^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Jagdish K. Tuli, and Edgardo Browne	NDS 185,560 (2022)	31-Aug-2022

Parent: ^{235}U: E=0.0; $J^{\pi}=7/2^{-}$; $T_{1/2}=7.04\times10^{8}$ y *1*; Q(α)=4678.1 *7*; %α decay=100

^{235}U-J^{π},$T_{1/2}$: From ^{235}U Adopted Levels in the ENSDF database (Feb 2014 update). No $T_{1/2}$ measurements have been reported after the 2014 evaluation.

^{235}U-Q(α): From 2021Wa16.

^{235}U-%α decay: %α=100 for ^{235}U decay. Other decay modes (SF and cluster): %SF=7×10^{-9}% *2*, %^{20}Ne=8×10^{-10}% *4*, %^{25}Ne≈8×10^{-10}%, %^{28}Mg=8×10^{-10}% from ^{235}U Adopted Levels in the ENSDF database (Feb 2014 update).

2018Ma03: measurement of absolute photon intensities in the range of 31-410 keV at four laboratories: 32 γ rays at JRC, Geel; eight γ rays at CIEMAT, Madrid; six γ rays each at ENEA, Rome and at CMI, Praha. Recommended values of Iγ/100 decays given for 32 γ rays, based on experimental data from all the four labs.

2017Le03, 2021LeZZ: measurement of relative and absolute photon intensities of Th x-rays, and 23 γ rays in the range 72-238 keV at CEA-LNHB-Saclay. Corrected relative-intensity data received March 5, 2021 from the first author of 2017Le03 (M.-C. Lépy as a private communication 2021LeZZ, as the evaluators enquired about some issues with the published values).

2006Al28: measurement of absolute gamma-ray intensities of six γ rays from 143 to 231 keV.

2005Ga36: measurement of energies and absolute intensities of 13 α groups using a silicon-implanted detector and enriched uranium at CIEMAT, Madrid in the frame of the EUROMET 591 cooperation project, with energies measured relative to Eα values of prominent α groups in the decays of ^{234}U and ^{236}U decay.

2004Da24: measurement of energies and intensities of 15 α groups using ^{235}U mass-separated source and a Passivated Implanted Planar Silicon (PIPS) detector at Orsay. Monte Carlo simulations.

1999Yu01: measured $\alpha\gamma$-coin and $\gamma\gamma$-coin involving the following γ rays: 143.7, 163.3, 182.7, 185.7, 202.1 and 205.3 keV, and the α transitions to the 0, 41.9, 96.1, 185.7, 205.3, 236.9, 277.8 and 387.8 keV levels. Measured relative $\gamma\gamma$-coin intensities, and extracted γ-branching ratios.

1999Ch12: measurement of absolute intensity of 185.7γ.

1996Ru11: measurement of absolute intensities of Th x rays and eight γ rays in the range of 109 to 205 keV at CEA-Saclay.

1992Li05: measurement of absolute intensities of eight γ rays in the range of 109 to 205 keV using highly enriched ^{235}U source at BNL.

1984He12: measurement of absolute intensities of five γ rays, and precise energies of six γ rays at Idaho Falls. Note that 1974HeYW, 1971KrZH, 1971Cl03 are from the same lab as 1984He12.

1983Ol01: measurement of absolute intensities of four γ rays at Idaho Falls.

1983Ba77: measurement of absolute intensities of 28 γ rays in the energy range of 25-247 keV, 18 γ rays from ^{235}U decay and 10 γ rays from ^{231}Th ε decay to ^{231}Ac, at AERE, Harwell. No information is available in the paper about gamma-ray energy measurements, and the values are listed by the authors without uncertainties.

1982Va04: measurement of absolute intensities of four γ rays in the energy range of 144-205 keV at JRC, Geel.

1977Ba72: measurement of energies and relative intensities of 50 γ rays.

1975Va11: measurement of energies and absolute intensities of 13 α groups, energies and absolute intensities of 42 γ rays in the energy range of 42-794 keV, and $\gamma\gamma$-coin at Orsay.

1974Te03: measurement of energies and relative intensities of 28 γ rays in the energy range of 31-390 keV at the University of Manitoba.

1974HeYW, 1971KrZH, 1971Cl03: measured energies and relative intensities of 34 γ rays at Idaho Falls; also a later work 1984He12 from the same lab.

1966Ga03: measured energies and absolute intensities of 32 α groups, and 17 γ rays in the energy range of 46-1010 keV, $\alpha\gamma$- and $\gamma\gamma$-coin using NaI(Tl) detector for γ rays. Eα values in this work may be lower by 6 keV due to calibration lines used as stated in 1971Ar48 evaluation.

1967Ch36: measured Eγ.

1965Wh05: measured α-particle energies and intensities of eight lines, half-life of ^{235}U decay.

1964Sc27: measured α-particle energies and intensities of ten lines.

1962Pi06 (also 1957Pi31 thesis): priv. comm. Eα, Iα, Eγ, Iγ for 11 α lines and seven γ rays, as listed in 1971Ar48 evaluation.

1961Ko11: measured α-particle energies and intensities of five α lines.

1961-Skillings, D.J.: cited by 1964Hy02, p.729: measured α-particle energies and intensities of eight lines, as listed in 1971Ar48 evaluation.

1960Ba44: measured α-particle energies and intensities of 13 lines.

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1960Vo07: measured α-particle energies and intensities of four lines, $\alpha\gamma$-coin and Eγ for four γ rays.
1959St49: measured half-life of 186 level from $\gamma\gamma$(t) and $\alpha\gamma$(t).
1958Fi10: measured Eγ for four γ rays, $\alpha\gamma(\theta)$. Level scheme proposed.
1957Wu39: measured Eα, Iα, Eγ, Iγ, half-life of ^{235}U decay, $\alpha\gamma$-coin for four α lines, and two γ rays.
1957Cl17: measured Eα of one line at 4396 keV *20*, and half-life of ^{235}U decay.
1956Jo25: measured Eγ, Iγ, $\gamma\gamma$-coin for nine γ rays.
1956Ma01: measured Eγ, Iγ, $\gamma\gamma$-coin for nine γ rays.
1955St04: measured Eγ, Iγ, $\alpha\gamma$-coin for four α rays.
1952Ve05: measured Eα, Iα.
1951Be97: measured Eγ, Iγ for five γ rays.
1951Gh22: measured Eα and Iα of four α lines: 4580 (10%), 4470(?) (≈3%), 4400 (83%) and 4200 (4%).
1949Ma37: evidence of a γ ray at 162 keV from the α decay of ^{235}U.
Others:
2021El04: measured ^{235}U/^{238}U ratio in ores by a focus on the 185.7-keV most intense γ ray emitted in the decay of ^{235}U.
2008Po06: measurement of $T_{1/2}(^{238}U)/T_{1/2}(^{235}U)=6.351$ *31* from high-resolution α-spectroscopy at JRC, Geel, in agreement with value from 1971Ja07.
2005Po02: measured α-spectrum. Monte Carlo simulations and imaging to investigate degradation of the alpha particle energy spectrum by thick samples. No data for individual α groups provided.
2004Va12: measurement of corrections due to scattering and self-absorption of α-particles from the source and from the backing material using 2π detectors, and Monte Carlo simulations.
Other evaluations:
2010BeZQ, 2009Hu07: DDEP evaluation of ^{235}U decay, covering literature up to June 2008.
1986LoZT: evaluated data at the IAEA for absolute intensities of 17 γ rays from 41-247 keV covering available data up to 1984.
Evaluators′ cautionary note: ^{235}U is a well known nuclide for nuclear structure and reactor applications. Although there have been many studies of its alpha decay to levels in ^{231}Th, including some recent ones such as 2018Ma03 and 2017Le03, yet evaluators′ analysis of the decay scheme suggests that while α-transitions are well established, yet several issues remain about gamma-ray and conversion electron spectroscopy to characterize the decay scheme fully. Most studies have either dealt with the determination of intensities of γ rays or the α particles, not focused on unraveling the intricacies of the decay scheme itself, with the exception of the decay scheme study by 1974Te03. Evaluators find following issues with the present decay scheme: lack of agreement between different studies for intensities of weak gamma rays (<1% or so relative intensity), and limited spectral information for intensities of several low-energy transitions (19.55, 41.1, 42.02, 54.25, 64.45, 95.7 keV) and multipolarities, intensities for some of which have been estimated by the evaluators from intensity balance arguments in the present decay scheme as much as possible. For some of the levels, direct feedings to levels deduced from gamma transition intensities in the present decay scheme do not agree well with the measured alpha-particle intensities to those levels. It is possible that there are still some missing low-energy, heavily converted transitions. In evaluators′ opinion, a dedicated and precise gamma-ray and conversion electron spectroscopic study is needed for a better understanding and completeness of the decay scheme, although, it would seem a challenging project.

^{231}Th Levels

The 156.78, 170.89, 227.4 and 390.2 levels proposed in 1974Te03; 279.5 and 338.0 levels in 1977Ba72; and 351.565 and 595.58 levels in 2010BeZQ (also 2009Hu07) DDEP evaluation have been omitted as these are not confirmed in ^{235}U α decay or other studies. The γ rays proposed from these levels have either been reassigned or not confirmed.
The decay scheme is primarily from 1975Va11, based on earlier level scheme in 1974Te03, and partially in 1966Ga03.
As a result of several α and γ lines reported only in 1966Ga03, not confirmed in later studies, the following levels proposed in this work, listed in their Table 1 and level-scheme Fig. 1 are omitted: 13, 33, 55, 75, 82, 114, 154, 168, 196, 224, 230, 253, 408, 428, 461, 501, 510, 620, 647, 700, 757, 810, 825 and 1010 keV.

E(level)†	J^π‡	$T_{1/2}$	Comments
0.0	$5/2^+$	25.57 h *8*	$T_{1/2}$: from the Adopted Levels.
41.9509 *17*	$7/2^+$		
96.126 *4*	$9/2^+$		
162.13 *6*	$11/2^+$		

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^{235}U α decay (7.04×10^8 y) 2005Ga36,2018Ma03,1975Va11 (continued)

^{231}Th Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$	Comments
185.7143 *17*	$5/2^-$	1.07 ns *8*	$T_{1/2}$: from the Adopted Levels. Other: 0.77 ns *12* (1959St49, $\gamma\gamma$(t) and $\alpha\gamma$(t)).
205.3098 *17*	$(7/2^-)$		
221.392 *20*	$3/2^+$	≤74 ps	
236.893 *7*	$9/2^-$		
240.8785 *25*	$5/2^+$		
275.423 *3*	$7/2^+$		
277.60 *8*	$(11/2^-)$		
301.70? *10*	$5/2^+$		
317.0790 *24*	$5/2^+$		
324.911 *7*	$(9/2)^+$		
331 *5*	$(13/2^-)$		
355 *5*	$7/2^+$		
377.562 *10*	$(7/2)^+$		
385.68? *4*	$(5/2^+$ to $11/2^+)$		
387.824 *4*	$7/2^-$		
452.189 *18*	$9/2^-$		
530.22 *5*	$(11/2^-)$		
562? *5*			
634.05 *4*	$(7/2^-)$		

† From least-squares fit to Eγ data. Uncertainties of the following γ rays were adjusted to obtain a reduced χ^2 consistent with critical χ^2=1.63: 0.10 keV from 0.05 keV for 120.35γ from 162.1 level, and 0.08 keV from 0.04 keV for 74.94γ from 236.9 level.

