice(N)= 4.1 6:18 1:9 1:12 1:6.4 10 (1970BrZN). $\alpha(\text{K})_{\text{exp}}=0.25$, $\alpha(\text{exp})=1.27$ (1968Ch03). $\alpha(\text{K}): \alpha(\text{L1+L2}): \alpha(\text{L3}): \alpha(\text{M+N}) = 6.0 \text{ } 5:2.7 \text{ } 3:0.41 \text{ } 5$:1.53 17 (2003Ah07). $\alpha(\text{K}): \alpha(\text{L1+L2}): \alpha(\text{L3}): \alpha(\text{M}): \alpha(\text{N}) = 7 \text{ } 2:3.7 \text{ } 6:0.6 \text{ } 2:2.1 \text{ } 4$:0.85 15 (1970BrZN).
227.38 2	227.379	6.8 3	M2+E3	0.52 +9-8	10.3 4	
256.65 8	318.31	0.13 1	[E1]		0.0611 9	
265.86 8	265.86	0.43 3	[E1]		0.0565 8	Since an E1 transition from 5/2[622] to 9/2[734] state would be K forbidden, there might be some M2 admixture in 265.86 γ . $\alpha(\text{M2})=7.10$.
284.2 1	345.89	0.12 1	[E1]		0.0489 7	
285.41 8	285.41	1.13 9	[E1]		0.0484	
289.3 1	516.68	0.070 7	[M1+E2]		0.9 7	
291.20 8	518.59	0.30 3	[M1+E2]		0.9 7	
315.8 1	581.67	0.024 3	[M1+E2]		0.7 6	
318.3 1	318.31	0.050 5	[E1]		0.0384	
345.9 1	345.89	0.043 4	[E1]		0.0322 5	
354.3 1	581.67	0.013 2	[M1+E2]		0.5 4	

[†] From 2003Ah07. Other measurements: 1968Ch03, 1970BrZN.[‡] Measured by 2003Ah07, except as noted otherwise. Absolute intensities were determined by 2003Ah07 by measuring the alpha rate of a thin ^{251}Cf source with a Si detector of known geometry and measuring the gamma spectrum with a Ge spectrometer of known absolute efficiency which was determined with a calibrated source. Earlier measurements: 1968Ch03, 1970BrZN. See also ^{247}Am β^- decay.[§] Transition was not observed. Existence is from the level scheme.[#] Determined by evaluator from $\alpha(\text{exp})$ (2003Ah07).[@] Deduced by evaluator from intensity balance.[&] Absolute intensity per 100 decays.

²⁵¹Cf α Decay 2003Ah07,1968Ch03,1970BrZN (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 decays by this branch

²⁵¹Cf₁₅₃ 1/2+ 0.0 898 y
%α=100
Q_α=6177.0⁹

²⁴⁶Cm(d,p),²⁴⁸Cm(d,t) 1971Br27

1971Br22: Single neutron transfer reaction studied with 12-MeV deuteron beam on ^{246,248}Cm targets. Protons and tritons were detected at angles of 90° and 140° by magnetic spectrograph detector. The (d,t) reaction was also studied with E(d)=16 MeV at 10°, 20°, 30°, 40° and 50°.

²⁴⁷Cm Levels

E(level)	Jπ [±]	Comments
(0.0 [§])	9/2-	
(59 [§] 3)	11/2-	
(137 [§])	13/2-	E(level): Not in Table III (1971Br27) but is given in the level scheme of Fig. 10 (1971Br27).
217 [§] 2	15/2-	
227 [#] 1	5/2+	
287 [@] 4	(7/2+)	
309 3		
318 [#] 3	9/2+	
336 5		
344 [@] 2	(9/2+)	
370 [?] 3		
381 [#] 5	(11/2+)	
398 [@] 4	(11/2+)	
404 ^{&} 1	1/2+	
417 [?] & 6	(3/2+)	
439 ^a 3	(9/2+)	
452 ^{&} 3	5/2+	
506 ^b 3	(1/2+)	
520 [†] & 2	(7/2+)	
520 ^b 2	(3/2+)	
550 ^{&} 2	(9/2+)	
584 3		
592 2		
604 ^b 3	(7/2+)	

Continued on next page (footnotes at end of table)

$^{246}\text{Cm}(\text{d,p}), ^{248}\text{Cm}(\text{d,t})$ 1971Br27 (continued) ^{247}Cm Levels (continued)

E(level)	$J\pi^{\dagger}$	Comments
668 ^c	5	(3/2+)
687 ^d	5	(11/2+)
699 ^b	2	(9/2+)
699 ^{†c}	2	(5/2+)
749 ^c	5	(7/2+)
784 ^e	4	(3/2-)
803	5	
819 ^e	4	(7/2-)
819 ^{†c}	4	(9/2+)
856	5	
897 ^e	5	(11/2-)
947	2	
957 ^f	2	(1/2-)
988	5	
1001 ^f	2	(3/2-, 5/2-)
1044	3	
1064	3	
1079 ^g	3	(5/2+)
1091	3	
1159	3	
1182 ^g	3	(9/2+)
1199?	4	
1239	5	
1247	5	
1271	3	
1283 ^h	3	(5/2-)
1317	3	
1356?	3	
1364	4	
1372	4	
1512	6	

[†] Level assumed doublet by authors.

[‡] Assignments made by 1971Br27. Estimated L-values and comparison of measured cross sections with the calculated "signatures" were the bases for spin and orbit assignments.

§ (A): 9/2[734] band.

(B): 5/2[622] band.

@ (C): 7/2[624] band.

& (D): 1/2[620] band.

a (E): 7/2[613] band?

b (F): 1/2[631] band.

c (G): 3/2[622] band?

d (H): 9/2[615] band?

e (I): 1/2[750] or [761] band? Usually accepted Nilsson assignment is 1/2[761]. 1/2[750] was used by 1971Br27 because of the wavefunction structure.

f (J): 1/2[501] band.

g (K): 3/2[631] band?

h (L): 5/2[503] band?

$^{248}\text{Cm}(^{209}\text{Bi}, ^{210}\text{Bi}\gamma)$ 2010Ta22

2010Ta22: Single-neutron transfer experiment was carried at the ATLAS facility of Argonne National Laboratory. A target of ^{248}Cm of $200\text{ }\mu\text{g}/\text{cm}^2$ was bombarded with ^{209}Bi beam at energy of 1450 MeV. The target had a $\approx 50\text{ mg}/\text{cm}^2$ Au substrate backing and a $200\text{ }\mu\text{g}/\text{cm}^2$ Au foil in front. x-ray and γ coincidences along with cross coincidence with the 569 and 319 keV transition in ^{207}Pb and ^{210}Bi allowed unambiguous band assignments. The γ -rays were detected using the Gammasphere array with ≈ 100 compton suppressed Ge detectors. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$, (x-ray)- γ coin and $\gamma\gamma\gamma$. High spin properties described in terms of the Woods-Saxon cranked shell model.

Others (Theoretical studies):

2011Zh03: Experimental high spin rotational bands observed in 2010Ta22 have been investigated using the cranked shell model (CSM) with the pairing correlations treated by particle number conserving (PNC) method. The experimental moment of inertia and alignments and variations with rotational frequency ω are reproduced well with these calculations.

 ^{247}Cm Levels

$E(\text{level})^\dagger$	$J\pi$	$E(\text{level})^\dagger$	$J\pi$	$E(\text{level})^\dagger$	$J\pi$
0.0 $\ddagger$	9/2-	808.8 $\ddagger$ 14	25/2-	2272.8 $\ddagger$ 21	41/2-
61.67 $\S$ 5	11/2-	958.8 $\S$ 15	27/2-	2488.8 $\S$ 23	43/2-
135.0 $\ddagger$ 10	13/2-	1119.8 $\ddagger$ 16	29/2-	2718.8 $\ddagger$ 23	45/2-
219.7 $\S$ 10	15/2-	1288.8 $\S$ 16	31/2-	2946.8 $\S$ 25	47/2-
314.9 $\ddagger$ 13	17/2-	1468.8 $\ddagger$ 17	33/2-	3189 $\ddagger$ 3	49/2-
421.8 $\S$ 13	19/2-	1656.8 $\S$ 18	35/2-	3428 $\S$ 3	51/2-
539.9 $\ddagger$ 14	21/2-	1854.8 $\ddagger$ 19	37/2-		
668.8 $\S$ 14	23/2-	2057.8 $\S$ 20	39/2-		

† From $E\gamma$'s, assuming 1 keV uncertainty for each $E\gamma$.

$\ddagger$ (A): $\nu 9/2[734], \alpha=+1/2$.

$\S$ (B): $\nu 9/2[734], \alpha=-1/2$.

