^{223}Th α decay (0.60 s) 1992Li09,1987El02,1989An13

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh et al. ,	NDS 175,1 (2021)	19-May-2021

Parent: ^{223}Th: E=0.0; J^π=(5/2$^+$); $T_{1/2}$=0.60 s *2*; Q(α)=7567 *4*; %α decay=100

^{223}Th-J^π,$T_{1/2}$: (5/2)$^+$ in ^{223}Th Adopted Levels in the ENSDF database (May 2001 update), based on analogy with 5/2$^+$ g.s. of isotonic ^{221}Ra, and also theoretical calculations by 1987Sh24. No new references for $T_{1/2}$ of ^{223}Th decay are available after the 2001 evaluation. Evaluators place the assignment in parentheses.

^{223}Th-Q(α): From 2021Wa16.

^{223}Th-%α decay: %α=100 for ^{223}Th α decay.

1992Li09: ^{223}Th produced in ^{208}Pb(^{18}O,3n),E=82 MeV, using >99% enriched ^{208}Pb target. Measured Eα, Iα, Eγ, %Iγ, $\alpha\gamma$ coin. Deduced γ-ray multipolarities from γ-ray transition intensity balances and I(K x-ray)/Iγ ratios. Revised decay scheme, in view of the results from in-beam gamma-ray spectroscopy, is given by 2001Sh14 (also 1993Sh43), together with a detailed theoretical analysis of structure of ^{219}Ra.

1987El02: ^{223}Th produced in ^{208}Pb(^{18}O,3n),E=83 MeV. Measured Eα, Eγ, Iγ, Ice, $\alpha\gamma$ coin, α(ce)-coin using Ge(Li) and Si(Li) detectors. Assignment of α-particle groups to ^{223}Th is based on agreement with Eα values from 1970Va13, and on the observation of Ra x-rays in coincidence with α particles.

1989An13: ^{223}Th produced in ^{208}Pb(^{22}Ne,α3n),E=100-130 MeV. Measured Eα, Iα using semiconductor detector.

1990An19: ^{223}Th produced in ^{205}Tl(^{22}Ne,p3n), E=100-109 MeV. Measured Eα, Iα using semiconductor detector.

1970Va13: ^{223}Th produced in ^{208}Pb(^{18}O,3n),E=108-130 MeV; ^{205}Tl(^{22}Ne,p3n),E≈100 MeV; ^{208}Pb(^{19}F,p3n),E=100-130 MeV. Measured Eα, Iα using semiconductor detector.

2001Sh14 (also 1993Sh43): analyzed spectroscopic data from reaction and α-decay experiments. Deduced levels, J, π, configurations.

The decay scheme presented here is from 1992Li09, as modified by 2001Sh14 on the basis of ^{208}Pb(^{14}C,3nγ) results in 2000Ri12. Evaluators′ assignment of (5/2$^+$) for 140-keV level, consistent with the favored α decay (HF=2.7) from ^{223}Th parent J^π(g.s.)=(5/2$^+$) This decay scheme supersedes that of 1987El02, which included γ rays of 57.1-, 68.2-, and 75.2 keV that defined levels at 57$^-$, 68.2-, and 145 keV. 1992Li09 did not see these γ rays in a γ-ray spectrum with about ten times better statistics.

The measured K x-ray intensity of 49% *3* (1992Li09) agrees well with 50% *5* deduced by evaluators (using the RADLST computer program), and confirms the self-consistency of the decay scheme adopted here. The total average radiation energy of 7572 keV *40*, deduced using the RADLST code, agrees with Q(α)=7567 keV *4* from 2021Wa16.