‡ From the Adopted Levels.

α radiations

Following 17 α lines reported by 1966Ga03 were not confirmed in later studies by 1975Va11, 2004Da24 and 2005Ga36: 4579 *3* (Iα=1.8), 4559 *3* (Iα=2.5), 4537 *10* (Iα<0.5), 4519 *3* (4552 in Table 1 of 1966Ga03 is erroneous) (Iα<1.0), 4510 *10* (Iα<0.5), 4478 *3* (Iα=1.6), 4424 *5* (Iα=1.8), 4368 *5* (Iα=6.1), 4339 *5* (Iα<1.0), 4184 *3* (Iα=1.3), 4164 *10* (Iα<0.5), 4131 *10* (Iα<0.5), 4091 *10*, 3945 *10*, 3892 *20*, 3825 *20* and 3769 *20*.

Following five α lines reported by 1960Ba44 were not confirmed in later studies by 1975Va11, 2004Da24 and 2005Ga36: 4578 *4* (Iα=1.5), 4522 ? *3*, 4426 ? *4* (Iα=1.5), 4368 *4* (Iα=6), 4339 *4* (Iα=1.5).

Eα†	E(level)	Iα†@	HF‡	Comments
3976& *5*	634.05	≈0.007	≈12	Eα,Iα: tentative α from 2004Da24. Other: 3977 *10* with no Iα (1966Ga03).
4042& *5*	562?	≈0.007	≈55	Eα,Iα: from 2004Da24. Not reported in 2005Ga36.
4080.6 *40*	530.22	0.0174 *3*	41.8 *8*	Eα: from 2005Ga36. Eα=4077 is stated by 2004Da24 as absent in the spectrum. Other: 4069 *10* (1966Ga03) with no Iα. Iα: from γ-ray transition intensity balance. Other: 0.016 *12* from α decay measurement (2005Ga36).
4152.5 *28*	452.189	0.297 *18*	11.5 *7*	Eα: unweighted average of 4153.0 keV *26* (2005Ga36) and 4152 keV *5* (2004Da24). Others: 4145 *6* (1975Va11), 4140 *3* (1966Ga03), ≈4149 (1964Sc27), 4153 (1962Pi06). Iα: weighted average of 0.286% *18* (2005Ga36) and 0.31% *2* (2004Da24). Others: 0.9 *2* (1975Va11), 1.0 (1966Ga03), ≈0.2 (1964Sc27), ≈0.3 (1962Pi06).
4216.0 *10*	387.824	6.10 *19*	1.94 *7*	Eα: unweighted average of 4216.2 keV *19* (2005Ga36) and 4215.8 keV *5* (2004Da24). 1991Ry01 evaluation recommended 4214.7 *19*. Others: 4209 *4* (1975Va11), 4210 *3* (1966Ga03), 4170 *20* (1965Wh05), 4211 *5* (1964Sc27), 4211 (1962Pi06), 4215 *5* (1961Ko11), 4211 *3* (1960Vo07), 4214 *4* (1960Ba44), 4200 (1951Gh22).

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^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

α radiations (continued)

Eα[†]	E(level)	Iα[†@]	HF[‡]	Comments
				Iα: unweighted average of 5.91% *7* (2005Ga36) and 6.28% *11* (2004Da24). Others: 5.7 *6* (1975Va11), 6.2 (1966Ga03), 5.0 *3* (1965Wh05), 6.0 (1964Sc27), 5.5 (1962Pi06), 4 (1961Ko11), 7 (1960Vo07), 5.5 (1960Ba44), 4.2 (1951Gh22).
4212	385.68?	0.0131[#] *2*	943 *16*	
4219 *6*	377.562	0.123 *6*	117 *6*	Eα: from 1975Va11. Iα: ≈0.9 from α decay, ≈0.11 from the decay scheme (1975Va11).
4248 *5*	355	0.07 *1*	320 *50*	Eα,Iα: from 2004Da24. Not reported in 2005Ga36. Other: 4240 *10* with Iα<0.5 (1966Ga03).
4266.2 *25*	331	0.230 *30*	150 *20*	Eα: weighted average of 4266.2 keV *25* (2005Ga36) and 4266 keV *5* (2004Da24). Others: 4267 *10* (1966Ga03), 4261 (1962Pi06). Iα: unweighted average of 0.200% *16* (2005Ga36) and 0.26% *2* (2004Da24). Others: <0.3 (1966Ga03), 0.4 (1964Sc27), 0.6 (1962Pi06).
4273	324.911	0.033[#] *4*	1.2×10^{3} *2*	
4282.6 *28*	317.0790	0.11 *4*	4.1×10^{2} *15*	Eα: unweighted average of 4283.2 keV *27* (2005Ga36) and 4282 keV *5* (2004Da24). Others: 4282 (1975Va11, tentative), 4289 *10* (1966Ga03). Iα: weighted average of 0.066% *13* (2005Ga36) and 0.14% *1* (2004Da24). Others: <0.5 (1966Ga03).
4296[&]	301.70?	0.00915[#] *11*	6.6×10^{3} *1*	Eα=≈4295 (tentative) value with no Iα (1975Va11).
4323.2 *10*	277.60	3.58 *20*	26 *2*	Eα: unweighted average of 4323.5 keV *20* (2005Ga36) and 4322.9 keV *6* (2004Da24). Others: 4322 *4* (1975Va11), 4319 *3* (1966Ga03), 4300 *20* (1965Wh05), 4318 *5* (1964Sc27), 4320 (1962Pi06), 4320 (1960Ba44). Iα: unweighted average of 3.37% *6* (2005Ga36) and 3.78% *8* (2004Da24). Others: 4.7 *5* (1975Va11), 3.5 (1966Ga03), 4.6 *8* (1965Wh05), 4.2 (1964Sc27), 2.9 (1962Pi06), 3 (1960Ba44). Iα: measured group intensity to 275-, 278-keV levels: Iα=4.6 *5*. I(γ+ce) balance at the 277.6 level shows a much larger feeding of ≈16% as compared to expected feeding of 3.58 *20* from Iα(4323α). Either there are missing γ-rays feeding this level or the measured Iα value is too low.
4323	275.423	0.167[#] *13*	58×10^{1} *5*	
4357	240.8785	0.21[#] *13*	8.7×10^{2} *54*	
4364.6 *8*	236.893	18.94 *13*	10.4 *1*	Eα: unweighted average of 4364.9 keV *16* (2005Ga36) and 4364.3 keV *4* (2004Da24). 1991Ry01 evaluation recommended 4366.1 *20*. Others: 4358 *4* (1975Va11), 4362 *5* (1966Ga03), 4340 *20* (1965Wh05), 4359 *5* (1964Sc27), 4361 (1962Pi06), 4368 (1960Ba44). Iα: weighted average of 19.00% *13* (2005Ga36) and 18.80% *20* (2004Da24). Others: 17 *2* (1975Va11), 12.3 (1966Ga03), 11.3 *20* (1965Wh05), 17.3 (1964Sc27), 19 (1962Pi06), 11 (1960Ba44).
4377	221.392	0.35[#] *19*	7.4×10^{2} *41*	
4395.7 *7*	205.3098	57.79 *36*	6.02 *6*	Eα: unweighted average of 4396.0 keV *13* (2005Ga36) and 4395.3 keV *4* (2004Da24). 1991Ry01 evaluation recommended 4397.8 *13*. Others: 4392 *3* (1975Va11), 4394 *3* (1966Ga03), 4370 *20* (1965Wh05), 4389 *5* (1964Sc27), 4391 (1962Pi06), 4394 *5* (1961Ko11), 4394 *3* (1960Vo07), 4394 *4* (1960Ba44), 4400 (1951Gh22). Iα: weighted average of 57.98% *22* (2005Ga36) and 57.11% *41* (2004Da24). Others: 54 *3* (1975Va11), 53.0 *13* (1966Ga03), 49 *3* (1965Wh05), 57.7 (1964Sc27), 58 (1962Pi06), 74 (1961Ko11), 84 (1960Vo07), 62 (1960Ba44), 85.6 (1951Gh22).
4415.1 *8*	185.7143	3.09 *6*	160 *4*	Eα: unweighted average of 4415.3 keV *15* (2005Ga36) and 4414.9 keV *5* (2004Da24). Others: 4411 *5* (1975Va11), 4411 *5* (1966Ga03), ≈4407 (1964Sc27), 4414 ? (1962Pi06), 4412 *4* (1960Ba44).

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^{235}U α decay (7.04×10^8 y) 2005Ga36,2018Ma03,1975Va11 (continued)

α radiations (continued)

Eα†	E(level)	Iα†@	HF‡	Comments
				Iα: weighted average of 3.11% *6* (2005Ga36) and 3.07% *7* (2004Da24). Others: 2.1 *2* (1975Va11), 2.3 (1966Ga03), ≈3 (1964Sc27), ≈4 ? (1962Pi06), 2 (1960Ba44).
4438.3 *22*	162.13	0.245 *26*	3.1×10^3 *3*	Eα: unweighted average of 4438.7 keV *20* (2005Ga36) and 4437.9 keV *40* (2004Da24). Others: 4435 *5* (1975Va11), 4438 *3* (1966Ga03) 4440 *40* (1965Wh05), 4440 ? (1962Pi06), 4438 *4* (1960Ba44). Iα: unweighted average of 0.219% *16* (2005Ga36) and 0.27% *2* (2004Da24). Others: ≈0.7 (1975Va11), 2.1 (1966Ga03), 1.5 *8* (1965Wh05), ≈0.6 (1962Pi06), 3 (1960Ba44).
4502.9 *11*	96.126	1.28 *4*	185×10^1 *6*	Eα: unweighted average of 4503.3 keV *20* (2005Ga36) and 4502.4 keV *7* (2004Da24). Others: 4501 *4* (1975Va11), 4496 *3* (1966Ga03), 4495 *5* (1964Sc27), 4497 (1962Pi06), 4496 *4* (1960Ba44). Iα: weighted average of 1.25% *4* (2005Ga36) and 1.32% *5* (2004Da24). Others: 1.7 *2* (1975Va11), 1.4 (1966Ga03), 1.4 (1964Sc27), 1.2 (1962Pi06), 1 (1960Ba44).
4556.5 *9*	41.9509	3.82 *6*	157×10^1 *3*	Eα: unweighted average of 4556.9 keV *17* (2005Ga36) and 4556.0 keV *4* (2004Da24). Others: 4555 *3* (1975Va11), 4550 *3* (1966Ga03), 4530 *20* (1965Wh05), 4550 *5* (1964Sc27), 4551 (1962Pi06), 4545 *10* (1961Ko11), 4558 *3* (1960Vo07), 4550 *4* (1960Ba44). Iα: weighted average of 3.87% *6* (2005Ga36) and 3.74% *8* (2004Da24). Others: 4.5% *5* (1975Va11), 1.7 (1966Ga03), 3.7 *5* (1965Wh05), 4.1 (1964Sc27), 3.7 (1962Pi06), 4 (1961Ko11), 2.5 (1960Vo07), 3 (1960Ba44).
4597.7 *7*	0.0	4.77 *7*	255×10^1 *4*	Eα: unweighted average of 4598.0 keV *13* (2005Ga36) and 4597.3 keV *4* (2004Da24). 1991Ry01 evaluation recommended 4596.4 *13*. Others: 4597 *3* (1975Va11), 4592 *3* (1966Ga03), 4590 *20* (1965Wh05), 4590 *5* (1964Sc27), 4592 (1962Pi06), 4580 *15* (1961Ko11), 4598 *3* (1960Vo07), 4592 (1960Ba44), 4580 (1951Gh22). Iα: weighted average of 4.74% *7* (2005Ga36) and 4.84% *9* (2004Da24). Others: 5.4 *5* (1975Va11), 1.2 (1966Ga03), 3.9 *5* (1965Wh05), 5.7 (1964Sc27), 4.7 (1962Pi06), 4 (1961Ko11), 6.5 (1960Vo07), <1 (1960Ba44), 10.2 (1951Gh22).