 $\gamma(^{247}\text{Cm})$

$E\gamma$	$E(\text{level})$	Comments
61.67 5	61.67	$E\gamma$: From Adopted Gammas.
(135 1)	135.0	
140 1	808.8	
150 1	958.8	
(158 1)	219.7	
161 1	1119.8	$E\gamma$: Spectral figure (Fig. 2) in 2010Ta22 indicates 170.
169 1	1288.8	
180 1	314.9	
	1468.8	
188 1	1656.8	
198 1	1854.8	
202 1	421.8	
225 1	539.9	
247 1	668.8	
269 1	808.8	
290 1	958.8	
311 1	1119.8	
330 1	1288.8	
349 1	1468.8	
368 1	1656.8	
386 1	1854.8	
401 1	2057.8	
418 1	2272.8	
431 1	2488.8	
446 1	2718.8	
458 1	2946.8	
470 1	3189	
481 † 1	3428	

† Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Q(β⁻)=-613 16; S(n)=6550 60; S(p)=4417 5; Q(α)=5890 5 2012Wa38.

Identification:

1965Mi08: ²⁴⁷Bk produced by irradiating ²⁴⁶Cm sample with He ions from the Argonne 150-cm cyclotron. It was then followed by chemical purification and mass spectrometric measurements. Half-life was measured.

1956Ch77: ^{244,245,246}Cm bombardment by 28-MeV He ions. Bk was chemically separated from the decay of ²⁴⁷Cf.

Theoretical and Systematical studies:

2013Ni13,2012Ni16: α decay T_{1/2} for transitions from ground-state to favored rotational bands using multichannel cluster model (MCCM).

2012Sa05: Partial T_{1/2}, α branching ratio to individual residual states using Coulomb and proximity potential model for deformed nuclei (CPPMDN).

2011Zh36: Systematic analysis of α decay to members of favored bands using the Geiger-Nuttall law. Calculated the partial half-lives.

2010Ni02: Systematics and calculations of T_{1/2} and relative intensities of α decay within the generalized density-dependent cluster model.

2004Pa40: Calculated deformation parameters and the proton one-quasiparticle states of heaviest nuclei using the macroscopic-microscopic approach.

2003Re14: Calculated binding energy and Qα and ground-state deformations 2002Du16: Calculated partial half-lives for α and cluster decays.

1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.

1995Mo29, 1980Ho32: Calculated ground-state masses and nuclear ground-state deformations.

1993Bu09: Calculated partial α decay half-life, α branching, and nuclear radius using the cluster model predictions.

1985Lo17: Calculation of spontaneous fission half-life of ground-state.

1981Mo24: Calculated ground-state electric multipole moments Q₂, Q₄ and masses.

1980Ho32: Calculated fission-barrier heights, deformation and energy at saddle-point were.

²⁴⁷Bk Levels

Cross Reference (XREF) Flags

- A ²⁴⁷Cf ε Decay
- B ²⁵¹Es α Decay
- C ²⁴⁶Cm(α,t) E=28, 29 MeV
- D ²⁴⁹Bk(p,t) E=15 MeV

E(level)	Jπ [†]	XREF	T _{1/2}	Comments
0.0 [‡]	3/2-	ABC	1380 y 250	%α≤100. A calculated half-life of ≈10000 y for spontaneous fission (1985Lo17) yields %SF=12. T _{1/2} : From 1965Mi08. Jπ: Favored α decay from g.s level in ²⁵¹ Es. Jπ: Band member; γ to 3/2- g.s. level. Jπ: L=0 in ²⁴⁹ Bk(p,t) reaction [Jπ(²⁴⁹ Bk)=7/2+]. Jπ: Band member in (α,t) data. Jπ: L=2 in ²⁴⁹ Bk(p,t) reaction [Jπ(²⁴⁹ Bk)=7/2+]; logft=6.05 for ε feeding from (7/2+) ²⁴⁷ Cf. Jπ: From band member in (α,t) data. Jπ: From band member in (p,t) data. Jπ: From band member in (α,t) and (p,t) data. Jπ: From band member in (p,t) data. Jπ: M1 294.1γ to 7/2+ level; 334.9γ to (3/2-) level, 305.2γ to (5/2-) level. Jπ: 337.3γ to 7/2+ level 334.9-keV. Jπ: (E1)407.0γ to 7/2+ level; M1+E2 447.8γ to (3/2-) level. Jπ: From band member in (α,t) data. Jπ: 363.9γ to (9/2-) level, 459.5γ to (5/2-) from 447.8-keV level. Jπ: From band member in (α,t) data. Jπ: From band member in (α,t) data. Jπ: From band member in (α,t) data. Jπ: From band member in (α,t) data. Jπ: From band member in (α,t) data. Jπ: From band member in (α,t) data. Jπ: (α,t) data. Jπ: From band member in (α,t) data.
29.88 [‡] 11	(5/2-)	ABC		
40.81 [‡] 11	7/2+	AB D		
71.60 [‡] 13	(7/2-)	ABC		
82.81 [‡] 23	(9/2)+	AB D		
125.5 [‡] 4	(9/2-)	A C		
137 [‡] 5	(11/2+)	D		
196 [‡] 3	(13/2+)	CD		
265 [‡] 2	(15/2+)	D		
334.92 [#] 12	(5/2)+	A		
378.1 [?] 6	(7/2+)	A		
447.80 [@] 9	(5/2-)	A		
487 ^{&} 3	(1/2+)	C		
489.4 [@] 3	(7/2-)	A		
518 ^{&} 5	(3/2+)	C		
541 [@] 3	(9/2-)	C		
587 [#] 4	(13/2+)	C		
704 ^a 4	(1/2-)	C		
743 ^a 3	(5/2-)	C		
815 ^a 4	(7/2-)	C		
828 ^a 5	(9/2-)	C		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

²⁴⁷Bk Levels (continued)

E(level)	Jπ [†]	XREF	Comments
904 ^b 3	(9/2-)	C	Jπ: From band member in (α,t) data.
983 3		C	Jπ: From band member in (α,t) data.
1149 4		C	Jπ: From band member in (α,t) data.
1166 ^c 4	(13/2+)	C	Jπ: From band member in (α,t) data.

[†] Spin and parity assignments from (α,t) were based on L-values deduced from angular distributions and on relative peak intensities. Assignments from (p,t) were based on comparison of experimental spectroscopic factors with calculated ones.

[‡] (A): 3/2[521] band.

[§] (B): 7/2[633] band.

[#] (C): 5/2[642] band.

[@] (D): 5/2[523] band.

[&] (E): 1/2[400] band. Assignments to this band were made by 1979Ah03 on the bases of spectroscopic factors for (α,t) reaction and the systematics of orbitals.

^a (F): 1/2[521] band. Assignments to this band were made by 1979Ah03 from (α,t) data.

^b (G): 7/2[514] band. Assignment was proposed by 1979Ah03 from (α,t) data and from systematics of orbitals.

^c (H): 9/2[624] band?. The assignment was suggested by 1979Ah03 from comparison of (α,t) spectroscopic factor with that for 13/2+, 9/2[624] state in ²⁵¹Es (1978Ah02).

γ(²⁴⁷Bk)

E(level)	Eγ [†]	Iγ [‡]	Mult. [§]	δ	α
29.88	29.9 2	100			
40.81	(10.9 [#])				
	40.8 3				
82.81	42.0 2	100			
334.92	294.1 1	100 8	M1		1.651
	305.2 3	0.91 14			
	334.9 2	2.9 3			
378.1?	337.3 5	100			
447.80	376.2 1	12.9 13			
	407.0 1	35 4	(E1)		0.0238
	417.9 [@] 1	62 5	M1+E2	0.68 24	0.494 10
	447.8 1	100 7	M1+E2	1.0 2	0.319 7
489.4	363.9 2	100 19			
	417.9 [@]				
	459.5 3	100 15			

[†] From ²⁴⁷Cf ε decay.

[‡] Relative photon intensities de-exciting each level, as measured in ²⁴⁷Cf ε decay.

[§] From ce data taken in ²⁴⁷Cf ε decay.

[#] Transition is expected but unobserved.

[@] Multiply placed.

Adopted Levels, Gammas (continued)

(F) $1/2[521]$
band.

(G) $7/2[514]$
band.

(H) $9/2[624]$
band?.

(13/2+) 1166

$^{247}_{97}\text{Bk}_{150}$

²⁴⁷Cf ε Decay 1979Ah03

Parent ²⁴⁷Cf: E=0.0; Jπ=(7/2+); T_{1/2}=3.11 h 3; Q(g.s.)=613 16; %ε decay=99.965 5.

²⁴⁷Cf-J, T_{1/2}: From Adopted Levels in ²⁴⁷Cf.

²⁴⁷Cf-Q(ε): From 2012Wa38.

1979Ah03: ²⁴⁷Cf produced by irradiating ²⁴⁶Cm with 40-MeV α-particle at the Argonne cyclotron. Chemical separation of the product was followed by isotope separation. γ spectra were measured with a Ge(Li) detector. Cd, Cu and Al absorbers were used to reduce summing-effect interference from intense Bk K x-rays. The electron spectra was measured with a cooled Si(Li) spectrometer with FWHM at 100 keV=1.0 keV.