^{219}Ra Levels

E(level)[†]	J^π[‡]	$T_{1/2}$	Comments
0.0[#]	(7/2$^+$)	9 ms *2*	$T_{1/2}$: from Adopted Levels.
16.6[#] *2*	(11/2$^+$)	10 ms *3*	%α≈100 (2018Sa45); %IT=? Only the α decay to ^{215}Rn has been observed by 2018Sa45. $T_{1/2}$: from Adopted Levels. The existence of this level is based upon the observation of 97-keV γ rays in coincidence with 7323 keV α particles that populate the 113.7-keV level (1992Li09). The isomeric character of this state, with an estimate of half-life, and its α decay mode, has been first proposed by 2018Sa45.
52.0[#] *3*	(3/2$^+$)		
113.74[@] *11*	(9/2$^+$)		
140.02[@] *9*	(5/2$^+$)		
151.97[@] *9*	(7/2$^+$)		
271.6? *8*			J^π: very tentative (9/2$^-$) (2001Sh14).
320.6 *4*	(3/2$^+$,5/2,7/2$^+$)		J^π: (5/2$^-$) from systematics in 2001Sh14.
328.3 *5*	(1/2$^+$ to 7/2$^+$)		J^π: very tentative (3/2$^-$) (2001Sh14).
404.75 *16*	(3/2$^+$,5/2,7/2$^+$)		J^π: (5/2$^-$) from systematics in 2001Sh14.
421.7 *12*			J^π: very tentative (7/2$^-$) (2001Sh14).
445.0 *3*	(5/2$^+$,7/2,9/2$^+$)		J^π: (7/2$^-$) from systematics in 2001Sh14.

Continued on next page (footnotes at end of table)

^{223}Th α decay (0.60 s) 1992Li09,1987El02,1989An13 (continued)

^{219}Ra Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	Comments
470.7 *5*	(5/2$^+$ to 11/2$^+$)	J$^{\pi}$: (9/2$^-$) from systematics in 2001Sh14.
515.4 *10*		J$^{\pi}$: very tentative (11/2$^-$) (2001Sh14).

[†] Deduced from least-squares fit to γ-ray energies.
[‡] From Adopted Levels, based mainly on proposed assignments by 2001Sh14 (also 1993Sh43) from their analysis of in-beam γ-ray data, band assignments, and analogy with band structures in ^{221}Ra and ^{223}Ra.
[#] Member of $K^{\pi}=(1/2^+)$ structure.
[@] Member of $K^{\pi}=(5/2^+)$ structure.

α radiations

Eα[†]	E(level)	Iα[†#]	HF[‡]	Comments
6928	515.4	0.4	17	
6972	470.7	0.6	16	
6998	445.0	1.5	8.2	
7021	421.7	0.3	50	
7037	404.75	1.9	9	
7107	328.3	<0.1	>310	
7120	320.6	0.7	49	
7286 *10*	151.97	26.4	5.1	Iα=28% *10* from γ-transition intensity balance. Eα: others: Eα=7285 *10*, measured in coincidence with 152γ (1987El02); Eα=7287 *10* (original Eα increased by 2 keV because of a change in the energy of the ^{215}Po calibration standard (1970Va13,1977Ma30)); Eα=7290 *10* (1990An19). Iα: others: 60 *10* (1970Va13,1977Ma30); 41 *5* (1990An19).
7298 *7*	140.02	55.3	2.7	Eα: other Eα=7296 *13* (1987El02). Iα=46% *8* from γ-transition intensity balance.
7323 *5*	113.74	13.2	14	Eα,Iα: other values: Eα=7320 *20*, Iα=81 *8*, multiplet (1989An13). Eα=7317 *10*, Iα=40 *10* (original Eα has been increased by 2 keV because of a change in the energy of the ^{215}Po calibration standard (1970Va13,1977Ma30)). Eα=7320 *10*, Iα=29 *5* (1990An19). Eα=7324 *10* (1987El02). Others: 1952Me13, 1969Ha32. Iα=10% *9* from γ-transition intensity balance.
7383[@]	52.0	<0.5	>570	Iα=0% *7* from γ-transition intensity balance.
7418[@]	16.6	<0.5	>750	
7435 *5*	0.0	≈1	≈440	Eα: value deduced by evaluators from Eα=7323 and E(level)=113.7, Eα=7298 and E(level)=140.0, and Eα=7286 and E(level)=152.0 (1992Li09). Eα=7432 reported by 1992Li09.