† Weighted average of values from 2005Ga36 and 2004Da24, unless otherwise specified. Other measurements: 1975Va11, 1966Ga03, 1962Pi06, 1960Ba44. Evaluation of four Eα values: 1991Ry01. For α intensities, evaluators have included the effect of normalizing the total alpha decay emission probability to 100% in the uncertainties of the individual alpha-particle emission probabilities.

‡ The nuclear radius parameter $r_0(^{231}Th)=1.52410$ *58* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides evaluated in 2020Si16.

From γ-ray transition intensity balance.

@ Absolute intensity per 100 decays.

& Existence of this branch is questionable.

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$

Iγ normalization, I(γ+ce) normalization: From %Iγ(185.7γ)=57.2% *6*, weighted average of nine independent measurements. See %Iγ comment for 185.7γ for details.
Measured intensities of x rays (2017Le03), absolute intensities are per 100 decays of ^{235}U, and relative intensities are with respect to Iγ=100.0 *12* for the 185.72-keV ground-state transition:
I(Th L_l x-rays)=0.599 *15* (absolute), 1.039 *26* (relative) (2017Le03).
I(Th L_α x-rays)=20.26 *44* (absolute), 35.2 *8* (relative) (2017Le03).
I(Th L_β x-rays)=17.42 *38* (absolute), 30.2 *6* (relative) (2017Le03).
I(Th L_γ x-rays)=2.43 *5* (absolute), 4.22 *9* (relative) (2017Le03).
I(Th total L x-rays)=40.7 *10* (absolute), 70.7 *17* (relative) (2017Le03).
I(Th $K_{\alpha2}$ x-rays)=3.73 *19* (absolute), 6.48 *35* (relative) (2017Le03).
I(Th $K_{\alpha1}$ x-rays)=4.62 *24* (absolute), 8.03 *43* (relative) (2017Le03).
I(Th $K_{\beta'1}$ x-rays)=1.46 *8* (absolute), 2.63 *14* (relative) (2017Le03).
I(Th $K_{\beta'2}$ x-rays)=0.431 *22* (absolute), 0.748 *40* (relative) (2017Le03).
Measured energies and absolute intensities of x rays (1996Ru11):
I(Th, $K_{\alpha1}$): E(x ray)=93.35, I(x ray)=5.56% *14*.
I(Th, $K_{\beta1}$): E(x ray)=105.6, I(x ray)=1.17% *5*.
Measured energies and absolute intensities of x rays (1975Va11):
I(Th, L_3,M_1): E(x ray)=11.118 *10*, I(x ray)=1.65% *45*.
I(Th, L_3,$M_{4,5}$): E(x ray)=12.994 *25*, I(x ray)=37.6% *42*.
I(Th, L_2,M_1): E(x ray)=14.519 *11*, I(x ray)=1.41% *27*.
I(Th, L_3,N_1)+I(Pa, L_2,M_1): E(x ray)=14.993 *30*, I(x ray)=1.10% *21*.
I(Th, L_1,M_2+L_3,N_5): E(x ray)=15.624 *20*, I(x ray)=12.7% *13*.
I(Th, L_2,M_4): E(x ray)=16.193 *10*, I(x ray)=68.1% *69*.
I(Th, L_2,N_1): E(x ray)=18.336 *30*, I(x ray)=0.46% *9*.
I(Th, L_2,N_4): E(x ray)=18.978 *5*, I(x ray)=10.6% *11*.
I(Th, L_2,O_4)+I(Pa, L_2,N_4): E(x ray)=19.580 *27*, I(x ray)=4.24% *45*.
Other: L- and M- x-rays: 1990Po14.
I(K x-rays)=11.8% *2*, deduced by evaluators from decay scheme using RADLST code.
The $\gamma\gamma$-coin measurements have been made by 1999Yu01, 1975Va11, 1974Te03 and 1966Ga03.
The $\alpha\gamma$-coin measurements have been made by 1999Yu01, 1975Va11 and 1966Ga03.
Most of the unplaced γ rays are considered as uncertain assignment to the decay of ^{235}U.
In 2010BeZQ (also 2009Hu07) DDEP evaluation, there is no confirming evidence from ^{235}U decay for the following γ rays and their placements: 97 *4* from 334 level; 255.365 *10*, 310.69 *6* and 350 *5* from 351.565 level; 397.27 *20* from 595.58 level, thus omitted in the present evaluation.

$^{231}_{90}Th_{141}$-6

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡][f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	$I_{(\gamma+ce)}$[f]	Comments
19.55 *5*		205.3098	(7/2$^-$)	185.7143	5/2$^-$	[M1]	114.7 *19*	118 *6*	%Iγ=0.583 *11* ce(L)/(γ+ce)=0.0196 *5*; ce(M)/(γ+ce)=0.723 *9* ce(N)/(γ+ce)=0.193 *4*; ce(O)/(γ+ce)=0.0457 *10*; ce(P)/(γ+ce)=0.00888 *20*; ce(Q)/(γ+ce)=0.000848 *19* α(L)=2.26 *4*; α(M)=83.7 *14* α(N)=22.3 *4*; α(O)=5.29 *9*; α(P)=1.027 *17*; α(Q)=0.0982 *16* E_γ: from 1977Ba72. Other: 19.59 (1975Va11, in coincidence data). $I_{(\gamma+ce)}$: from γ-ray transition intensity balance at 185, 205 levels. Other value of 90% *6* in 1999Yu01, and I(γ+ce)(19.6)/I(γ+ce)(205)=17.2, giving relative I(γ+ce)=165, inconsistent with transition intensity balance of 132 *3*.
31.60 *5*	0.08[b] *3*	236.893	9/2$^-$	205.3098	(7/2$^-$)	[M1]	110.7 *16*		%Iγ=0.046 *17* α(L)=83.6; α(M)=20.2 α(N)=5.4; α(O)=1.27; α(P)=0.25; α(Q)=0.024 Mult.: E2 admixture is possible but less likely as it would imply intensity balance issues at the 236.9 level. E_γ: weighted average of 31.60 *5* (1977Ba72), 31.59 *14* (1975Va11), 31.50 *20* (1974Te03), 31.6 *1* (1971KrZH). I_γ: 0.08 *3* from unweighted average of 0.138 *16* (2018Ma03), 0.074 *9* (1975Va11), and 0.03 *1* (1974Te03). Other: 0.080 (1977Ba72). Note a large difference between different measurements. Measured %Iγ=0.079 *9* (2018Ma03).
34.7[h] *1*	0.065	275.423	7/2$^+$	240.8785	5/2$^+$	[M1]	83.9 *14*		%Iγ=0.037 α(L)=63.4 *11*; α(M)=15.3 *3* α(N)=4.08 *7*; α(O)=0.966 *16*; α(P)=0.188 *3*; α(Q)=0.0179 *3* E_γ,I_γ: from 1977Ba72, tentative placement.
41.1		277.60	(11/2$^-$)	236.893	9/2$^-$	[M1]	51.0 *7*		α(L)=38.5 *6*; α(M)=9.28 *13* α(N)=2.48 *4*; α(O)=0.586 *9*; α(P)=0.1138 *16*; α(Q)=0.01086 *16* E_γ: from coincidence data in 1975Va11. I_γ: intensity balance issues at 277.6 level do not permit estimating intensity of 41.1-keV γ ray. It is probably a weak γ transition. α: for assumed uncertainty of 0.2 keV.

$^{231}_{90}Th_{141}$-7

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	δ[d]	α[g]	$I_{(\gamma+ce)}$[f]	Comments
42.02 *10*	0.119 *14*	41.9509	$7/2^+$	0.0	$5/2^+$	M1+E2	0.95 *10*	3.7×10^2 *4*	44.9 *8*	%Iγ=0.069 *7* ce(L)/(γ+ce)=0.73 *6*; ce(M)/(γ+ce)=0.20 *3* ce(N)/(γ+ce)=0.053 *8*; ce(O)/(γ+ce)=0.0118 *17*; ce(P)/(γ+ce)=0.0020 *3*; ce(Q)/(γ+ce)=1.91×10^{-5} *23* α(L)=2.7×10^2 *3*; α(M)=73 *8* α(N)=19.4 *21*; α(O)=4.3 *5*; α(P)=0.72 *8*; α(Q)=0.0070 *4* E_γ: weighted average of 41.95 *10* (1977Ba72), 42.1 *1* (1975Va11), 41.96 *15* (1974Te03), 42.1 *2* (1971KrZH). Other: 41.96 (1983Ba77). I_γ: weighted average of 0.122 *14* (2018Ma03), 0.105 *18* (1983Ba77). Others: 0.07 *3* (1974Te03), 111 (1977Ba72), 0.030 (1975Va11), ≈0.093 (1971KrZH). Measured %Iγ=0.070 *8* (2018Ma03), 0.06 *1* (1983Ba77). $I_{(\gamma+ce)}$: From γ-ray transition intensity balance and Iα feeding the 42 level. Mult.,δ: From I(γ+ce) and Iγ.
51.21 *5*	0.059[b] *13*	236.893	$9/2^-$	185.7143	$5/2^-$	[E2]		274 *4*		%Iγ=0.034 *7* α(L)=201 *3*; α(M)=54.9 *9* α(N)=14.70 *22*; α(O)=3.27 *5*; α(P)=0.539 *8*; α(Q)=0.001465 *22* E_γ: weighted average of 51.20 *5* (1977Ba72), 51.7 *4* (1975Va11), 51.20 *10* (1974Te03). Other: 51.2 (1971KrZH). I_γ: from 1975Va11. Others: 0.019 *9* (2018Ma03), 0.029 (1977Ba72), 0.007 *3* (1974Te03). Value from 1975Va11 is preferred as it gives a better intensity balance at the 236.9 level. Measured %Iγ=0.010 *5* (2018Ma03).
54.1[h] *1*	<0.002	275.423	$7/2^+$	221.392	$3/2^+$	[E2]		210 *4*		%Iγ<0.0011 α(L)=154 *3*; α(M)=42.1 *7* α(N)=11.27 *19*; α(O)=2.51 *5*; α(P)=0.413 *7*; α(Q)=0.001153 *19* E_γ: from 1977Ba72. Other: 54.1 (1975Va11, in coincidence data, however, authors placed this γ from 96-keV level). I_γ: from γ-ray transition intensity balance at 221.4 level. Other: 0.052 for 54.1+54.25 (1977Ba72).
54.25 *5*	0.028[b] *9*	96.126	$9/2^+$	41.9509	$7/2^+$	M1+E2	0.85 *25*	1.00×10^2 *29*		%Iγ=0.016 *5*