1977Ah01: Experimental evidence for the identification of the deformed proton orbital 1/2[521].

²⁴⁷Bk Levels

E(level)	Jπ [†]	T _{1/2}
0.0 [‡]	3/2-	1380 y 250
29.88 [‡] 11	(5/2-)	
40.81 [§] 11	7/2+	
71.60 [‡] 13	(7/2-)	
82.81 [§] 23	(9/2)+	
125.5 [‡] 4	(9/2-)	
334.92 [#] 12	(5/2)+	
378.1? [#] 6	(7/2+)	
447.80 [@] 9	(5/2-)	
489.4 [@] 3	(7/2-)	

[†] From Adopted Levels.

[‡] (A): 3/2[521] band.

[§] (B): 7/2[633] band.

[#] (C): 5/2[642] band.

[@] (D): 5/2[523] band.

β⁺, ε Data

Eε	E(level)	Iε ^{†‡}	Log ft	Comments
(124 16)	489.4	0.032 7	6.99 18	
(165 16)	447.80	1.60 16	5.65 16	
(235 [§] 16)	378.1?			
(278 16)	334.92	2.7 3	6.18 10	
(488 [§] 16)	125.5			
(530 16)	82.81	21 3	6.05 7	Iε: Total ε feeding to the 82.81-, and 125.5-keV levels.
(541 [§] 16)	71.60			
(572 16)	40.81	74 12	5.58 8	Iε: Total ε feeding to the 29.88-, 40.81-, and 71.60-keV levels.
(583 16)	29.88			

[†] Electron-capture intensity per 100 ε decay, deduced from intensity balance at each level.

[‡] For intensity per 100 decays, multiply by 1.00635 5.

[§] Existence of this branch is questionable.

γ(²⁴⁷Bk)

x-rays:

K x-ray measurements are from 1979Ah03.

x-ray intensities given are in same units as the photons.

Eγ	Iγ	Transitions
107.2 1	2130 150	Kα ₂ x-ray
112.1 1	3370 240	Kα ₁ x-ray
126.2 2	1260 90	Kβ ₁ ' x-ray
130.3 2	470 40	Kβ ₂ ' x-ray

Continued on next page (footnotes at end of table)

²⁴⁷Cf ε Decay 1979Ah03 (continued)

 $\gamma(^{247}\text{Bk})$ (continued)

The total observed K x-ray intensity is 7230 300; the calculated intensity due to internal conversions (153 10) and those due to electron captures (6250 996) deduced from ε branchings and theoretical K/ε ratios for Q+=613 16 keV yield 6403 996 for total K x-ray intensity. Experimental K-shell fluorescence yield of 0.971 4 (1979Ah01) was used in calculations. For Q+=570 keV, the calculated total K x-ray intensity is 6682 1031.

I_γ normalization: To convert I_γ's to per 100 ε decays, a normalization factor of 0.0104 9 was obtained by the evaluator from the sum of transition intensities feeding the ground-state. Any possible direct ε feeding to g.s. is neglected since, for log^f_{int}>8.5, one obtains Iε<0.1%.

E _γ [†]	E(level)	I _γ [‡] #	Mult.§	δ	α	I(γ+ce)@	Comments
(10.9)	40.81						
29.9 2	29.88	23.1 18	[M1+E2]	0.124 4	361 12	87 11	Ice(M):Ice(N+O)=1650 200:620 60. 1.2 2≤I _γ ≤ 34 4 from Ice(M) and α(M)(E2)=1360 50, α(M)(M1)=48.8 12 If δ(29.9γ)=0.124 4, as it is for the similar intraband transition, 32.6γ in ²⁴¹ Am (see 2005Ma88) and α(M)(M1+E2)=68.7 23; α(N+O)(M1+E2)=25.95 82 (BrICC: 2008Ki07), then I _γ (weighted average)=23.1 18. With α=361 12, I(γ+ce)= 87 11.
40.8 3	40.81	0.18 4	[M2]		6450 250		Ice(M):Ice(N+O)250 50:100 20. I _γ : 0.18 4 from Ice(M) and α(M)(M2)=1360 30.
(41.7)	71.60						
42.0 2	82.81	17.4 17	[M1+E2]	0.13 2	117 7	21.1 31	Ice(M):Ice(N+O)=370 40:140 20. 1.4 2≤I _γ ≤21 2 from Ice(M) and α(M)(E2)=260 8, α(M)(M1)=17.9 4. If δ(42.0γ)=0.13 2, as it is for the similar intraband transition, 41.805 γ in ²⁴⁹ Bk (see 2011Ab07) and α(M)(M1+E2)=21.9 14; α(N+O)(M1+E2)=7.65 41, then I _γ (weighted average)=17.4 17 With α=117 7, I(γ+ce)= 21.1 31.
(53.9)	125.5						
(71.6)	71.60						
(95.6)	125.5						
294.1 1	334.92	98 7	M1		1.651		α(K)exp:α(L)exp:α(M)exp=1.40:0.27:0.08; Ice(K):Ice(L):Ice(M)=137 12:26 3:8 2.
305.2 3	334.92	0.89 14	[E1]		0.0430		
334.9 2	334.92	2.8 3	[E1]		0.0354		
337.3& 5	378.1?	≈0.6	[M1]		1.130		
363.9 2	489.4	1.1 2	[M1+E2]		0.5 4		
376.2 1	447.80	7.1 7	[M1+E2]		0.5 4		
407.0 1	447.80	19 2	(E1)		0.0238		α(K)exp<0.11, α(L)exp<0.11; Ice(K):Ice(L)=<2:<2.
417.9 ^a 1	447.80	34 3	M1+E2	0.58 2	0.494 10		δ: From α(exp) and α(theory)(BrICC: 2008Ki07). α(K)exp=0.38, α(L)exp=0.08; Ice(K):Ice(L)=13 2:2.8 9.
417.9 ^a	489.4						
447.8 1	447.80	55 4	M1+E2	0.92 2	0.319 7		δ: From α(exp) and α(theory)(BrICC: 2008Ki07). α(K)exp=0.24, α(L)exp=0.06; Ice(K):Ice(L)=13 2:3.1 9.
459.5 3	489.4	1.10 16	[M1+E2]		0.28 21		

[†] Measurements of 1979Ah03.

[‡] Measurements of 1979Ah03.

§ From conversion electron data of 1979Ah03. Absolute conversion coefficients were determined by measuring γ and ce spectra of a ²⁰³Hg source at identical geometries. Multipolarities in square brackets are from level scheme; they were not determined experimentally.

For absolute intensity per 100 decays, multiply by 0.0104 9.

@ For absolute intensity per 100 decays, multiply by 0.99965 5.

Footnotes continued on next page

²⁴⁷Cf ε Decay 1979Ah03 (continued)

γ(²⁴⁷Bk) (continued)

& Placement of transition in the level scheme is uncertain.

a Multiply placed.

²⁵¹Es α Decay 1979Ah03

Parent ²⁵¹Es: E=0.0; Jπ=3/2-; T_{1/2}=33 h I; Q(g.s.)=6598 3; %α decay=0.5 2.

²⁵¹Es-J,T_{1/2}: From Adopted Levels in ²⁵¹Es (2013Br09).

²⁵¹Es-Q(α): From 2012Wa38.

1979Ah03: ²⁵¹Es produced from decay of ²⁵¹Fm followed by mass separation. The α-particle spectrum was measured with the Argonne double focussing magnetic spectrometer (FWHM=5 keV) and Au-Si surface barrier detector (FWHM=13.0 keV).

²⁴⁷Bk Levels

E(level)	Jπ
0.0 [†]	3/2-
31 [†] 4	(5/2-)
42 [‡] 4	7/2+
72 [†] 4	(7/2-)
84 [‡] 4	(9/2)+

[†] (A): 3/2[521] band member.

[‡] (B): 7/2[633] band member.

α radiations

Eα [†]	E(level)	Iα [‡] #	HF [§]
6410 3	84	3.3 6	33 15
6422 3	72	3.0 6	42 19
6452 3	42	3.3 7	53 24
6462 3	31	9.4 10	21 9
6492 3	0.0	81.0 16	3.4 14

[†] From 1979Ah03. Uncertainties are from spectrometer calibration.

[‡] Alpha intensities per 100 α decays, measured by 1979Ah03.

Footnotes continued on next page

²⁵¹Es α Decay ¹⁹⁷⁹Ah03 (continued)

α radiations (continued)

§ $r_0(^{247}\text{Bk})=1.4753\ 83$, unweighted average of $r_0(^{246}\text{Cm})=1.4836\ 5$ and $r_0(^{248}\text{Cf})=1.4670\ 8$ (1998Ak04), is used in calculations of HF.
For α intensity per 100 decays, multiply by 0.005 2.

