^{235}Np α decay (396.1 d) 1973Br12

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}Np: E=0; J^π=5/2$^+$; $T_{1/2}$=396.1 d *12*; Q(α)=5193.8 *15*; %α decay=0.00260 *13*

^{235}Np-J^π,$T_{1/2}$: From ^{235}Np Adopted Levels in the ENSDF database (Feb 2014 update). No new experimental references for half-life after this update.

^{235}Np-Q(α): From 2021Wa16.

^{235}Np-%α decay: %α=0.00260 *13* (1986AgZV, measurement of x-rays from ^{235}Np and ^{236}Np ε decay, and alpha particles from ^{237}Np α decay). Others: %α=0.0035 *4* (1956Ho46, Iα/K x ray+L x ray, it is not clear whether correction for εM+ had been applied); 0.0012 *1* (1957Th37); 0.00159 (1958Gi05, Iα/K x ray+L x ray, with correction for εM+/εL=0.46); ≈0.002 (1984Wh02, K x ray/Iα).

1973Br12 (also 1970BrZX): ^{235}Np produced in ^{235}U(d,2n),E(d)=12 MeV using an enriched target, followed by chemical separation. Measured Eα, Iα, Eγ, Iγ, $\alpha\gamma$-coin using semiconductor detector for α particles with FWHM=14.5 keV, and Ge(Li) detector for γ rays. A magnetic field to the source was applied to reduce spurious peaks in the singles α spectrum, caused by the true coincidences between conversion electrons and α particles.

1986AgZV: measured %α branching ratio from the decay of ^{235}Np.

Others:

1987Ha07: ^{235}Np produced in ^{238}U(p,4n),E(p)=50 MeV reaction. Measured Eα, Iα, x rays.

1984Wh02: ^{235}Np produced in ^{235}U(p,n),E(p)=50 MeV reaction. Measured x ray and α spectra, the latter with peaks at 4.88 and 4.96 MeV. Deduced %α branching ratio from ^{235}Np decay.

1958Gi05, 1957Th37, 1956Ho46: measured %α branching ratio from ^{235}Np decay.

Evaluators′ note: the decay scheme seems fairly complete, except for spectral information about low-energy γ transitions of 9.18 and 17.19 keV.

^{231}Pa Levels

E(level)†	J^π‡	$T_{1/2}$‡	Comments
0.0#	3/2−	32570 y *130*	
9.2# *10*	1/2−		
58.570# *3*	7/2−	274 ps *10*	
84.2152@ *20*	5/2+	45.1 ns *13*	$T_{1/2}$: other: 37 ns *4* (1956Ho46, delayed coincidence). Proposed configuration=π3/2[651] (1973Br12).
101.409@ *4*	7/2+	0.7 ns *2*	
102.2687@ *21*	3/2+	0.7 ns *2*	
111.647@ *13*	(9/2+)		
169.4 *4*	11/2−		
174? *1*	(5/2−)		
183.4956& *25*	5/2+	≤0.19 ns	
247.317 *6*	7/2+		
303?& *7*	(9/2+)		

† From least-squares fit to Eγ data.

‡ From the Adopted Levels.

\# Proposed member of configuration=π1/2[530] (1973Br12).

@ Proposed member of configuration=π3/2[651] (1973Br12).

& Proposed member of configuration=π5/2[642] (1973Br12).

^{235}Np α decay (396.1 d) 1973Br12 (continued)

α radiations

Eα[†#]	E(level)	Iα[@]	HF[‡]	Comments
4809[&] *7*	303?	≈0.1	≈52	Eα=4806 *7* (1973Br12).
4862 *3*	247.317	0.7 *1*	18 *3*	Eα=4859 *3* (1973Br12). Iα=0.8 *3*, deduced by evaluators from γ-ray transition intensity balance. Eα=4873 keV *5*, Iα=0.8 (1960Gi03).
4925 *2*	183.4956	11.5 *5*	2.88 *20*	Eα=4922 *2* (1973Br12). Iα=20.1 *11*, deduced by evaluators from γ-ray transition intensity balance. HF: Low alpha hindrance factor is consistent with $5/2^+$, 5/2[642] favored state assignment. Eα=4934 keV *5*, Iα=11.8 (1960Gi03).
4934[&]	174?	<0.1	>360	Iα: upper limit from Iγ values from 174 level.
4940 *6*	169.4	≈0.6	≈68	Eα=4937 *6* (1973Br12). Iα=0.8 *3*, deduced by evaluators from γ-ray transition intensity balance.
4997 *4*	111.647	≈6	≈16	Eα=4994 *4* (1973Br12).
≈5007[&]	102.2687	≤0.5	≥210	Iα=−2.7 *22* from transition intensity balance,
5008 *4*	101.409	24 *8*	4.7 *16*	Eα=5004 *4* (1973Br12). Iα=33 *10*, deduced by evaluators from γ-ray transition intensity balance.
5025 *2*	84.2152	53 *8*	2.8 *5*	Eα=5022 *2* (1973Br12). Iα=48 *11*, deduced by evaluators from γ-ray transition intensity balance. Eα=5024 keV *5*, Iα=83.6 (1960Gi03). HF: Low alpha hindrance factor is due to strong mixing of this $5/2^+$, 3/2[651] state with the $5/2^+$, 5/2[642] favored state at 183.5 keV through the Coriolis interaction.
5051 *2*	58.570	1.8 *3*	119 *21*	Eα=5048 *2* (1973Br12).
5100 *3*	9.2	≈0.2	≈2200	Eα=5097 *3* (1973Br12).
5108 *3*	0.0	1.5 *2*	348 *51*	Eα=5105 *3* (1973Br12). Eα=5104 keV *5*, Iα=3.8 (1960Gi03).