$^{231}_{90}Th_{141}$-8

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [d]	δ [d]	α [g]	$I_{(\gamma+ce)}$ [f]	Comments
										ce(L)/(γ+ce)=0.73 *16*; ce(M)/(γ+ce)=0.196 *72* ce(N)/(γ+ce)=0.052 *21*; ce(O)/(γ+ce)=0.0118 *48*; ce(P)/(γ+ce)=0.00198 *79*; ce(Q)/(γ+ce)=3.2×10^{-5} *11* α(L)=74 *21*; α(M)=19.8 *58* α(N)=5.3 *16*; α(O)=1.19 *35*; α(P)=0.200 *56*; α(Q)=0.0033 *6* E_γ: From 1977Ba72. Other: 54.1 (1975Va11, in coincidence data, see also possible placement from 275 level). I_γ: 0.028 *9* (2018Ma03). Other: 0.052 for 54.25+54.1 (1977Ba72). Measured %Iγ=0.016 *5* (2018Ma03).
64.45 *5*		452.189	9/2$^-$	387.824	7/2$^-$	[M1+E2]		52 *39*	0.16 *5*	%Iγ=0.0017 *14* ce(L)/(γ+ce)=0.72 *39*; ce(M)/(γ+ce)=0.19 *19* ce(N)/(γ+ce)=0.052 *54*; ce(O)/(γ+ce)=0.012 *12*; ce(P)/(γ+ce)=0.0020 *20*; ce(Q)/(γ+ce)=3.2×10^{-5} *33* α(L)=38 *28*; α(M)=10.3 *79* α(N)=2.8 *21*; α(O)=0.62 *47*; α(P)=0.104 *74*; α(Q)=0.0017 *12* E_γ,I_γ: from 1977Ba72. $I_{(\gamma+ce)}$: deduced from γ-ray transition intensity balance. Other: Iγ=0.031 (1977Ba72).
72.7 *2*	0.54 *6*	277.60	(11/2$^-$)	205.3098	(7/2$^-$)	[E2]		50.8 *10*		%Iγ=0.309 *34* α(L)=37.1 *8*; α(M)=10.20 *20* α(N)=2.73 *6*; α(O)=0.608 *12*; α(P)=0.1005 *20*; α(Q)=0.000333 *6* E_γ: from coincidence data in 1975Va11. Others: 72.74 (1983Ba77). I_γ: unweighted average of 0.481 *32* (2018Ma03), 0.591 *32* (2017Le03). Others: 0.89 *9* (1983Ba77, seems too large); 0.20 (1975Va11, seems too low). Weighted average is the same, but reduced χ^2=5.9 is high. Note that, based on intensity balance at the 277.6 level, assuming negligible intensity for 41.1 transition, the measured photon intensity is much too large by a factor of ≈4 with the expected relative intensity of 0.14. Measured %Iγ=0.275 *18* (2018Ma03), 0.341 *18* (2017Le03), 0.51 *5* (1983Ba77).
[x]73.72[#] *5*	0.018[#]									%Iγ=0.0103

$^{231}_{90}Th_{141}$-9

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [d]	α [g]	Comments
74.94 *4*	0.128 [b] *23*	236.893	9/2$^-$	162.13	11/2$^+$	[E1]	0.252 *4*	%Iγ=0.073 *13* α(L)=0.190 *3*; α(M)=0.0464 *7* α(N)=0.01216 *18*; α(O)=0.00274 *4*; α(P)=0.000471 *7*; α(Q)=2.46×10^{-5} *4* E_γ: weighted average of 75.02 *5* (1975Va11), 74.76 *20* (1974Te03), 74.92 *3* (1974HeYW). Others: 74.56 *5* (1977Ba72, unresolved doublet); 74.91 (1983Ba77). I_γ: 0.128 *23* (2018Ma03). Others: 0.222 *12* (2017Le03), 0.89 *9* (1983Ba77), 0.103 for 74.56+74.25 (1977Ba72), 0.13 (1975Va11), 0.09 *1* (1974Te03), 0.25 *8* (1974HeYW). Values in 2017Le03 and 1983Ba77 are precise but seem too high. Measured %Iγ=0.073 *13* (2018Ma03), 0.128 *7* (2017Le03), 0.51 *5* (1983Ba77). Values from 2017Le03 and 1983Ba77 seem too high.
(76.198 [e] *4*)	0.0081	317.0790	5/2$^+$	240.8785	5/2$^+$	[M1+E2]	24 *17*	%Iγ=0.0046 α(L)=18 *12*; α(M)=4.8 *34* α(N)=1.29 *89*; α(O)=0.29 *20*; α(P)=0.050 *31*; α(Q)=1.02×10^{-3} *75* E_γ,I_γ: from (n,γ) (1987Wh01), intensity from Iγ(76.198)/Iγ(317.063) in (n,γ).
95.7		317.0790	5/2$^+$	221.392	3/2$^+$			E_γ: from coincidence data in 1975Va11; not seen in (n,γ) (1987Wh01).
96.09 *2*	0.222 [c] *12*	96.126	9/2$^+$	0.0	5/2$^+$	[E2]	13.58 *19*	%Iγ=0.127 *7* α(L)=9.93 *14*; α(M)=2.73 *4* α(N)=0.731 *11*; α(O)=0.1629 *23*; α(P)=0.0270 *4*; α(Q)=0.0001141 *16* E_γ: from 1974Te03. Others: 96.2 (1977Ba72), 96.1 (1975Va11, in $\alpha\gamma$-coin). I_γ: 0.222 *12* (2017Le03). Other: 0.16 *2* (1974Te03). Measured %Iγ=0.128 *7* (2017Le03).
109.176 *31*	2.86 *11*	205.3098	(7/2$^-$)	96.126	9/2$^+$	[E1]	0.0932 *13*	%Iγ=1.64 *7* α(L)=0.0704 *10*; α(M)=0.01709 *24* α(N)=0.00450 *7*; α(O)=0.001023 *15*; α(P)=0.000182 *3*; α(Q)=1.077×10^{-5} *15* E_γ: LWM weighted average of 109.25 *5* (1977Ba72), 109.25 *5* (1975Va11), 109.145 *10* (1974Te03), 109.12 *5* (1974HeYW). Regular weighted average is 109.152 *16*, with reduced χ^2=2.86 as compared to critical χ^2=2.6 at 95% confidence level. Other: 109.17 (1983Ba77). I_γ: weighted average: 3.18 *30* (2018Ma03), 2.74 *15* (2017Le03), 3.15

$^{231}_{90}Th_{141}$-10

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
								11 (1996Ru11), 3.82 *30* (1992Li05), 2.67 *9* (1983Ba77), 2.59 *37* (1975Va11), 3.1 *3* (1974Te03), 2.77 *40* (1974HeYW). Others: 3.82 *30* (1992Li05) seems high and 1.799 (1977Ba72) seems low. Including the value from 1992Li05 gives weighted average of 2.89 *11*, but with reduced χ^2=3.5 compared to critical χ^2=2.0 at 95% confidence level. Other: 1.799 (1977Ba72). Measured %Iγ=1.82 *17* (2018Ma03, power moderated mean (PMM) of 1.59 *7*, 1.84 *30* and 2.09 *16*), 1.58 *8* (2017Le03), 1.80 *6* (1996Ru11), 2.17 *17* (1992Li05), 1.53 *5* (1983Ba77).
115.45 *5*	0.0442 *5*	277.60	(11/2$^-$)	162.13	11/2$^+$	[E1]	0.348 *5*	%Iγ=0.0253 *4* α(K)=0.267 *4*; α(L)=0.0609 *9*; α(M)=0.01475 *21* α(N)=0.00388 *6*; α(O)=0.000885 *13*; α(P)=0.0001577 *23*; α(Q)=9.52×10^{-6} *14* E_γ: weighted average of 115.45 *5* (1977Ba72), 115.5 *2* (1975Va11), 115.2 *5* (1974HeYW). I_γ: weighted average of 0.0442 *5* (2017Le03), 0.057 *20* (1975Va11). Others: 0.21 *5* (1974HeYW, seems too high), 0.030 (1977Ba72). Measured %Iγ=0.0255 *3* (2017Le03).
120.35 *5*	0.038[b] *17*	162.13	11/2$^+$	41.9509	7/2$^+$	[E2]	5.04 *7*	%Iγ=0.022 *10* α(K)=0.256 *4*; α(L)=3.50 *5*; α(M)=0.960 *14* α(N)=0.257 *4*; α(O)=0.0574 *9*; α(P)=0.00956 *14*; α(Q)=5.28×10^{-5} *8* E_γ: from 1977Ba72. Other: 120.0 (1975Va11, in coincidence data). I_γ: 0.038 *17* (2018Ma03). Other: 0.045 (1977Ba72). Measured %Iγ=0.022 *10* (2018Ma03).
136.55 *5*	0.0447[c] *27*	377.562	(7/2)$^+$	240.8785	5/2$^+$	[M1+E2]	5.3 *24*	%Iγ=0.0256 *16* α(K)=3.2 *30*; α(L)=1.57 *40*; α(M)=0.41 *13* α(N)=0.110 *35*; α(O)=0.0250 *73*; α(P)=0.0044 *10*; α(Q)=1.8×10^{-4} *15* E_γ: from 1977Ba72. Other: 136.6 (1975Va11, in coincidence data). I_γ: 0.0447 *27* (2017Le03). Other: 0.020 (1977Ba72). Measured %Iγ=0.0258 *15* (2017Le03).
140.759 *20*	0.369 *25*	236.893	9/2$^-$	96.126	9/2$^+$	[E1]	0.218 *3*	%Iγ=0.211 *14* α(K)=0.1696 *24*; α(L)=0.0364 *5*; α(M)=0.00879 *13* α(N)=0.00232 *4*; α(O)=0.000531 *8*; α(P)=9.58×10^{-5} *14*; α(Q)=6.13×10^{-6} *9* E_γ: weighted average of 140.75 *5* (1977Ba72), 140.80 *8* (1975Va11), 140.758 *20* (1974Te03), 140.75 *10* (1974HeYW). Other: 140.75 (1983Ba77). I_γ: unweighted average of 0.392 *25* (2018Ma03), 0.287 *22* (2017Le03),