²⁴⁶Cm(α ,t) E=28, 29 MeV ¹⁹⁷⁹Ah03, ¹⁹⁷⁷Ah01

¹⁹⁷⁹Ah03: Thin ²⁴⁶Cm target was bombarded by α -particles at the Argonne FN tandem Van de Graaff accelerator. Tritons were detected with Kodak NTB-50 photographic emulsion plates at 80° and 90° with bombarding α energies of 28.0 MeV and 29.0 MeV respectively. Elastically scattered α -particles were detected with a Au-Si surface barrier detector at 60° to determine the absolute differential cross sections.

¹⁹⁷⁷Ah01: Experimental evidence for the identification of the deformed proton orbital 1/2[521].

²⁴⁷Bk Levels

E(level)	$J\pi^{\ddagger}$	$S^{\dagger}$	E(level)	$J\pi^{\ddagger}$	$S^{\dagger}$	E(level)	$J\pi^{\ddagger}$	$S^{\dagger}$
0.0 §	3/2-	0.14 3	518 [@] 5	3/2+	0.09 3	828 ^b 5	9/2-	0.35 10
30 § 3	5/2-	0.18	541 ^{&} 3	9/2-	0.60 12	904 ^c 3	9/2-	1.36 20
72 § 3	7/2-	1.40 13	587 ^a 4	13/2+	0.22 7	983 3		
130 § 3	9/2-		704 ^b 4	1/2-	0.23 5	1149 4		
196 # 3	13/2+	3.82 28	743 ^b 3	5/2-	0.83 9	1166 ^d 4	13/2+	0.77 16
487 [@] 3	1/2+	0.21 5	815 ^b 4	7/2-	0.35 7			

[†] (2J+1)S=(d σ /d Ω)/N θ (DWBA), where N=120.

[‡] Spin and orbital assignments were based on comparison of the experimental and calculated spectroscopic factors.

§ (A): 3/2[521] band member.

(B): 7/2[633] band member.

@ (C): 1/2[400] band member.

& (D): 5/2[523] band member.

a (E): 5/2[642] band member.

b (F): 1/2[521] band member.

c (G): 7/2[514] band member.

d (H): 9/2[624] band member?

²⁴⁹Bk(p,t) E=15 MeV ¹⁹⁸³De19

¹⁹⁸³De19: ²⁴⁹Bk target was bombarded by 15-MeV protons from Princeton University AVF cyclotron. Tritons were magnetically analyzed by a QDDD spectrometer and detected with a position-sensitive gas proportional counter (FWHM=8 keV) backed by a plastic scintillator. Data were taken at intervals of 5° from $\theta=10^\circ$ to 90°. DWBA analysis was performed.

$J\pi(^{249}\text{Bk})=7/2+$.

²⁴⁷Bk Levels

E(level) [†]	$J\pi^{\ddagger}$	L [§]	Relative Intensity of peak at $\theta=20^\circ$	Comments
41 1	7/2+ [#]	0	100	The differential cross section at $\theta=20^\circ$ for the 41-keV level was estimated to be about 30 $\mu\text{b/sr}$.
84 1	9/2+ [#]	2	48	
137 5	11/2+ [#]		25	
196 1	13/2+ [#]		9.7	
265 2	15/2+ [#]		6.5	

[†] From ¹⁹⁸³De19. FWHM=8 keV No levels above 300 keV were observed.

[‡] $J\pi$ for the 41- and 196-keV levels known previously in ¹⁹⁷⁷Ah01; $J\pi$'s for all other levels were deduced by ¹⁹⁸³De19 from relative peak intensities, and from energy fit to the rotational band.

§ From angular distribution (¹⁹⁸³De19).

7/2[633] band, Coriolis mixed with the 5/2[642] band.

Adopted Levels, Gammas

Q(β⁻)=-2475 25; S(n)=6059 15; S(p)=5150 60; Q(α)=6495 15 2012Wa38.

Identification:

1956Ch77: Determined ²⁴⁴Cm(α,n) excitation function 1954Gh12: ²⁴⁷Cf produced by irradiating ²³⁸U with ¹⁴N ions. at the Berkeley Crocker Laboratory 60 inch cyclotron. It was then followed by chemical separation. Measured half-life=2.7 h.

1954Hu50: He ion bombardment of ²⁴⁴Cm followed by fast chemical Measured x-rays and determined half-life (2.5 h and =3 h).

Other experimental work:

1987Ch30: Measured ²⁴⁹Cf(¹⁶O,¹⁶O 2n) production cross-sections.

1987Gr13: Measured ²⁴⁹Cf(¹³⁶Xe,X) production cross-sections.

1987We01: Measured ²⁴⁸Cm(¹²⁹Xe,X) and ²⁴⁸Cm(¹³²Xe,X) production cross-sections.

Theoretical and systematical studies:

2013Zd01: Calculated half-lives for α and cluster decay using a phenomenological model based on Gamow theory.

2012Ni16: Calculated α decay T_{1/2} for transitions from ground-state to favored rotational bands using Multicluster Channel Model.

2012Zh01: Comparison of the low-lying one-quasineutron band for N=149 isotones between the experimental values and calculated values using the cranked shell model (CSM) with pairing correlations.

2011Ad15,2010Ad17: One-quasiparticle levels using the microscopic-macroscopic modified TCSM, QPM and the self-consistent SHFB approaches.

2011Ha06: Systematic analysis of experimental work in N=149 isotones.

2011Zh36: Systematics and calculated partial half life of α decay to members of favored band. Accurate expressions are proposed for the evaluation of partial half-lives of these transitions based on microscopic quantum tunneling theory.

2010Ni02: Systematics and calculations of T_{1/2} and relative intensities of α decay within the generalized density-dependent cluster model.

2010Ni02: Systematics and calculations of T_{1/2} and relative intensities of α decay within the generalized density-dependent cluster model.

2006Sh19: Calculated energy levels of ground-state rotational band in N=149 isotones.

2005Pa73: Calculated neutron one-quasiparticle states of heavy nuclei within a macroscopic-microscopic approach.

2002Du16: Calculated partial half-lives for α and cluster decays.

1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.

1995Mo29,1980Ho32: Calculated ground-state masses and nuclear ground-state deformations.

1993Bu09: Calculated partial α decay half-life, α branching, and nuclear radius using the cluster model predictions.

1985Lo17: Calculation of spontaneous fission half-life of ground-state.

1981Mo24: Calculated ground-state electric multipole moments Q₂, Q₄ and masses.

1980Ho32: Calculated fission-barrier heights, deformation and energy at saddle-point were.

²⁴⁷Cf Levels

Cross Reference (XREF) Flags

A ²⁵¹Fm α Decay

B ²⁴⁷Es ε Decay (4.55 min)

E(level)	Jπ	XREF	T _{1/2}	Comments
0.0 [†]	(7/2+)	AB	3.11 h 3	%ε=99.965 5; %α=0.035 5. Branchings were determined by 1984Ah02 from measured alpha and Cm K x-ray intensity ratio of 4.7×10 ⁻⁴ 5; the K x-ray intensity was taken as 72.3 per 100 ε decays. T _{1/2} : From 1984Ah02 and 1979Ah03. Other measurements: 2.45 h 15 (1956Ch77), 2.5 h (1954Hu50). Jπ: Analogy to ²⁴⁵ Cm suggests 7/2[624] neutron orbital.
55.00 [†] 11	(9/2+)	A		Jπ: M1+E2 55.0γ to (7/2+) g.s.
122.09 [†] 11	(11/2+)	A		Jπ: E2 122.1γ to (7/2+) g.s.; M1+E2 67.1γ to (9/2+).
201.0 [†] 4	(13/2+)	A		Jπ: Energy fit to the 7/2[624] band.
383.2 [‡] 3	(5/2+)	A		Jπ: M1 383.2γ to (7/2+) g.s.; energy fit to the 5/2[622] band.
427.2 [‡] 4	(7/2+)	A		Jπ: γ's to (5/2+) and (9/2+) states; energy fit to the 5/2[622] band.
480.40 [§] 9	(9/2-)	A		Jπ: E1 358.3γ to (11/2+) and E1 480.4γ to (7/2+). Favoured α transition from ²⁵¹ Fm with HF=1.63 13.
531.99 [§] 21	(11/2-)	A		Jπ: γ's to (9/2-), (9/2+), (11/2+) and (13/2+) states; energy fit to the 9/2[734] band.
551.0 [‡] 10	(11/2+)	A		Jπ: γ to (9/2+) state; energy fit to 5/2[622] band.
595 [§] 4	(13/2-)	A		Jπ: Energy fit to the 9/2[734] band.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

²⁴⁷Cf Levels (continued)

E(level)	J π	XREF	Comments
634 $\frac{3}{2}^-$ 5	(13/2+)	A	J π : Energy fit to 5/2[622] band (11/2+) member.
678.0 $^{\#}$ 6	(7/2-)	A	J π : γ 's to the (7/2+) and (9/2+); analogy to a similar band at 644 keV in ^{245}Cm , 1973Ah02 suggested the 7/2-, 7/2[743] assignment.
738.0 $^{\#}$ 8	(9/2-)	A	J π : γ 's to the (9/2+), (11/2+) states of the g.s. band; energy fit to the 7/2[743] band.