[†] From 1992Li09, unless otherwise specified. Uncertainty of 5 keV in energy is estimated by evaluators. Values of Iα deduced by evaluators from γ-transition intensity balances are given under comments.
[‡] The nuclear radius parameter r$_0$(^{219}Ra)=1.5478 *22* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides from 2020Si16.
[#] Absolute intensity per 100 decays.
[@] Existence of this branch is questionable.

^{223}Th α decay (0.60 s) 1992Li09,1987El02,1989An13 (continued)

$\gamma(^{219}Ra)$

Iγ normalization: Absolute γ-ray intensities (per 100 decays of parent) are reported by 1992Li09.

E_γ [†]	I_γ [†#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α [@]	$I_{(\gamma+ce)}$ [#]	Comments
38.2 *3*	0.07 *3*	151.97	(7/2$^+$)	113.74	(9/2$^+$)	(M1+E2)	0.31 *15*	132 *62*	9.3 *19*	α(L)=1.0×10^2 *4*; α(M)=25 *11* α(N)=6 *3*; α(O)=1.4 *6*; α(P)=0.22 *8*; α(Q)=0.0074 *4* $I_{(\gamma+ce)}$: from in-out intensity balance at 113.7 level. 20% uncertainty is assumed by the evaluators. δ: from α=132 *62*, deduced by evaluators from γ-ray transition intensity balance at the 113-keV level using measured α intensity of 13.2% from 1992Li09.
52.0 *3*	0.03 *1*	52.0	(3/2$^+$)	0.0	(7/2$^+$)	[E2]		216 *7*		α(L)=159 *5*; α(M)=43.1 *14* α(N)=11.4 *4*; α(O)=2.41 *8*; α(P)=0.345 *11*; α(Q)=0.000738 *22*
88.0 *5*	0.5 *4*	140.02	(5/2$^+$)	52.0	(3/2$^+$)	[M1+E2]		11 *7*	6.3 *22*	α(L)=8 *5*; α(M)=2.1 *14*; α(N)=0.6 *4*; α(O)=0.12 *8*; α(P)=0.018 *10*; α(Q)=0.0004 *3* $I_{(\gamma+ce)}$: from γ-ray transition intensity balance at 52-keV level using %α=0 for 52-keV level (1992Li09). I_γ: from I(γ+ce) and α(theory) for assumed mult=[M1+E2].
97.14 *17*	0.9 *1*	113.74	(9/2$^+$)	16.6	(11/2$^+$)	M1		3.39		α(L)exp=1.4 *3* (1987El02) α(L)=2.57 *4*; α(M)=0.614 *10*; α(N)=0.1619 *25*; α(O)=0.0369 *6* α(P)=0.00644 *10*; α(Q)=0.000506 *8* E_γ: weighted average of 97.2 *2* (1992Li09) and 97.10 *17* (1987El02). Mult.: α(L)exp is ≈60% lower than the theoretical value for M1 (1987El02), however, no other multipolarity is consistent with this conversion coefficient, thus definite M1 is assigned for 97.14-keV transition.
113.74 *11*	1.6 *2*	113.74	(9/2$^+$)	0.0	(7/2$^+$)	M1[‡]		10.83		α(L)exp=1.4 *3* (1987El02) α(K)=8.68 *13*; α(L)=1.627 *24*; α(M)=0.389 *6* α(N)=0.1026 *15*; α(O)=0.0234 *4*; α(P)=0.00408 *6*; α(Q)=0.000320 *5* E_γ: weighted average of 113.8 *1* (1992Li09) and 113.55 *17* (1987El02).
119.6[&]		271.6?		151.97	(7/2$^+$)					

$^{219}_{88}Ra_{131}$-3

^{223}Th α decay (0.60 s) 1992Li09,1987El02,1989An13 (continued)

$\gamma(^{219}Ra)$ (continued)