$^{231}_{90}Th_{141}$-11

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡][f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
								0.373 *26* (1983Ba77), 0.39 *6* (1975Va11), 0.46 *5* (1974Te03), 0.31 *3* (1974HeYW). Weighted average is 0.347 *23*, but with reduced χ^2=3.76 as compared to critical χ^2=2.2 at 95% confidence level. Other: 0.300 (1977Ba72). Measured %Iγ=0.224 *14* (2018Ma03), 0.165 *13* (2017Le03), 0.214 *15* (1983Ba77).
142.40 *5*	0.009	530.22	(11/2$^-$)	387.824	7/2$^-$	[E2]	2.48 *4*	%Iγ=0.005 α(K)=0.253 *4*; α(L)=1.627 *23*; α(M)=0.446 *7* α(N)=0.1196 *17*; α(O)=0.0267 *4*; α(P)=0.00447 *7*; α(Q)=3.14×10^{-5} *5* E_γ,I_γ: from 1977Ba72 only.
143.765 *2*	19.11 *14*	185.7143	5/2$^-$	41.9509	7/2$^+$	E1	0.207 *3*	%Iγ=10.93 *14* α(K)=0.1615 *23*; α(L)=0.0344 *5*; α(M)=0.00833 *12* α(N)=0.00220 *3*; α(O)=0.000503 *7*; α(P)=9.08×10^{-5} *13*; α(Q)=5.84×10^{-6} *9* E_γ: weighted average of Eγ=143.768 *3* (1984He12, 143.78 *2* in 1974HeYW from the same lab); 143.75 *5* (1977Ba72); 143.77 *2* (1975Va11); 143.753 *8* (1974Te03); 143.764 *2* (1987Wh01, (n,γ), curved-crystal). Other: 143.76 (1983Ba77). I_γ: weighted average of 19.00 *28* (2018Ma03), 18.80 *24* (2017Le03), 19.06 *35* (1996Ru11), 19.3 *11* (1992Li05), 19.25 *14* (1984He12, 18.0 *9* in 1974HeYW), 19.50 *27* (1983Ol01), 18.67 *35* (1983Ba77), 18.96 *35* (1982Va04), 19.4 *20* (1975Va11), 19.6 *20* (1974Te03) Others: 17.37 (1977Ba72); I(γ+ce)(144)/I(γ+ce)(186)=0.202 (1999Yu01). Measured %Iγ=10.87 *16* (2018Ma03, power moderated mean (PMM) of 11.0 *4*, 10.64 *26*, 10.9 *4* and 10.92 *13*), 10.83 *14* (2017Le03), 10.9 *2* (1996Ru11), 10.99 *61* (1992Li05), 11.01 *8* (1984He12), 10.93 *15* (1983Ol01), 10.7 *2* (1983Ba77), 10.9 *2* (1982Va04). Other: 13.39 *6* (2006Al28) is discrepant due to contribution from other activities.
147.0[h]		387.824	7/2$^-$	240.8785	5/2$^+$			E_γ: tentative γ from coincidence data (1975Va11).
150.937 *20*	0.128 *16*	387.824	7/2$^-$	236.893	9/2$^-$	[M1+E2]	3.9 *19*	%Iγ=0.073 *9* α(K)=2.4 *22*; α(L)=1.07 *19*; α(M)=0.28 *7* α(N)=0.074 *18*; α(O)=0.017 *4*; α(P)=0.0030 *5*; α(Q)=1.4×10^{-4} *11* E_γ: weighted average of 150.85 *5* (1977Ba72), 150.94 *3* (1975Va11), 150.939 *20* (1974Te03), 150.96 *3* (1974HeYW). Other: 150.95 (1983Ba77). I_γ: weighted average of 0.135 *16* (2018Ma03), 0.084 *23* (2017Le03), 0.115 *17* (1983Ba77), 0.141 *19* (1975Va11), 0.14 *2* (1974Te03), 0.20 *5*

$^{231}_{90}Th_{141}$-12

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	δ[d]	α[g]	Comments
									(1974HeYW). Other: 0.129 (1977Ba72). Measured %Iγ=0.076 *9* (2018Ma03), 0.048 *13* (2017Le03), 0.066 *10* (1983Ba77).
163.357 *2*	8.87 *7*	205.3098	(7/2$^-$)	41.9509	7/2$^+$	(E1)		0.1525 *22*	%Iγ=5.07 *7* α(K)=0.1197 *17*; α(L)=0.0248 *4*; α(M)=0.00599 *9* α(N)=0.001581 *23*; α(O)=0.000364 *5*; α(P)=6.61×10^{-5} *10*; α(Q)=4.40×10^{-6} *7* E_γ: weighted average of 163.357 *3* (1984He12, 163.363 *10* in 1974HeYW from the same lab); 163.25 *5* (1977Ba72); 163.36 *2* (1975Va11); 163.349 *9* (1974Te03); 163.358 *2* (1987Wh01, (n,γ), curved-crystal). Other: 163.35 (1983Ba77). I_γ: weighted average of 8.99 *14* (2018Ma03), 8.57 *12* (2017Le03), 8.90 *9* (1996Ru11), 8.77 *21* (1992Li05), 8.95 *7* (1984He12, 8.52 *55* in 1974HeYW), 9.04 *14* (1983Ol01), 8.67 *17* (1983Ba77), 8.70 *17* (1982Va04), 8.9 *9* (1975Va11), 8.74 *90* (1974Te03). Other: 7.28 (1977Ba72). Measured %Iγ=5.14 *8* (2018Ma03, power moderated mean (PMM) of 5.20 *19*, 5.15 *13*, 5.13 *25* and 5.11 *7*), 4.94 *7* (2017Le03), 5.09 *5* (1996Ru11), 4.98 *12* (1992Li05), 5.12 *4* (1984He12), 5.07 *8* (1983Ol01), 4.97 *10* (1983Ba77), 5.0 *1* (1982Va04). Other: 6.75 *3* (2006Al28) is discrepant due to contribution from other activities.
173.0 *10*	0.020 *9*	377.562	(7/2)$^+$	205.3098	(7/2$^-$)	[E1]		0.1323 *19*	%Iγ=0.011 *5* α(K)=0.1041 *15*; α(L)=0.0213 *3*; α(M)=0.00515 *8* α(N)=0.001359 *20*; α(O)=0.000313 *5*; α(P)=5.70×10^{-5} *8*; α(Q)=3.86×10^{-6} *6* E_γ: from 1975Va11. Other: 173.4 *1* (1974HeYW), where uncertainty appears underestimated, as with 0.1 keV uncertainty, the fit is poor as indicated by large χ^2 in the least-squares fitting procedure. E_γ: weighted average of 173.0 *10* (1975Va11), 173.4 *1* (1974HeYW). I_γ: weighted average of 0.011 *9* (1975Va11), 0.03 *1* (1974HeYW).
[x]175.70[#&] *5* (179.297[e] *2*)	0.132[#] 0.022 *5*	275.423	7/2$^+$	96.126	9/2$^+$	M1(+E2)	0.25 *25*	3.4 *4*	%Iγ=0.076 %Iγ=0.0126 *29* α(K)=2.7 *4*; α(L)=0.540 *11*; α(M)=0.131 *5* α(N)=0.0350 *13*; α(O)=0.00825 *24*; α(P)=0.001585 *23*; α(Q)=0.000142 *19* E_γ,I_γ: from (n,γ) (1987Wh01), intensity from Iγ(179)/Iγ(233)=0.40 *8* in (n,γ).

$^{231}_{90}Th_{141}$-13

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
182.1[h]		277.60	(11/2$^-$)	96.126	9/2$^+$			E_γ: tentative γ, probably very weak, from coincidence data (1975Va11).
182.504 *10*	0.719 *25*	387.824	7/2$^-$	205.3098	(7/2$^-$)	[M1+E2]	2.1 *13*	%Iγ=0.411 *15* α(K)=1.4 *13*; α(L)=0.527 *18*; α(M)=0.136 *13* α(N)=0.036 *4*; α(O)=0.0083 *6*; α(P)=0.001503 *22*; α(Q)=7.9×10^{-5} *64* E_γ: weighted average of 182.60 *5* (1977Ba72), 182.7 *2* (1975Va11), 182.65 *15* (1974Te03), 182.72 *20* (1974HeYW), 182.500 *8* (1987Wh01, (n,γ), curved crystal). Other: 182.57 (1983Ba77). I_γ: unweighted average of 0.68 *7* (2018Ma03), 0.750 *25* (2017Le03), 0.75 *9* (1996Ru11), 0.592 *30* (1983Ba77), 0.78 *17* (1975Va11), 0.74 *25* (1974Te03), 0.74 *7* (1974HeYW). Weighted average is 0.69 *3*, but reduced χ^2=2.95 is larger than critical χ^2=2.10. Others: 1.41 *18* in 1992Li05 is too high; 0.546 (1977Ba72); I(γ+ce)(183)/I(γ+ce)(202)=0.28 *4*, as stated in text of 1999Yu01, which disagrees with 0.45 from several other measurements. Measured %Iγ=0.39 *4* (2018Ma03, power moderated mean (PMM) of 0.367 *15* and 0.47 *13*), 0.432 *14* (2017Le03), 0.43 *5* (1996Ru11), 0.80 *10* (1992Li05), 0.339 *17* (1983Ba77).
185.713 *2*	100.0 *12*	185.7143	5/2$^-$	0.0	5/2$^+$	E1	0.1124 *16*	%Iγ=57.2 *9* α(K)=0.0887 *13*; α(L)=0.0179 *3*; α(M)=0.00433 *6* α(N)=0.001142 *16*; α(O)=0.000263 *4*; α(P)=4.82×10^{-5} *7*; α(Q)=3.32×10^{-6} *5* E_γ: weighted average of Eγ=185.722 *4* (1984He12, 185.718 *10* in 1974HeYW from the same lab); 185.65 *5* (1977Ba72); 185.72 *2* (1975Va11); 185.712 *10* (1974Te03); 185.712 *1* (1987Wh01, (n,γ), curved-crystal). Other: 185.71 (1983Ba77). I_γ: weighted average of 100.0 *12* (2018Ma03), 100.0 *12* (2017Le03), 100.0 *35* (1999Ch12), 100.00 *35* (1996Ru11), 100.0 *23* (1992Li05), 100.0 *9* (1984He12, 100 *5* in 1974HeYW), 100.0 *14* (1983Ol01), 100.0 *10* (1983Ba77), 100.0 *16* (1982Va04). Others: 100 (1977Ba72), 100 (1975Va11), 100.0 (1974Te03). Measured %Iγ=57.2 *7* (2018Ma03, power moderated mean (PMM) of 58.3 *21*, 57.32 *29*, 57.6 *21* and 56.6 *7*), 57.6 *7* (2017Le03), 58 *2* (1999Ch12), 57.2 *2* (1996Ru11), 56.8 *13* (1992Li05), 57.2 *5* (1984He12), 56.1 *8* (1983Ol01), 57.3 *6* (1983Ba77), 57.5 *9*