[†] (A): 7/2[624] band. A=6.1.

[‡] (B): 5/2[622] band. A=5.9. Population and depopulation of the 9/2+ (expected at 484 keV) member should be obscured by the strongly populated (9/2-) state at 480.4 MeV.

§ (C): 9/2[734] band. A=4.8 By considering the relative values of the reduced transition rates for γ 's from the 9/2- member of this band to the 7/2, 9/2 and 11/2 members of the g.s. band, 1973Ah02 suggested that this band is strongly CORIOLIS mixed.

(D): 7/2[743] band. A=6.7.

 $\gamma(^{247}\text{Cf})$

E(level)	$E\gamma$	$I\gamma^\dagger$	Mult.	δ	α
55.00	55.0 2	100	M1+E2	0.51 5	122 11
122.09	67.1 2	100 18	M1+E2	0.45 10	50 8
	122.1 2	100 18	E2		9.12
383.2	383.2 3	100	M1		0.943
427.2	44.0 4				
	372.2 4				
480.40	358.3 1	33.0 $\frac{1}{2}$ 21	E1		0.0319
	425.4 1	100 $\frac{1}{2}$ 6	E1		0.0225
	480.4 1	41.1 $\frac{1}{2}$ 21	E1		0.0178
531.99	51.4 4				
	331.0 3	65 13			
	410.0 3	93 13			
	477.0 3	100 15			
551.0	496 1	100			
678.0	623.0 8	27 8			
	678.0 8	100 23			
738.0	616 1	$\approx$ 100			
	683 1	$\approx$ 80			

[†] Relative photon intensities normalized to 100 for the strongest γ from each level.

[‡] Relative photon intensities of transitions de-exciting the 480.4-keV level could be incorrect, if these photons include γ 's de-exciting an obscured 9/2+ member of the 5/2[622] band, expected at about 484 keV.

^{247}Es ϵ Decay

Parent ^{247}Es : $E=0.0$; $J\pi=(7/2+)$; $T_{1/2}=4.55$ min 26; $Q(\text{g.s.})=2475$ 25; $\% \epsilon + \% \beta^+$ decay=93.0.

$^{247}\text{Es}-J, T_{1/2}$: From Adopted Levels in ^{247}Cf .

$^{247}\text{Es}-Q(\epsilon)$: From 2012Wa38.

^{247}Es ϵ decay scheme has not been studied.

 ^{247}Cf Levels

E(level)	$J\pi$	Comments
0.0	(7/2+)	$J\pi$: From Adopted Levels.

 ^{251}Fm α Decay 1973Ah02

Parent ^{251}Fm : $E=0.0$; $J\pi=(9/2-)$; $T_{1/2}=5.30$ h 8; $Q(\text{g.s.})=7425.1$ 20; $\% \alpha$ decay=1.80 13.

$^{251}\text{Fm}-J, T_{1/2}$: From Adopted Levels in ^{251}Fm (2013Br09).

$^{251}\text{Fm}-Q(\alpha)$: From 2012Wa38.

1973Ah02: ^{251}Fm was produced by bombarding 32-MeV α on ^{249}Cf . The α -particle decay was measured with the Argonne magnetic alpha spectrometer (FWHM=5 keV) and 14 position-sensitive Au-Si surface barrier detectors. γ -rays associated with the α decay was identified by α - γ coincidence measurements for which the γ 's were detected with a Ge(Li)diode.

 ^{247}Cf Levels

E(level)	$J\pi$	$T_{1/2}$	Comments
0.0 [†]	(7/2+)	3.11 h 3	$T_{1/2}$: From α decay measurement of ^{247}Cf (1984Ah02).
55.00 [†] 11	(9/2+)		
122.09 [†] 11	(11/2+)		
201.0 [†] 4	(13/2+)		
383.2 [‡] 3	(5/2+)		
427.2 [‡] 4	(7/2+)		
480.40 [§] 9	(9/2-)		
531.99 [§] 21	(11/2-)		
551.0 [‡] 10	(11/2+)		
595 [§] 4	(13/2-)		
634 [‡] 5	(13/2+)		
678.0 [#] 6	(7/2-)		
738.0 [#] 8	(9/2-)		

[†] (A): 7/2[624] band member.

[‡] (B): 5/2[622] band member.

[§] (C): 9/2[734] band member.

[#] (D): 7/2[743] band member.

 α radiations

α branching was deduced by 1978Ah02 as 1.80% 13 from measured Einsteinium K x-ray/ α ratio of 40 2 and estimated Einsteinium K x-ray intensity of 0.733 39 per ϵ decay.

$E\alpha^{\dagger}$	E(level)	$I\alpha^{\ddagger\#}$	HF [§]	$E\alpha^{\dagger}$	E(level)	$I\alpha^{\ddagger\#}$	HF [§]
6580 3	738.0	0.26 4	39 7	6886 2	427.2	1.7 1	141 14
6639 3	678.0	0.56 6	34 5	6929 2	383.2	1.8 1	204 20
6682 4	634	0.07 3	430 190	7107 5	201.0	=0.05	=41638
6721 3	595	0.44 4	102 13	7185 3	122.09	0.29 3	1.49×10^4 20
6763 3	551.0	0.38 6	184 33	7252 3	55.00	0.93 8	8.5×10^3 10
6783 2	531.99	4.8 2	17.6 16	7306 3	0.0	1.5 1	8690 880
6834 2	480.40	87.0 9	1.63 13				

[†] From 1973Ah02. The original energies have been increased by 1 keV, as recommended by 1991Ry01, due to change in calibration energy.

[‡] Intensity per 100 α decays measured by 1973Ah02.

[§] $r_0(^{247}\text{Cf})=1.4725$ 55, unweighted average of $r_0(^{248}\text{Cf})=1.4670$ 8 and $r_0(^{246}\text{Cf})=1.478$ 14 (1998Ak04), is used in the calculations of HF.

[#] For α intensity per 100 decays, multiply by 0.0180 13.

²⁵¹Fm α Decay 1973Ah02 (continued)

 $\gamma(^{247}\text{Cf})$

x-rays (Cf): 1973Ah02

E(x-ray)	I(x-ray)	Transitions
109.8 2	1.20 13	K α_2 x-ray
115.0 2	1.8 2	K α_1 x-ray
129.5 3	0.65 9	K β_1 ' x-ray
133.6 4	0.24 5	K β_2 ' x-ray

See 1972Di02 for very accurate K x-ray energies and relative transition probabilities.

K fluorescence yield for californium was deduced by 1979Ah01 to be $w_K=0.973$ 4 from K x-ray and K Auger-electron intensities.

 $\alpha\gamma$: See 1973Ah02 for coincidence data.

E $\gamma^\dagger$	E(level)	I $\gamma^\ddagger$ @	Mult.§	δ	α	I(γ +ce)@	Comments
44.0 4	427.2	1.26 14				1.26 14	Ice(M)=0.7 2. I(γ +ce)=1.26 14 deduced from intensity balance.
51.4 4	531.99	3.74 23				3.74 23	Ice(M)=0.8 2. I(γ +ce)=3.74 23 deduced from intensity balance.
55.0 2	55.00	0.58 8	M1+E2	0.47 4	108 9	63.2 13	Ice(L1+L2):Ice(L3):Ice(M):Ice(N+O)= 33 3:14.5 15:12.2 13:5.2 6. δ : From α (M)(exp) and α (theory)(BrICC: 2008Ki07).
67.1 2	122.09	0.28 5	M1+E2	0.50 1	50.8 12	14.5 7	Ice(L1+L2):Ice(L3):Ice(M):Ice(N+O)=7.8 8:=2:2.9 4: 1.1 2. δ : From α (M)(exp) and α (theory)(BrICC: 2008Ki07).
122.1 2	122.09	0.28 5	E2		8.88	2.8 3	Ice(L1+L2):Ice(L3):Ice(M):Ice(N+O)=1.10 16:0.70 12: 0.70 13:0.4 1.
331.0 3	531.99	0.35 7	[E1]		0.0372	0.36 7	
358.3 1	480.40	17.5# 17	E1		0.0316	18.1 17	Ice(K)=0.44 6.
372.2 4	427.2	0.25 5	[M1]		0.942	0.44 10	
383.2 3	383.2	1.09# 13	M1		0.870	2.0 2	Ice(K):Ice(L)=0.85 14:=0.2.
410.0 3	531.99	0.50 7	[E1]		0.0241	0.51 7	
425.4 1	480.40	53# 5	E1		0.0224	54 5	Ice(K):Ice(L)=0.87 14:=0.2.
477.0 3	531.99	0.54 8	[E1]		0.0179	0.55 8	
480.4 1	480.40	21.8# 19	E1		0.01768	22.2 19	Ice(K):Ice(L)=1.0 1:0.25 8.
496 1	551.0	=0.08	[M1]		0.430	=0.11	
616 1	738.0	=0.05	[E1]		0.01110	=0.05	
623.0 8	678.0	0.07 2	[E1]		0.01087	0.07 2	
678.0 8	678.0	0.26 6	[E1]		0.00933	0.26 6	
683 1	738.0	=0.04	[E1]		0.00921	=0.04	

 † From 1973Ah02.