E_γ [†]	I_γ [†#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α [@]	Comments
124.4[&]		445.0	$(5/2^+,7/2,9/2^+)$	320.6	$(3/2^+,5/2,7/2^+)$				
140.01 *9*	5.8 *6*	140.02	$(5/2^+)$	0.0	$(7/2^+)$	M1[‡]		5.99	α(L)exp=0.9 *1* α(K)=4.81 *7*; α(L)=0.895 *13*; α(M)=0.214 *3* α(N)=0.0565 *8*; α(O)=0.01288 *19*; α(P)=0.00225 *4*; α(Q)=0.0001761 *25* E_γ: weighted average of 140.0 *1* (1992Li09) and 140.02 *9* (1987El02). Mult.: α(L)exp is consistent with M1 (δ(E2/M1)<0.5) (1987El02).
151.99 *10*	3.7 *4*	151.97	$(7/2^+)$	0.0	$(7/2^+)$	M1+E2[‡]	0.95 *+90−50*	3.3 *10*	α(L)exp=0.77 *14*; α(M)exp=0.18 *8* α(K)=2.1 *11*; α(L)=0.86 *10*; α(M)=0.22 *4* α(N)=0.059 *9*; α(O)=0.0128 *18*; α(P)=0.00203 *17*; α(Q)=8.E−5 *4* E_γ: weighted average of 152.0 *1* (1992Li09) and 151.98 *12* (1987El02). Mult.,δ: from α=3.3 *10* (deduced by evaluators from γ-ray transition intensity balance at the 152-keV level using measured α intensity of 26.4% from 1992Li09). α(L)exp and α(M)exp from 1987El02 give δ(E2/M1)<1.0.
157.8[&]		271.6?		113.74	$(9/2^+)$				
168.8 *5*	0.06 *3*	320.6	$(3/2^+,5/2,7/2^+)$	151.97	$(7/2^+)$				
188.4 *7*	≈0.02	328.3	$(1/2^+$ to $7/2^+)$	140.02	$(5/2^+)$				
252.8 *2*	0.30 *9*	404.75	$(3/2^+,5/2,7/2^+)$	151.97	$(7/2^+)$				
264.7 *2*	0.7 *2*	404.75	$(3/2^+,5/2,7/2^+)$	140.02	$(5/2^+)$				
268.0 *10*	≈0.1	320.6	$(3/2^+,5/2,7/2^+)$	52.0	$(3/2^+)$				
276.1 *6*	0.04 *2*	328.3	$(1/2^+$ to $7/2^+)$	52.0	$(3/2^+)$				
293.0 *5*	0.20 *5*	445.0	$(5/2^+,7/2,9/2^+)$	151.97	$(7/2^+)$				
305.0 *5*	0.2 *1*	445.0	$(5/2^+,7/2,9/2^+)$	140.02	$(5/2^+)$				
318.8 *7*	0.06 *3*	470.7	$(5/2^+$ to $11/2^+)$	151.97	$(7/2^+)$				
320.6 *8*	≈0.02	320.6	$(3/2^+,5/2,7/2^+)$	0.0	$(7/2^+)$				
331.3 *5*	0.2 *1*	445.0	$(5/2^+,7/2,9/2^+)$	113.74	$(9/2^+)$				
353.0	≈0.02	404.75	$(3/2^+,5/2,7/2^+)$	52.0	$(3/2^+)$				
356.9 *7*	0.10 *6*	470.7	$(5/2^+$ to $11/2^+)$	113.74	$(9/2^+)$				
401.7 *10*	0.06 *3*	515.4		113.74	$(9/2^+)$				
421.7 *12*	≈0.03	421.7		0.0	$(7/2^+)$				

[†] From 1992Li09 unless otherwise stated.
[‡] Deduced from K x ray/Iγ ratios in $\alpha\gamma$ coin experiments (1992Li09).

$^{219}_{88}Ra_{131}$-4

γ(^{219}Ra) (continued)

[#] 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.