$^{231}_{90}Th_{141}$-14

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
								(1982Va04). Weighted average of these values is 57.2 *6*, with uncertainty increased to 1% in 1983Ol01. Others: 80.19 *4* (2006Al28, discrepant due to contribution from other activities e.g. ^{226}Ra decay), 54.9 *15* (1966Ga03, scintillation detector).
194.942 *7*	1.113 *23*	236.893	9/2$^-$	41.9509	7/2$^+$	[E1]	0.1002 *14*	%Iγ=0.637 *15* α(K)=0.0792 *11*; α(L)=0.01589 *23*; α(M)=0.00383 *6* α(N)=0.001011 *15*; α(O)=0.000233 *4*; α(P)=4.28×10^{-5} *6*; α(Q)=2.98×10^{-6} *5* E_γ: weighted average of 194.944 *7* (1984He12, 194.94 *2* in 1974HeYW, same lab as 1984He12); 194.95 *5* (1977Ba72); 194.94 *2* (1975Va11); 194.938 *10* (1974Te03). Other: 194.94 (1983Ba77). I_γ: weighted average of 1.15 *7* (2018Ma03), 1.178 *31* (2017Le03), 1.066 *35* (1996Ru11), 1.09 *9* (1992Li05), 1.093 *23* (1983Ba77), 1.09 *11* (1975Va11), 1.06 *16* (1974Te03), 1.20 *10* (1974HeYW). Other: 1.17 (1977Ba72). Measured %Iγ=0.66 *4* (2018Ma03, power moderated mean (PMM) of 0.635 *24* and 0.71 *10*), 0.678 *18* (2017Le03), 0.61 *2* (1996Ru11), 0.618 *48* (1992Li05), 0.626 *13* (1983Ba77).
198.927 *3*	0.074 *5*	240.8785	5/2$^+$	41.9509	7/2$^+$	M1	2.64 *4*	%Iγ=0.042 *3* α(K)=2.11 *3*; α(L)=0.400 *6*; α(M)=0.0963 *14* α(N)=0.0257 *4*; α(O)=0.00608 *9*; α(P)=0.001180 *17*; α(Q)=0.0001119 *16* E_γ: weighted average of 198.75 *10* (1977Ba72), 198.88 *6* (1975Va11), 198.898 *15* (1974Te03), 198.91 *6* (1974HeYW), 198.928 *2* (1987Wh01, (n,γ), curved-crystal). Other: 198.93 (1983Ba77). I_γ: weighted average of 0.077 *5* (2018Ma03), 0.082 *11* (1983Ba77), 0.057 *9* (1975Va11), 0.08 *1* (1974Te03), 0.05 *2* (1974HeYW). Others: 0.286 *25* in 2017Le03 seems discrepant; 0.17 for 198.75+199.6 (1977Ba72). Measured %Iγ=0.044 *3* (2018Ma03), 0.165 *14* (2017Le03), 0.047 *6* (1983Ba77).
[x]199.6[#] *1*	<0.17[#]							%Iγ<0.10 I_γ: 0.17 for 198.75+199.6.
202.110 *3*	1.87 *6*	387.824	7/2$^-$	185.7143	5/2$^-$	[M1+E2]	1.58 *95*	%Iγ=1.07 *4* α(K)=1.09 *94*; α(L)=0.367 *17*; α(M)=0.0938 *22* α(N)=0.0251 *7*; α(O)=0.00578 *9*; α(P)=0.00105 *8*; α(Q)=5.9×10^{-5} *48* E_γ: weighted average of 202.106 *6* (1984He12, 202.13 *3* in 1974HeYW, from the same lab); 202.05 *5* (1977Ba72); 202.12 *2* (1975Va11), 202.105 *12* (1974Te03); 202.111 *3* (1987Wh01, (n,γ), curved crystal). Other: 202.11 (1983Ba77).

$^{231}_{90}Th_{141}$-15

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡][f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
								I_γ: unweighted average of 1.85 *5* (2018Ma03), 2.062 *42* (2017Le03), 1.85 *7* (1996Ru11), 2.04 *12* (1992Li05), 1.885 *35* (1983Ba77), 1.87 *19* (1975Va11), 1.88 *20* (1974Te03), 1.54 *10* (1974HeYW). Regular weighted average is 1.91 *5*, but reduced χ^2=4.4 as compared to critical χ^2=2.0. Other: 2.19 (1977Ba72).
								Measured %Iγ=1.06 *3* (2018Ma03, power moderated mean (PMM) of 1.07 *4*, 1.06 *12*, 1.08 *11* and 1.051 *24*), 1.187 *24* (2017Le03), 1.06 *4* (1996Ru11), 1.16 *7* (1992Li05), 1.08 *2* (1983Ba77).
205.311 *2*	8.80 *9*	205.3098	(7/2$^-$)	0.0	5/2$^+$	(E1)	0.0887 *13*	%Iγ=5.03 *7* α(K)=0.0703 *10*; α(L)=0.01397 *20*; α(M)=0.00336 *5* α(N)=0.000889 *13*; α(O)=0.000205 *3*; α(P)=3.77×10^{-5} *6*; α(Q)=2.66×10^{-6} *4*
								E_γ: weighted average of 205.318 *4* (1984He12, 205.311 *12* in 1974HeYW from the same lab); 205.25 *5* (1977Ba72); 205.31 *2* (1975Va11); 205.312 *10* (1974Te03); 205.309 *2* (1987Wh01, (n,γ), curved-crystal). Other: 205.30 (1983Ba77).
								I_γ: weighted average of 8.81 *14* (2018Ma03), 8.88 *12* (2017Le03), 8.81 *9* (1996Ru11), 8.77 *25* (1992Li05), 8.67 *9* (1984He12, 9.08 *55* in 1974HeYW), 8.97 *16* (1983Ol01), 8.81 *9* (1983Ba77), 8.70 *35* (1982Va04), 8.7 *9* (1975Va11), 8.55 *70* (1974Te03). Other: 9.65 (1977Ba72).
								Measured %Iγ=5.04 *8* (2018Ma03, power moderated mean (PMM) of 5.08 *19*, 5.06 *12*, 5.08 *23* and 5.00 *7*), 5.11 *7* (2017Le03), 5.04 *5* (1996Ru11), 4.98 *14* (1992Li05), 4.96 *5* (1984He12), 5.03 *9* (1983Ol01), 5.05 *5* (1983Ba77), 5.0 *2* (1982Va04). Other: 7.74 *4* (2006Al28) is discrepant due to contribution from other activities.
215.30 *5*	0.0516 *35*	452.189	9/2$^-$	236.893	9/2$^-$	[M1+E2]	1.31 *81*	%Iγ=0.0295 *20* α(K)=0.92 *78*; α(L)=0.29 *3*; α(M)=0.0750 *23* α(N)=0.0201 *6*; α(O)=0.00463 *25*; α(P)=0.00084 *10*; α(Q)=5.0×10^{-5} *40*
								E_γ: weighted average of 215.30 *10* (1977Ba72), 215.28 *5* (1975Va11), 215.26 *20* (1974Te03), 215.31 *5* (1974HeYW).
								I_γ: weighted average of 0.0524 *35* (2018Ma03), 0.050 *6* (1975Va11), 0.05 *1* (1974Te03), 0.050 *15* (1974HeYW, 0.74 in 1971KrZH seems erroneous). Other: 0.044 (1977Ba72).
								Measured %Iγ=0.030 *2* (2018Ma03).
221.392 *20*	0.201 *11*	221.392	3/2$^+$	0.0	5/2$^+$	M1	1.96 *3*	%Iγ=0.115 *6* α(K)=1.566 *22*; α(L)=0.296 *5*; α(M)=0.0712 *10*

$^{231}_{90}Th_{141}$-16

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	δ[d]	α[g]	Comments
									α(N)=0.0190 *3*; α(O)=0.00450 *7*; α(P)=0.000872 *13*; α(Q)=8.28×10^{-5} *12* E_γ: weighted average of 221.40 *5* (1977Ba72), 221.38 *2* (1975Va11), 221.397 *25* (1974Te03), 221.375 *30* (1974HeYW), 221.399 *1* (1987Wh01, (n,γ), curved-crystal). Other: 221.40 (1983Ba77). I_γ: weighted average of 0.192 *14* (2018Ma03), 0.206 *34* (2017Le03), 0.199 *11* (1983Ba77), 0.204 *19* (1975Va11), 0.21 *5* (1974Te03), 0.22 *2* (1974HeYW). Other: 0.219 (1977Ba72). Measured %Iγ=0.110 *8* (2018Ma03, power moderated mean (PMM) of 0.117 *5* and 0.101 *10*), 0.119 *20* (2017Le03), 0.114 *6* (1983Ba77).
[x]225.7 *2*	0.0032 *10*								%Iγ=0.0018 *6* E_γ,I_γ: from 1974HeYW only, Iγ=0.11 in 1971KrZH.
228.785 *6*	0.0121 *18*	324.911	$(9/2)^+$	96.126	$9/2^+$	M1		1.79 *3*	%Iγ=0.0069 *10* α(K)=1.429 *20*; α(L)=0.270 *4*; α(M)=0.0649 *9* α(N)=0.01731 *25*; α(O)=0.00410 *6*; α(P)=0.000796 *12*; α(Q)=7.55×10^{-5} *11* E_γ: weighted average of 228.7 *1* (1977Ba72), 228.78 *5* (1975Va11), 228.8 *1* (1974HeYW), 228.785 *6* (1987Wh01, (n,γ), curved-crystal). I_γ: weighted average of 0.0117 *18* (2018Ma03) and 0.015 *5* (1974HeYW). Others: 0.002 (1977Ba72), 0.013 (1975Va11). Measured %Iγ=0.0067 *10* (2018Ma03).
233.470 *3*	0.058 *4*	275.423	$7/2^+$	41.9509	$7/2^+$	M1		1.688 *24*	%Iγ=0.0332 *23* α(K)=1.350 *19*; α(L)=0.255 *4*; α(M)=0.0613 *9* α(N)=0.01636 *23*; α(O)=0.00387 *6*; α(P)=0.000752 *11*; α(Q)=7.13×10^{-5} *10* E_γ: weighted average of 233.55 *10* (1977Ba72), 233.50 *3* (1975Va11), 233.49 *3* (1974Te03), 233.53 *4* (1974HeYW), 233.469 *3* (1987Wh01, (n,γ), curved-crystal). Other: 233.50 (1983Ba77). I_γ: weighted average of 0.056 *4* (2018Ma03), 0.051 *9* (1983Ba77), 0.056 *37* (1975Va11), 0.06 *2* (1974Te03), 0.075 *10* (1974HeYW). Other: 0.056 (1975Va11). Measured %Iγ=0.032 *2* (2018Ma03), 0.029 *5* (1983Ba77).
240.876 *4*	0.119 *7*	240.8785	$5/2^+$	0.0	$5/2^+$	M1(+E2)	0.3 *3*	1.45 *22*	%Iγ=0.068 *4* α(K)=1.14 *21*; α(L)=0.228 *13*; α(M)=0.0553 *21* α(N)=0.0148 *6*; α(O)=0.00348 *16*; α(P)=0.00067 *5*; α(Q)=6.1×10^{-5} *11*