 ‡ Photon intensity per 100 α decays of ²⁵¹Fm, measured by 1973Ah02, unless otherwise indicated.

 $§$ From γ and ce work of 1973Ah02. I(ce)'s are given per 100 α decays. Multipolarities in square brackets are from the level scheme; they were not determined experimentally.

 $\#$ From 1978Ah02.

 $@$ For absolute intensity per 100 decays, multiply by 0.0180 13.

^{251}Fm α Decay 1973Ah02 (continued)

Decay Scheme

 Intensities: I(γ +ce) per 100 parent decays

Adopted Levels, Gammas

Q(β⁻)=-3100 SY; S(n)=7400 SY; S(p)=2802 20; Q(α)=7462 20 2012Wa38.
ΔQ(β⁻)=120, ΔS(n)=220 (syst, 2012Wa38).

Identification:

1989Ha27: Observed in ²⁴⁹Cf(p,3n) and ²³⁸U(¹⁴N,5n).
1973Es01: Produced from ²⁴³Am(¹²C,α4n). Identified by emitted α energies, T_{1/2} and excitation functions.
1967Mi06: Synthesized from ²³⁸U(¹⁴N,5n). Identified by emitted α energies, T_{1/2} and excitation functions.

Theoretical studies:

2012Ni16: α decay T_{1/2} for transitions from ground-state to favored rotational bands using Multicluster Channel Model.
2012Zh01: Comparison of the low-lying one-quasineutron band for Z=99 isotopes between the experimental values and calculated values using the cranked shell model (CSM) with pairing correlations.
2003Re14: Calculated binding energy, QA and deformations using the deformed RMF theory.
2002Lo05: Calculated binding energies, pairing gaps and deformations using RMF+BCS theory.
2002Du16: Calculated partial half-lives for α and cluster decays.
1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values and partial half-lives for α and β decays.
1996St28: α decay through deformed barrier and anisotropies for alphas were calculated.
1993Bu09: Calculated partial α decay half-life, α branching, and nuclear radius using the cluster model predictions.
1981Mo24: Calculated ground-state electric multipole moments Q₂, Q₄ and masses.
1980Ho32: Calculated mass excess, S(n), S(p), Q(β), Q(α), fission-barrier heights, deformation and energy at saddle-point.

Systematic Studies:

2006Ch52: Systematics studies of one-quasiparticle states in Es isotopes using Skyrme-HFB calculations.

²⁴⁷Es Levels

Cross Reference (XREF) Flags

A ²⁵¹Md α Decay
B ²⁴⁷Fm ε Decay (31 s)

E(level)	Jπ	XREF	T _{1/2}	Comments
0.0	(3/2-)	A		Jπ: 3/2-[521].
0+x	(7/2+)	AB	4.55 min 26	E(level): X=30 keV. %α=7; %ε+%β ⁺ =93. XREF: B(?). Proposed configuration=7/2[633](1989Ha27). Observation of the ground-state in ²⁴⁷ Fm ε decay is indirect. α branching was estimated by 1967Mi06 from observed α yield and calculated total cross section for ²³⁸ U(¹⁴ N,5N) reaction. Jπ: Analogy to ²⁴⁹ Es suggests 7/2[633] state. T _{1/2} : From 1989Ha27. Others: 5.0 min 3 (1967Mi06), 4.7 min 3 (1973Es01). Jπ: Suggested by theoretical calculations in 2006Ch52. Proposed configuration=7/2[514] (based upon multipolarities proposed for depopulating γ transitions).
50.9+x 3	(9/2+)	A		
293.69+x 10	(7/2-)	A		

γ(²⁴⁷Es)

E(level)	Eγ	Iγ	Mult.	Comments
50.9+x	(50)		(M1)	Eγ: γ transition has not been observed. Eγ is from level energies. Transition considered to be highly converted (2006Ch52).
293.69+x	242.7 3	16 2	(E1)	Mult.: E2 is also possible but less likely.
	293.7 1	100	(E1)	

²⁴⁷Fm ϵ Decay (31 s)

Parent ²⁴⁷Fm: E=0.0; J π =(7/2+); T_{1/2}=31 s *I*; Q(g.s.)=3100 syst; % ϵ +% β^+ decay=36.
²⁴⁷Fm-J, T_{1/2}: From Adopted levels in ²⁴⁷Fm.
²⁴⁷Fm-Q(ϵ): 3100 120 (syst, 2012Wa38).
 (% ϵ +% β^+)=36 determined by 1967Fl15 from α activities of ²⁴⁷Fm and ²⁴⁷Es.
 The ϵ + β^+ decay scheme has not been studied.

²⁴⁷Es Levels

E(level)

0.0

²⁵¹Md α Decay 2006Ch52,2005He27

Parent ²⁵¹Md: E=0.0; J π =(7/2-); T_{1/2}=4.27 min 26; Q(g.s.)=7963 4; % α decay=10 *I*.
²⁵¹Md-T_{1/2}: From measured half-life of 7550 α from decay of ²⁵¹Md (2006Ch52).
²⁵¹Md-Q(α): From 2012Wa38. Q(g.s.)= 7965 1 from E α =7550 to 293+x level (2006Ch52); Q(g.s.)=7955 10 from E α =7540 10 to 293+x, assuming x is small.
²⁵¹Md-J: From Adopted Levels in ²⁵¹Md (2013Br09).
²⁵¹Md: Proposed configuration=7/2[514] (2005He27).
²⁵¹Md-% α decay: % α =10 *I* from comparison of the intensities in α - α and recoil- α coincidences in α decay of ²⁵⁵Lr grand-mother nucleus (2006Ch52).
 2006Ch52: ²⁵¹Md isotope produced in α decay of ²⁵⁵Lr isotope. Parent nuclide produced by ²⁰⁹Bi(⁴⁸Ca,2n) reaction, in two separate experiments conducted at JYFL and GANIL. In both experiments, an incident beam energy of E=217 MeV was used. Recoil products separated from the primary beam in each. JYFL: Measured recoil products, E α , I α , and tof using a Multi-Wire Proportional Counter gas detector, two double-sided Si strip detectors (DSSSD) and a "box" of 28 pin-diodes surrounding the two DSSSDs. GANIL: Measured recoiled products, E γ , I γ , E α , I α , ce, and tof using a "galotte" detector (mylar foil and micro-channel plate detector), a DSSSD, four cooled Si detectors (BEST) and four segmented Ge detectors (EXOGAM).
 Theoretical calculations using Hartree-Fock-Bogoliubov (HFB) with Skyrme were performed to interpret the experimental results.
 2005He27: ²⁵¹Md produced from α decay of ²⁵⁵Lr. ²⁵⁵Lr produced by the ²⁰⁹Bi(⁴⁸Ca,2n) reaction with beam energy E=4.55-4.65 MeV/nucleon. Evaporation residues were separated from the primary beam by velocity filter SHIP at GSI facility. Measured (fragments)- α coin, α - γ coin, prompt and delayed γ -rays, and K x-rays. γ -rays were detected with a 'Clover' detector and a position sensitive (PIPS) detector was used to measure the α decay.

²⁴⁷Es Levels

E(level)	J π	Comments
0.0	(3/2-)	J π : Possibly 3/2-[521] (2005He27).
0+x	(7/2+)	Proposed configuration=7/2[633] (1989Ha27). E(level): The assignment to g.s. is not certain; 3/2[521] and 7/2[633] orbitals are close in energy and either could be the g.s., 2005He27 estimate that 7/2+ bandhead of 7/2[633] band lies $\approx$ 30 keV above the 3/2- bandhead of 3/2[521] band.
50.9+x 3	(9/2+)	E(level): The unobserved transition depopulating this level is shown by 2006Ch52 to be a highly-converted (possibly M1) transition. J π : Suggested by theoretical calculations in 2006Ch52.
293.69+x 10	(7/2-)	Proposed configuration=7/2[514] (based upon multipolarities proposed for depopulating γ transitions).

α radiations

α line at 7590 5 in the α spectrum in 2006Ch52 is assigned to a sum line with an intensity of 13 3 relative to 87 3 for 7550 α . This line was not clear if it was present in the work of 2005He27.