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

$^{219}_{88}Ra_{131}$-5

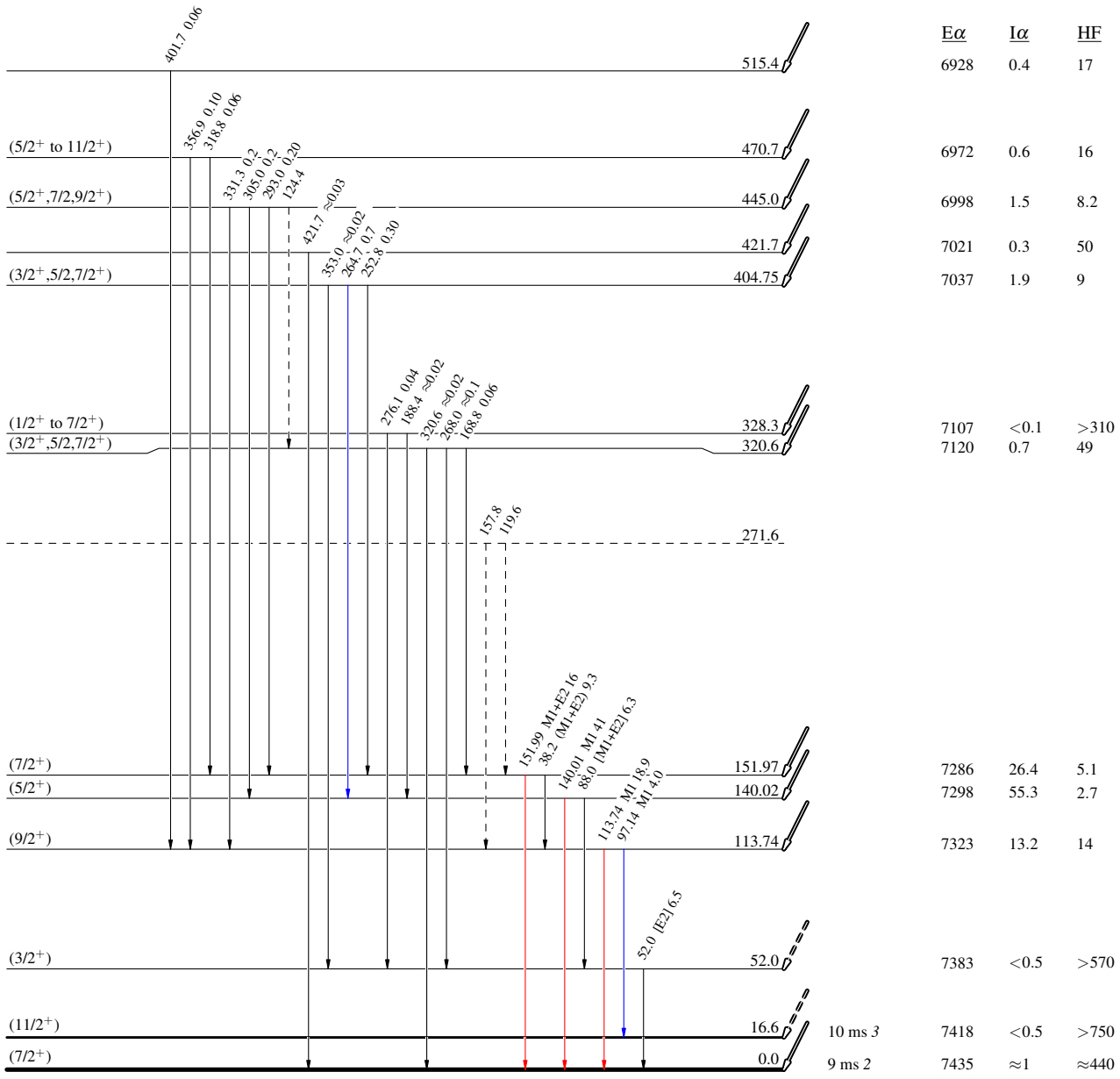
^{223}Th α decay (0.60 s) 1992Li09,1987El02,1989An13

Decay Scheme

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

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)

$(5/2^+)$ 0.0 0.60 s *2*
Q_α=7567 *4* %α=100
$^{223}_{90}Th_{133}$



Eα	Iα	HF
6928	0.4	17
6972	0.6	16
6998	1.5	8.2
7021	0.3	50
7037	1.9	9
7107	<0.1	>310
7120	0.7	49
7286	26.4	5.1
7298	55.3	2.7
7323	13.2	14
7383	<0.5	>570
7418	<0.5	>750
7435	≈1	≈440

$^{219}_{88}Ra_{131}$