$^{231}_{90}Th_{141}$-17

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	δ[d]	α[g]	Comments
									E_γ: weighted average of 240.87 *3* (1975Va11), 240.95 *4* (1974Te03), 240.93 *4* (1974HeYW), 240.875 *3* (1987Wh01, (n,γ), curved-crystal). Others: 240.75 *5* (1977Ba72, seems discrepant, although agrees within $\approx2\sigma$). Other: 240.89 (1983Ba77). I_γ: weighted average of 0.112 *7* (2018Ma03), 0.133 *11* (1983Ba77), 0.11 *3* (1974Te03), 0.14 *3* (1974HeYW). Others: 0.175 *10* in 2017Le03 is precise but seems discrepant; 0.156 (1977Ba72); 0.148 (1975Va11). Measured %Iγ=0.064 *4* (2018Ma03), 0.101 *5* (2017Le03), 0.076 *6* (1983Ba77).
246.83 *3*	0.089 *5*	452.189	9/2$^-$	205.3098	(7/2$^-$)	[M1]		1.445 *20*	%Iγ=0.0509 *29* α(K)=1.157 *17*; α(L)=0.218 *3*; α(M)=0.0525 *8* α(N)=0.01400 *20*; α(O)=0.00331 *5*; α(P)=0.000643 *9*; α(Q)=6.10×10^{-5} *9* E_γ: weighted average of 246.85 *5* (1977Ba72), 246.84 *2* (1975Va11), 246.59 *10* (1974Te03), 246.83 *4* (1974HeYW). Other: 246.87 (1983Ba77). I_γ: weighted average of 0.084 *5* (2018Ma03), 0.093 *5* (1983Ba77), 0.08 *3* (1974Te03), 0.11 *3* (1974HeYW). Others: 0.15 (1975Va11), 0.117 for 246.85+251.5 (1977Ba72). Measured %Iγ=0.048 *3* (2018Ma03), 0.053 *3* (1983Ba77).
[x]251.5[#] *1*	<0.117[#]								%Iγ<0.067 I_γ: 0.117 for 246.85+251.5.
266.47 *5*	0.0115 *18*	452.189	9/2$^-$	185.7143	5/2$^-$	[E2]		0.245 *4*	%Iγ=0.0066 *10* α(K)=0.0921 *13*; α(L)=0.1121 *16*; α(M)=0.0303 *5* α(N)=0.00810 *12*; α(O)=0.00183 *3*; α(P)=0.000312 *5*; α(Q)=6.01×10^{-6} *9* E_γ: weighted average of 266.50 *5* (1975Va11), 266.40 *10* (1974Te03), 266.44 *8* (1971KrZH). I_γ: weighted average of 0.0117 *18* (2018Ma03), 0.011 *3* (1974Te03). Others: 0.017 (1975Va11), 0.0093 (1971KrZH). Measured %Iγ=0.0067 *10* (2018Ma03).
275.129 *2*	0.041 *14*	317.0790	5/2$^+$	41.9509	7/2$^+$	M1+E2	0.6 *1*	0.84 *6*	%Iγ=0.023 *8* α(K)=0.65 *5*; α(L)=0.145 *5*; α(M)=0.0355 *10* α(N)=0.00949 *25*; α(O)=0.00223 *7*; α(P)=0.000422 *15*; α(Q)=3.5×10^{-5} *3* E_γ: from (n,γ) data in 1987Wh01. Others: for 275 doublet from

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

γ(^{231}Th) (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [d]	δ [d]	α [g]	Comments
									^{235}U decay: 275.50 *5* (1977Ba72), 275.24 *20* (1975Va11), 275.35 *15* (1974Te03), 275.4 *1* (1971KrZH), I_γ: from Iγ(275.129)/Iγ(317.062)=21.7 *54* in (n,γ) (1987Wh01). uncertainty of 25% is assumed in Iγ for 317.1γ by the evaluators. Others for 275γ doublet from ^{235}U decay: 0.0559 *35* (2018Ma03), 0.164 *9* (2017Le03), 0.09 *1* (1974Te03), 0.200 (1977Ba72), 0.056 (1975Va11), ≈0.074 (1971KrZH). Total intensity for the 275 doublet deduced on the basis of branching ratios is 0.056 *20*, almost in perfect agreement with values from 2018Ma03, 1975Va11 and 1971KrZH, but in disagreement with values from 2017Le03 and 1977Ba72. Measured %Iγ=0.032 *2* (2018Ma03), 0.094 *5* (2017Le03) for 275γ doublet.
275.428 *4*	0.015 *4*	275.423	7/2$^+$	0.0	5/2$^+$	M1(+E2)	0.25 *25*	1.02 *12*	%Iγ=0.0086 *23* α(K)=0.81 *11*; α(L)=0.157 *9*; α(M)=0.0379 *18* α(N)=0.0101 *5*; α(O)=0.00239 *13*; α(P)=0.00046 *3*; α(Q)=4.3×10^{-5} *6* E_γ: from (n,γ) data in 1987Wh01. Others: for 275 doublet from ^{235}U decay: 275.50 *5* (1977Ba72), 275.24 *20* (1975Va11), 275.35 *15* (1974Te03), 275.4 *1* (1971KrZH), I_γ: from Iγ(275.428)/Iγ(233.469)=0.25 *6* in (n,γ) (1987Wh01). Others for 275γ doublet from ^{235}U decay: 0.0559 *35* (2018Ma03), 0.164 *9* (2017Le03), 0.09 *1* (1974Te03), 0.200 (1977Ba72), 0.056 (1975Va11), ≈0.074 (1971KrZH). Total intensity for the 275 doublet deduced on the basis of branching ratios is 0.056 *20*, almost in perfect agreement with values from 2018Ma03, 1975Va11 and 1971KrZH, but in disagreement with values from 2017Le03 and 1977Ba72. Measured %Iγ=0.032 *2* (2018Ma03), 0.094 *5* (2017Le03) for 275γ doublet.
[x]279.50[#&] *5*	0.463[#]								%Iγ=0.26
281.440 *9*	0.011	377.562	(7/2)$^+$	96.126	9/2$^+$	M1		1.005 *14*	%Iγ=0.0063 α(K)=0.804 *12*; α(L)=0.1515 *22*; α(M)=0.0364 *5* α(N)=0.00970 *14*; α(O)=0.00230 *4*; α(P)=0.000446 *7*; α(Q)=4.23×10^{-5} *6* E_γ: weighted average of 281.42 *5* (1975Va11), 281.441 *9* (1987Wh01, (n,γ), curved-crystal). I_γ: from 1975Va11.
282.92 *5*	0.0079 *23*	324.911	(9/2)$^+$	41.9509	7/2$^+$	[M1+E2]		0.60 *40*	%Iγ=0.0045 *13*

$^{231}_{90}Th_{141}$-19

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [d]	α [g]	Comments
								α(K)=0.44 *36*; α(L)=0.119 *31*; α(M)=0.030 *6* α(N)=0.0080 *16*; α(O)=0.0019 *5*; α(P)=3.43×10^{-4} *97*; α(Q)=2.3×10^{-5} *19* E_γ: weighted average of 283.0 *1* (1977Ba72), 282.92 *5* (1975Va11), 283.1 *2* (1971KrZH). γ not seen in (n,γ) (1987Wh01). I_γ: arithmetic mean of 0.007 (1977Ba72), 0.011 (1975Va11), 0.0056 (1971KrZH).
289.56 *4*	0.0093 [b] *17*	385.68?	($5/2^+$ to $11/2^+$)	96.126	$9/2^+$	[D,E2]	0.49 *45*	%Iγ=0.0053 *10* E_γ: from 1975Va11. I_γ: 0.0093 *17* (2018Ma03). Other: 0.013 (1975Va11). Measured %Iγ=0.0053 *10* (2018Ma03).
291.2		452.189	$9/2^-$	162.13	$11/2^+$			E_γ: from coincidence data in 1975Va11, intensity is not available.
291.65 *3*	0.064 *8*	387.824	$7/2^-$	96.126	$9/2^+$	[E1]	0.0396 *6*	%Iγ=0.037 *5* α(K)=0.0317 *5*; α(L)=0.00598 *9*; α(M)=0.001433 *20* α(N)=0.000379 *6*; α(O)=8.81×10^{-5} *13*; α(P)=1.642×10^{-5} *23*; α(Q)=1.254×10^{-6} *18* E_γ: weighted average of 291.65 *5* (1977Ba72), 291.65 *3* (1975Va11), 291.58 *15* (1974Te03), 291.6 *1* (1971KrZH). I_γ: unweighted average of 0.0477 *33* (2018Ma03), 0.0733 *44* (2017Le03), 0.07 *1* (1974Te03). Weighted average is 0.058 *9*, but reduced χ^2=11.6 is too high. Others: 0.167 (1977Ba72), 0.056 (1975Va11), ≈0.037 (1971KrZH). Measured %Iγ=0.0273 *19* (2018Ma03), 0.0422 *25* (2017Le03).
[x]294.3 [#&] *1*	0.058 [#]							%Iγ=0.033
301.7 [h] *1*	0.0093	301.70?	$5/2^+$	0.0	$5/2^+$	M1	0.829 *12*	%Iγ=0.0053 α(K)=0.664 *10*; α(L)=0.1249 *18*; α(M)=0.0300 *5* α(N)=0.00800 *12*; α(O)=0.00189 *3*; α(P)=0.000368 *6*; α(Q)=3.49×10^{-5} *5* E_γ,I_γ: from 1975Va11, γ unplaced. This γ may correspond to 301.741 *3* in (n,γ) (1987Wh01).
[x]310.69 *6*	0.0093							%Iγ=0.0053 E_γ,I_γ: from 1975Va11. Other: Eγ=311.6 *6*, Iγ=0.0030 (1971KrZH).
317.063 *12*	0.0019	317.0790	$5/2^+$	0.0	$5/2^+$	M1	0.723 *10*	%Iγ=0.0011 α(K)=0.579 *9*; α(L)=0.1089 *16*; α(M)=0.0261 *4*

$^{231}_{90}Th_{141}$-20

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [d]	α [g]	Comments
								α(N)=0.00697 *10*; α(O)=0.001651 *24*; α(P)=0.000320 *5*; α(Q)=3.04×10^{-5} *5* E_γ: weighted average of 317.10 *8* (1975Va11), and 317.062 *12* (1987Wh01, (n,γ), curved-crystal spectrometer). I_γ: from 1975Va11.
[x]325.80[#] *10*	0.007[#]							%Iγ=0.004
343.5 *2*	0.0125[c] *11*	385.68?	(5/2$^+$ to 11/2$^+$)	41.9509	7/2$^+$	[D,E2]	0.30 *27*	%Iγ=0.0072 *6* E_γ: from 1975Va11. I_γ: 0.0125 *11* (2017Le03). Other: 0.13 (1975Va11). Measured %Iγ=0.0072 *6* (2017Le03).
[x]345.4[#] *1*	<0.126[#]							%Iγ<0.072 I_γ: 0.126 for 345.4+345.9.
345.92 *3*	0.060 *8*	387.824	7/2$^-$	41.9509	7/2$^+$	[E1]	0.0272 *4*	%Iγ=0.034 *5* α(K)=0.0219 *3*; α(L)=0.00403 *6*; α(M)=0.000964 *14* α(N)=0.000255 *4*; α(O)=5.95×10^{-5} *9*; α(P)=1.115×10^{-5} *16*; α(Q)=8.81×10^{-7} *13* E_γ: weighted average of 345.90 *5* (1977Ba72), 345.93 *3* (1975Va11), 345.84 *15* (1974Te03). Other: 345.91 (1971KrZH). I_γ: unweighted average of 0.066 *5* (2018Ma03), 0.0431 *32* (2017Le03), 0.07 *1* (1974Te03). Regular weighted average is 0.051 *8*, but reduced χ^2=9.5 is too high. Others: 0.13 (1975Va11), 0.126 for 345.4+345.9 (1977Ba72), 0.0030 (1971KrZH). Measured %Iγ=0.038 *3* (2018Ma03), 0.0248 *18* (2017Le03).
356.03 *5*	0.0042[b] *14*	452.189	9/2$^-$	96.126	9/2$^+$	[E1]	0.0255 *4*	%Iγ=0.0024 *8* α(K)=0.0206 *3*; α(L)=0.00377 *6*; α(M)=0.000903 *13* α(N)=0.000239 *4*; α(O)=5.57×10^{-5} *8*; α(P)=1.046×10^{-5} *15*; α(Q)=8.31×10^{-7} *12* E_γ: from 1975Va11. Other: 356.0 *2* (1971KrZH). I_γ: 0.0042 *14* (2018Ma03). Other: 0.0093 (1975Va11). Measured %Iγ=0.0024 *8* (2018Ma03).
[x]368.5[#&] *1*	<0.120[#]							%Iγ<0.069 I_γ: 0.120 for 368.5+371.8.
[x]371.8[#&] *1*	<0.120[#]							%Iγ<0.069 I_γ: 0.120 for 368.5+371.8.
387.84 *3*	0.0484 *42*	387.824	7/2$^-$	0.0	5/2$^+$	[E1]	0.0213 *3*	%Iγ=0.0277 *24*