E $\alpha^{\dagger}$	E(level)	I $\alpha^{\S}$	HF ‡	Comments
7550 1	293.69+x	100	1.12 15	E α : Others: 7540 10 (2005He27); 7310 30 (1973Es01).

† Energies from JYFL experiment in 2006Ch52, which had better resolution.

‡ r₀(²⁴⁷Es)=1.476 20, estimated by the evaluator from the r₀ systematics given in 1998Ak04.

§ For α intensity per 100 decays, multiply by 0.10 *I*.

²⁵¹Md α Decay 2006Ch52,2005He27 (continued)

$\gamma(^{247}\text{Es})$

$E\gamma^\dagger$	E(level)	$I\gamma^\ddagger$	Mult.	Comments
(50)	50.9+x		(M1)	Highly converted transition.
242.7 3	293.69+x	16 2	(E1)	Mult.: E2 is also possible but less likely.
293.7 1	293.69+x	100	(E1)	$\alpha(\text{K})_{\text{exp}}\leq 0.08$; $\alpha(\text{L})_{\text{exp}}\leq 0.16$ (2005He27). $I\gamma$: $I\gamma(293)/I\gamma(243)=4.4\ 2$ (2006Ch52).

[†] From α - γ coincidences in 2005He27 with higher precision.

[‡] From 2005He27.

Adopted Levels

Q(β⁻)=-4260 SY; S(n)=6590 SY; S(p)=3520 SY; Q(α)=8258 10 2012Wa38.
ΔQ(β⁻)=240, ΔS(n)=120, ΔS(p)=250 (syst, 2012Wa38).

Identification:

1967Fl15: Synthesized from ²³⁹Pu(¹²C,⁴N). Identified by emitted α energies, T_{1/2} and excitation functions.

Theoretical studies:

2012Zh01: Comparison of the low-lying one-quasineutron band for N=147 isotones between the experimental values and calculated values using the cranked shell model (CSM) with pairing correlations.

2011Ad15: One-quasiparticle levels for N=147 nuclei using the microscopic-macroscopic modified TCSM, QPM and the self-consistent SHFB approaches.

2009Sa25: Calculated α decay T_{1/2} using semi-empirical formulas, and compared with experimental values and systematics.

2006Sh19: Calculated energy levels of ground-state rotational band in N=147 isotones.

2005Pa73: Calculated neutron one-quasiparticle states of heaviest nuclei within a macroscopic-microscopic approach.

2002Du16: Calculated partial half-lives for α and cluster decays.

1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values.

1995Mo29, 1980Ho32: Calculated ground-state masses and nuclear ground state deformations.

1993Bu09: Calculated partial α decay half-life, α branching, nuclear radius using the cluster model predictions.

1985Cw01: Calculated fission barrier.

1981Mo24: Calculated ground-state electric multipole moments Q₂, Q₄ and masses.

1980Ho32: Calculated mass excess, S(n), S(p), Q(β), Q(α), fission-barrier heights, deformation and energy at saddle-point.

²⁴⁷Fm Levels

Cross Reference (XREF) Flags

A ²⁵¹No α Decay (0.80 s)

B ²⁵¹No α Decay (1.02 s)

E(level)	Jπ	XREF	T _{1/2}	Comments
0.0	(7/2+)	AB	31 s 1	%α=64. T _{1/2} : From 2006He27. Others: 57 s +30-17 (2009Fo02), 29 s 1 (2004He28), 37 s +21-10 (1989He03), 35 s 4 (1967FL15). Jπ: From favoured alpha transition (HF=0.68) from g.s level in ²⁵¹ No and proposed configuration=7/2[624] (2006He27,2004He28).
45 7	(1/2+)	AB	5.1 s 2	%IT=12 2 (2006He27); %α=88 2. Jπ: From favoured alpha transition (HF=1.1) from 106-keV level in ²⁵¹ No and proposed configuration=1/2[631] (2006He27,2004He28). T _{1/2} : From 2006He27. Other: 4.3 s 4 (2004He28). E(level): From 2006He27 based on the mean value derived from the α energy in the αK x-ray measurement and the difference in measured Q(α) values for decays from g.s. to g.s and g.s to isomeric states.

²⁵¹No α Decay (0.80 s) 2006He27,2004He28

Parent ²⁵¹No: E=0.0; Jπ=(7/2+); T_{1/2}=0.80 s 1; Q(g.s.)=8752 16; %α decay=84 16.

²⁵¹No-J,T_{1/2}: From Adopted Levels in ²⁵¹No (2013Br09).

²⁵¹No-Q(α): From 2012Wa38. Others: 8751 16 from Eα=8612 16 (2006He27).

²⁵¹No-T_{1/2}: From 2006He27. Others: 0.78 s +38-22, 0.78 s 2 (2004He28), 0.76 s 3 (2001He35), 0.8 s 2 (1967Gh01).

²⁵¹No: Proposed configuration=7/2[624] (2006He27,2004He28).

²⁵¹No-%α decay: %α=91 +9-22, %SF<0.3, %ε is expected to be small %α is from total number of ²⁵⁵Rf α decays and the number of α-α correlations in α decay chain: ²⁵⁵Rf-²⁵¹No-²⁴⁷Fm (2001He35).

2009Fo02: ²⁵¹No produced in the α decay of ²⁵⁵Rf, which is the daughter from the α decay of ²⁵⁹Sg. ²⁵⁹Sg was produced in the ²⁰⁸Pb(⁵²Cr,n) reaction at the Lawrence Berkeley National Laboratory with ⁵²Cr beam energy ranging between E=250-267 MeV. Decay products were observed using a detector array consisting of 48 vertically position-sensitive detector strips. Measured α spectra and half-live from six ²⁴⁷Fm decays resulting from α decays of ²⁵¹No to ²⁴⁷Fm.

2006He27: ²⁵¹No produced by the ²⁰⁶Pb(⁴⁸Ca,3n) reaction at E=4.80 MeV/nucleon ⁴⁸Ca beam at UNILAC accelerator at GSI, and from α decay of ²⁵⁵Rf. Reaction products were separated from the primary beam by the SHIP velocity filter and implanted into a position-sensitive 16-strip PIPS detector.

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²⁵¹No α Decay (0.80 s) 2006He27,2004He28 (continued)

Measured E_γ, I_γ, γγ, α-γ coin, ce, and lifetimes with a clover detector.

2004He28: ²⁵¹No was produced via ²⁰⁶Pb(⁴⁸Ca,3n) reaction at E_{lab}=230.5 MeV ⁴⁸Ca beam at UNILAC accelerator at GSI.

Reaction products were separated from the primary beam by the SHIP velocity filter and implanted into a position-sensitive 16-strip PIPS detector for α measurement.

Measured E_γ, I_γ, γγ, α-γ coin, ce, and lifetimes with a clover detector.

2001He35: ²⁵¹No was produced via ²⁵⁵Rf α decay at the filter SHIP at GSI. HPGe detectors were used to measure α-γ coin, ce half-life.

1989He03: ²⁵¹No was produced via α decay chain of ²⁵⁵104 at GSI. Measured α and T_{1/2} with surface barrier detectors.

1967Gh01: ²⁵¹No was produced via ²⁴⁴Cm(¹²C,5n) at Berkeley heavy-ion linear accelerator. α spectra and T_{1/2} were measured.

All data are from 2006He27, unless otherwise stated.

²⁴⁷Fm Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	(7/2+)	31 s 1	%α=64 (2006He27); %ε+%β ⁺ =36. T _{1/2} : From 2006He27. Others: 57 s +30-17 (2009Fo02), 29 s 1 (2004He28), 37 s +21-10 (1989He03), 35 s 4 (1967FL15). Proposed configuration=7/2[624] (2006He27,2004He28).
45 7	(1/2+)	5.1 s 2	%IT=12 2 (2006He27); %α=88 2. T _{1/2} : From 2006He27. Other: 4.3 s 4 (2004He28). E(level): From 2006He27 based on the mean value derived from the α energy in the αK x-ray measurement and the difference in measured Q(α) values for decays from g.s. to g.s and g.s to isomeric states. Other: ≈29 keV (2004He28). Proposed configuration=1/2[631] (2006He27,2004He28).

α radiations

Eα [†]	E(level)	Iα ^{†@}	HF [#]	Comments
8524 § 17		≈0.5	≈133	Eα: Statistical uncertainty=8.
8552 § 17		≈1	≈66	Eα: Statistical uncertainty=8.
8562 17	45	≈0.3	≈161	Eα: Statistical uncertainty=7. Eα=8578 10 (2001He35).
8571 § 17		≈0.5	≈133	Eα: Statistical uncertainty=7.
8612 16	0.0	≈98	≈0.68	Eα: Statistical uncertainty=4. Eα=8608 5 (2004He28), 8621 10 (2001He35).

[†] Disagreements between the relative intensities of two alpha groups observed by 1967Gh01, 1989He03 and 2001He35 were explained by 2004He28 by existence of two separate α decaying ²⁵¹No parent states which were produced in different amounts in direct reactions than in α decay of ²⁵⁵Rf. Alpha's assigned to these two parent states were followed by different alpha activities.

[‡] Three types of uncertainties are combined in quadrature: statistical uncertainty of 4-8 keV; systematic uncertainty of 15 keV from calibration methods/standards; uncertainty of 3 keV due to reproducibility of an α peak energy.

§ Tentative line in the α spectrum. Possibly contributed by summing of main α-line with conversion electrons from highly-converted transition(s).

r₀(²⁴⁷Fm)=1.4708 58, unweighted average of r₀(²⁴⁶Fm)=1.465 7 and r₀(²⁴⁸Fm)=1.4765 19 1998Ak04) is used in calculations for hindrance factors.

@ For α intensity per 100 decays, multiply by 0.84 16.

²⁵¹No α Decay: 1.02 s 2006He27,2004He28

Parent ²⁵¹No: E=106 6; Jπ=(1/2+); T_{1/2}=1.02 s 3; Q(g.s.)=8752 16; %α decay=100.

²⁵¹No-E: based upon difference in measured Q(α) values for decays to the 1/2+ isomer state in ²⁴⁷Fm from the ground and 1/2+ isomer state in ²⁵¹No (2006He27). Other: ≈87 keV (2004He28).

²⁵¹No-J: From Adopted Levels in ²⁵¹No (2013Br09).

²⁵¹No-T_{1/2}: From 2006He27. Other: 0.93 s 6 (2004He28).

²⁵¹No-Q(α): From 2012Wa38. Others: 8751 16 from Eα=8612 16 (2006He27).

²⁵¹No: Proposed configuration=1/2[631] (2006He27,2004He28).

²⁵¹No-%α decay: assumed %α=100; no γ rays observed by 2006He27.

2006He27: ²⁵¹No produced by the ²⁰⁶Pb(⁴⁸Ca,3n) reaction at E=4.80 MeV/nucleon ⁴⁸Ca beam at UNILAC accelerator at GSI, and from α decay of ²⁵⁵Rf. Reaction products were separated from the primary beam by the SHIP velocity filter and implanted into a position-sensitive 16-strip PIPS detector.

Measured E_γ, I_γ, γγ, α-γ coin, ce, and lifetimes with a clover detector.

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^{251}No α Decay: 1.02 s 2006He27,2004He28 (continued)

2004He28: ^{251}No was produced via $^{206}\text{Pb}(^{48}\text{Ca},3n)$ reaction at $E_{\text{lab}}=230.5$ MeV ^{48}Ca beam at UNILAC accelerator at GSI.

Reaction products were separated from the primary beam by the SHIP velocity filter and implanted into a position-sensitive 16-strip PIPS detector for α measurement.

Measured E_γ , I_γ , $\gamma\gamma$, α - γ coin, ce, and lifetimes with a clover detector.

 ^{247}Fm Levels

E(level)	J π	T $_{1/2}$	Comments
0.0	(7/2+)	31 s 1	% α =64 (2006He27). T $_{1/2}$: From 2006He27. Other: 29 s 1 (2004He28). Proposed configuration=7/2[624] (2006He27,2004He28).
45 7	(1/2+)	5.1 s 2	%IT=12 2 (2006He27). E(level): from 2006He27 based on the mean value derived from the α -K X ray measurement and the difference in measured Q(α) values for decays from g.s. to g.s and g.s to isomeric states. T $_{1/2}$: From 2006He27. Other: 4.3 s 4 (2004He28). Proposed configuration=1/2[631] (2006He27,2004He28).

 α radiations

E $\alpha^\dagger$	E(level)	I $\alpha^\S$	HF ‡	Comments
8625 18		≈ 2	≈ 74	E α : tentatively assigned to the decay of the 1/2+ state in ^{251}No as its energy is higher than the g.s. to g.s. α -decay from ^{251}No to ^{247}Fm . Statistical uncertainty=10 keV.
8668 16	45	≈ 98	≈ 1.1	E α : Statistical uncertainty=4 keV. E α =8665 8 (2004He28).

† Three types of uncertainties are combined in quadrature: statistical uncertainty of 4–8 keV; systematic uncertainty of 15 keV from calibration methods/standards; uncertainty of 3 keV due to reproducibility of an α peak energy.

‡ $r_0(^{247}\text{Fm})=1.4708\ 58$, unweighted average of $r_0(^{246}\text{Fm})=1.465\ 7$ and $r_0(^{248}\text{Fm})=1.4765\ 19$ 1998Ak04) is used in calculations for hindrance factors.

§ Absolute intensity per 100 decays.

Adopted Levels

S(n)=8250 SY; S(p)=1540 SY; Q(α)=8764 IO 2012Wa38.
ΔS(n)=330, ΔS(p)=210 (syst, 2012Wa38).

Identification and Experimental Studies:

- 2010An08: ²⁴⁷Md activity produced in the ²⁰⁹Bi(⁴⁰Ar,2n) reaction with E(⁴⁰Ar)=187 MeV at UNILAC, GSI. Evaporation residues (ER) separated with the SHIP velocity filter and implanted into a position sensitive Si strip detector. Measured Eα, Iα, ER-α(t), ER-SF(t), Eγ, Iγ using tof detectors, an array of position sensitive Si detectors, and a Ge clover detector. See also 2006An13, 2004He23.
- 2005He27: ²⁴⁷Md produced via ²⁰⁹Bi(⁴⁰Ar,2n)reaction at UNILAC, GSI with E(⁴⁰Ar)=4.95 MeV/u. The residues were separated by the SHIP velocity filter and implanted on position sensitive PIPS detectors for α decay. α-γ coin were measured with a clover detector. α activity observed at 8422 IO keV.
- 1994HoZW: ²⁴⁷Md produced via ²⁰⁹Bi(⁴⁰Ar,2n)reaction at UNILAC, GSI with E(⁴⁰Ar)=4.78 MeV/u. Two fission events assigned preliminary to the g.s. ²⁴⁷Md were observed with T_{1/2}=0.23 s +19-12. α activity observed at 8424 keV with T_{1/2}=1.12 s 22.
- 1981Mu12: Discovery of ²⁴⁷Md from heavy ion fusion reaction ²⁰⁹Bi(⁴⁰Ar,2n) with E(⁴⁰Ar)=4.8 MeV/u from UNILAC at GSI. The residues were separated by the SHIP velocity filter and implanted on position sensitive surface barrier detectors for α decay and spontaneous fission measurement. α activity observed at 8428 keV 25.

Theoretical studies:

- 2010Ad19: One-quasiparticle levels for Md isotopes using the microscopic-macroscopic modified TCSM.
- 2005Re16: Calculated spontaneous fission half lives using Swiatecki's formula, by its generalized form, and by a new formula where the blocking effect of unpaired nucleon on the half-lives has been taken into account with different mechanisms.
- 2004Pa40: Calculated deformation parameters and the proton one-quasiparticle states of heaviest nuclei using the macroscopic-microscopic approach.
- 2002Du16: Calculated partial half-lives for α and cluster decays.
- 1997Mo25: Calculated ground-state binding energy, proton and neutron pairing gaps, neutron and proton separation energies, Q values.
- 1995Mo29, 1980Ho32: Calculated ground-state masses and nuclear ground state deformations.
- 1993Bu09: Calculated partial α decay half-life, α branching, nuclear radius using the cluster model predictions.
- 1985Cw01: Calculated fission barrier.
- 1981Mo24: Calculated ground-state electric multipole moments Q₂, Q₄ and masses.

²⁴⁷Md Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	(7/2-)	1.2 s 1	%α>99.9; %SF<0.1 (2010An08). %SF: <1% in Fig. 4 in 2010An08. T _{1/2} : From evaporation residue 8416 α(t) correlations in 2010An08. Note that there is some inconsistency in 2010An08, with T _{1/2} =1.2 s 1 quoted in the text and Table 1, however, T _{1/2} =1.3 s 1 is given in Fig. 2 and Fig. 4. Others: 2.9 s +17-12 (1981Mu12), 1.12 s 22 (1994HoZW). Jπ: From hindrance factor=1 from ²⁴⁷ Md α decay to 209.6-keV level in ²⁴³ Es and proposed configuration=7/2[514] (2010An08).
0+x	(1/2-)	0.25 s 4	E(level): X<264 keV (2010An08). %IT=79 5; %SF=21 5. T _{1/2} : From a total of 24 counts of spontaneous fission events obtained in 2010An08. Note that there is some inconsistency in 2010An08, with T _{1/2} =0.25 s 4 quoted in Table 1 and Fig. 4. however, T _{1/2} =0.24 s 7 is given in the text. Jπ: Proposed configuration=1/2[521] (2010An08) and from hindrance factor=2.5 from ²⁴⁷ Md α decay to (1/2-) level in ²⁴³ Es.

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