$^{231}_{90}Th_{141}$-21

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ[†]	I_γ[‡ f]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[d]	α[g]	Comments
								α(K)=0.01717 *24*; α(L)=0.00312 *5*; α(M)=0.000745 *11* α(N)=0.000197 *3*; α(O)=4.60×10^{-5} *7*; α(P)=8.66×10^{-6} *13*; α(Q)=6.99×10^{-7} *10* E_γ: weighted average of 387.85 *10* (1977Ba72), 387.84 *3* (1975Va11), 387.79 *15* (1974Te03). Other: 387.85 (1971KrZH). I_γ: weighted average of 0.0455 *35* (2018Ma03), 0.0488 *45* (2017Le03), 0.07 *1* (1974Te03). Others: 0.278 (1977Ba72), 0.015 (1975Va11). Measured %Iγ=0.026 *2* (2018Ma03), 0.0281 *26* (2017Le03).
[x]390.27 *20*	0.070 *2*							%Iγ=0.0400 *12* E_γ,I_γ: from 1974Te03 only, placed from a 390 level, but the 233.4γ placed by the authors from the same level is now assigned from 275 level. The assignment of this γ to ^{235}U decay is questionable as with the reported intensity in 1974Te03, it should have been seen in other studies.
410.29 *4*	0.0040[b] *11*	452.189	9/2$^-$	41.9509	7/2$^+$	[E1]	0.0189 *3*	%Iγ=0.0023 *6* α(K)=0.01527 *22*; α(L)=0.00275 *4*; α(M)=0.000657 *10* α(N)=0.0001741 *25*; α(O)=4.07×10^{-5} *6*; α(P)=7.66×10^{-6} *11*; α(Q)=6.25×10^{-7} *9* E_γ: from 1975Va11. Other: 410.2 *2* (1971KrZH). I_γ: 0.0040 *11* (2018Ma03). Other: 0.0056 (1975Va11). Measured %Iγ=0.0023 *6* (2018Ma03).
(428.71[e] *4*)	≈0.0024	634.05	(7/2$^-$)	205.3098	(7/2$^-$)	M1+E0(+E2)	0.19 *13*	%Iγ≈0.0014 α(K)=0.15 *11*; α(L)=0.033 *15*; α(M)=0.0082 *32* α(N)=0.00220 *85*; α(O)=5.2×10^{-4} *21*; α(P)=9.7×10^{-5} *43*; α(Q)=7.7×10^{-6} *57* E_γ,I_γ: from (n,γ) (1987Wh01). Intensity from Iγ(429)/Iγ(448)=1.2 *7* in 1987Wh01. α(exp)=1.33(α(K)exp=0.66 *4* in (n,γ), 1987Wh01).
[x]433.0[#] *5*	0.007[#]							%Iγ=0.004
448.40 *6*	0.0019	634.05	(7/2$^-$)	185.7143	5/2$^-$	[M1+E2]	0.17 *12*	%Iγ=0.0011 α(K)=0.129 *97*; α(L)=0.029 *13*; α(M)=0.0072 *29* α(N)=0.00193 *77*; α(O)=4.5×10^{-4} *19*; α(P)=8.5×10^{-5} *39*; α(Q)=6.8×10^{-6} *50* E_γ: weighted average of 448.40 *6* (1975Va11), 448.339 *18* (1987Wh01, (n,γ), curved crystal). Other: 447.5 *2* (1971KrZH). I_γ: from 1975Va11. Placement based on (n,γ) (1987Wh01).
[x]455.1[@] *1*	0.015[@]							%Iγ=0.009

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11 (continued)

$\gamma(^{231}Th)$ (continued)

E_γ [†]	I_γ [‡ f]	E_i(level)	Comments
[x]517.9[@] 2	0.00074[@]		%Iγ=0.00042
[x]742.5[@ a] 2	0.00074[@]		%Iγ=0.00042
[x]794.7[@ a] 1	0.0011[@]		%Iγ=0.0006

[†] The γ-ray energies have been measured using Ge(Li) or Ge detectors by 1984He12, 1977Ba72, 1975Va11, 1974Te03 and 1974HeYW (also 1971KrZH, 1971Cl03). Other: 1983Ba77. See comments for individual γ rays for recommended values.

[‡] The γ-ray intensities, using Ge or Ge(Li) detectors have been measured by 2018Ma03 (32 γ rays), 2017Le03 and 2021LeZZ (23 γ rays), 2006Al28 (6 γ rays), 1999Ch12 (185.7γ), 1996Ru11 (8 γ rays and x rays), 1992Li05 (8 γ rays), 1984He12 (5 γ rays), 1983Ol01 (4 γ rays), 1983Ba77 (18 γ rays), 1982Va04 (4 γ rays), 1977Ba72 (50 γ rays), 1975Va11 (42 γ rays), 1974Te03 (28 γ rays), 1974HeYW (also 1971KrZH, 1971Cl03, 34 γ rays). Intensities in different studies were converted to relative intensities relative to 100.0 for the 185.7 γ ray. See comments for individual γ rays for recommended relative values. In 2018Ma03, recommended intensities for 9 γ rays are from power-moderated mean method (PMM) of collaborative measurements at different metrology labs (JRC, CIEMAT, ENEA, CMI), as listed in authors′ Table 5. In 2017Le03, evaluators have used revised relative intensities received March 01, 2021 from the first author, in deducing recommended relative γ-ray intensities, as the published relative intensities in 2017Le03 were found to be inconsistent by evaluators.

[#] This γ from 1977Ba72 only.

[@] This γ from 1975Va11 only.

[&] Assignment of this γ to ^{235}U decay in 1977Ba72 is considered highly questionable by evaluators, as with the reported intensity in this work, it should have been detected in other studies.

[a] Assignment to ^{235}U α decay is uncertain.

[b] From 2018Ma03, relative intensity deduced by evaluators by renormalizing the absolute intensities in 2018Ma03 to Iγ=100.0 for the 185.7γ.

[c] Relative intensity from 2017Le03 (as revised in March 01, 2021 communication from the first author). Absolute intensity from this work is given in comments.

[d] From the Adopted Gammas, unless otherwise stated.

[e] Unobserved but expected γ ray.

[f] For absolute intensity per 100 decays, multiply by 0.572 *6*.

[g] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with "Frozen Orbitals" approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

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

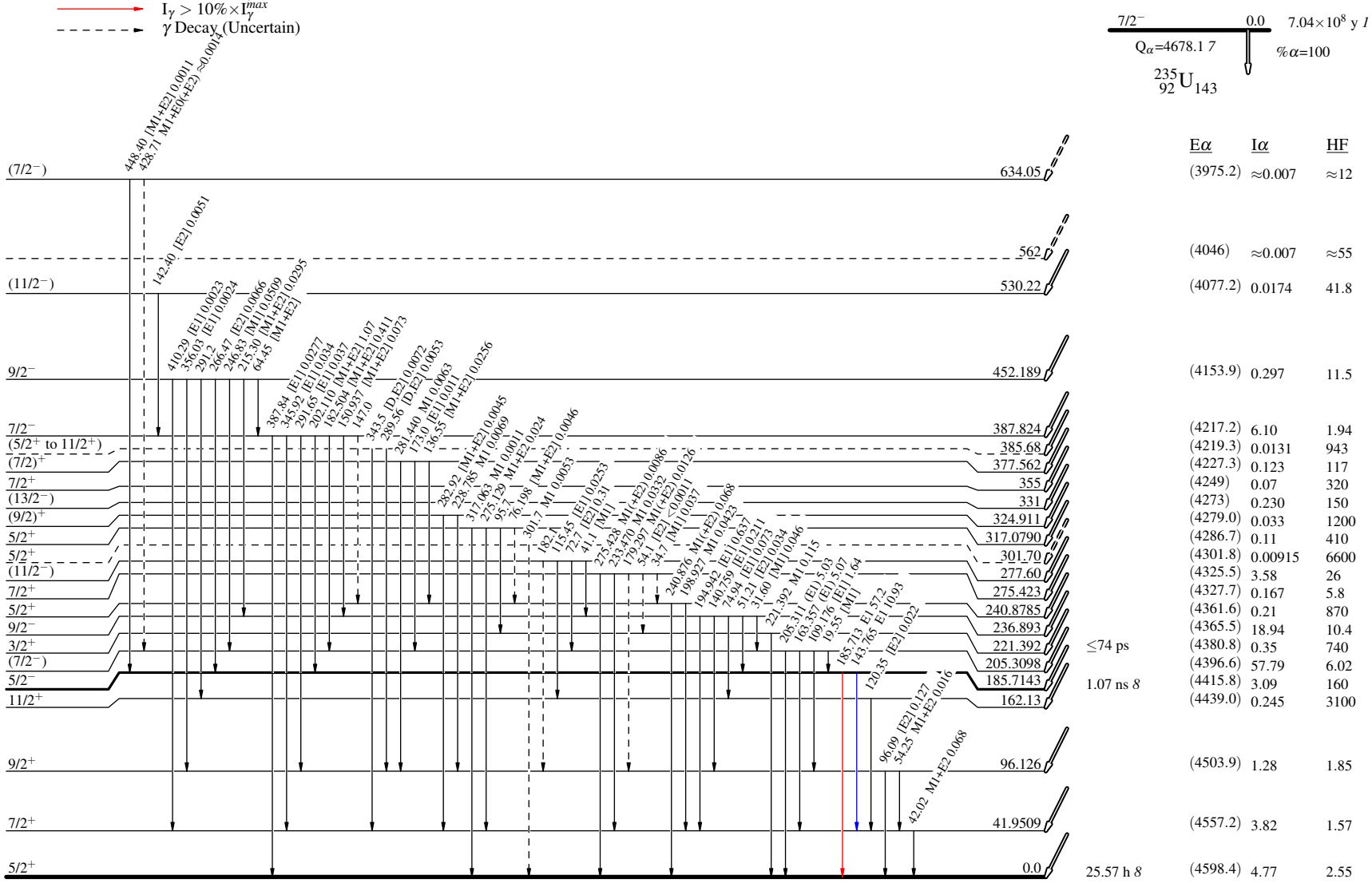
[x] γ ray not placed in level scheme.

$^{231}_{90}Th_{141}$-23

^{235}U α decay (7.04×10^{8} y) 2005Ga36,2018Ma03,1975Va11

Decay Scheme

Intensities: I_γ per 100 parent decays



$^{231}_{90}Th_{141}$-24