† From 1973Br12, recalibrated by 1991Ry01. Recalibrated values given here are ≈2 keV higher than those deduced from Q(α) (2021Wa16).

‡ The nuclear radius parameter $r_0(^{231}Pa)$=1.51623 *36* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides, as given in 2020Si16, and in the data file of the ALPHAD-RadD code.

\# Evaluators have adjusted by 9 keV Eα values from 1960Gi03 given in comments. Original Eα are relative to ^{237}Np(86α)=4781 keV. Values given here are relative to ^{237}Np(86α)=4789.8 (1991Ry01).

@ For absolute intensity per 100 decays, multiply by 2.60×10^{-5} *13*.

& Existence of this branch is questionable.

γ(^{231}Pa)

Iγ normalization: The γ-ray intensities in 1973Br12 are per 100 α decays, deduced from their $\alpha\gamma$-coin results.

E_γ [†]	I_γ [#b]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [a]	δ [a]	α [c]	$I_{(\gamma+ce)}$ [b]	Comments
(9.183)		9.2	1/2$^-$	0.0	3/2$^-$					E_γ: from the Adopted Gammas.
(17.195 *21*)		101.409	7/2$^+$	84.2152	5/2$^+$	(M1)		166 *3*	39[&] *10*	α(L)=1.4; α(M)=122.6 *18*; α(N)=32.7 *5*; α(O)=7.75 *12*; α(P)=1.505 *22*; α(Q)=0.144 *2*
(18.055 *18*)		102.2687	3/2$^+$	84.2152	5/2$^+$	M1+E2	0.040 *+18−0*	218 *18*	10[&] *2*	α(L)=45 *15*; α(M)=128 *8* α(N)=34 *2*; α(O)=8.1 *4*; α(P)=1.55 *5*; α(Q)=0.124 *1*
(25.65 *2*)	14.3[@] *7*	84.2152	5/2$^+$	58.570	7/2$^-$	E1		4.37 *6*		%Iγ=0.000372 *26* α(L)=3.26 *5*; α(M)=0.843 *12* α(N)=0.219 *4*; α(O)=0.0471 *7*; α(P)=0.00673 *10*; α(Q)=0.000196 *3*
(53.2 *8*)	≈3.7	111.647	(9/2$^+$)	58.570	7/2$^-$	[E1]		0.64 *3*	≈6	%Iγ≈9.5×10^{-5} α(L)=0.483 *21*; α(M)=0.119 *6* α(N)=0.0313 *14*; α(O)=0.0070 *3*; α(P)=0.00114 *5*; α(Q)=4.53×10^{-5} *16* $I_{(\gamma+ce)}$: from Iα value, if 53.2γ is the only decaying transition. I_γ: from I(γ+ce) and α.
58.5700 *24*	0.50 *3*	58.570	7/2$^-$	0.0	3/2$^-$	E2		155.5 *22*		%Iγ=1.30×10^{-5} *10* α(L)=113.6 *16*; α(M)=31.3 *5* α(N)=8.43 *12*; α(O)=1.90 *3*; α(P)=0.306 *5*; α(Q)=0.000818 *12* E_γ: 58.5 *4* (1973Br12). Iγ=0.6 *2* (1973Br12) is imprecise. Iγ=0.50 *3* deduced by evaluators from Iγ(25.6)=14.3 *7*, Iα(58)=1.8 *3*, and intensity balance at 58-keV level.
(63.86 *3*)	0.007[@] *4*	247.317	7/2$^+$	183.4956	5/2$^+$	M1+E2	0.6 *3*	39 *16*		%Iγ=1.8×10^{-7} *10* α(L)=28 *12*; α(M)=7.5 *33* α(N)=2.03 *88*; α(O)=0.47 *20*; α(P)=0.079 *31*; α(Q)=0.0023 *5*
81.2280 *21*	1.5 *1*	183.4956	5/2$^+$	102.2687	3/2$^+$	M1(+E2)	0.00 *8*	7.66 *20*		%Iγ=3.90×10^{-5} *33* α(L)=5.78 *14*; α(M)=1.40 *4* α(N)=0.374 *11*; α(O)=0.0898 *24*; α(P)=0.0172 *4*; α(Q)=0.001422 *22* E_γ: 81.2 *2* (1973Br12).
(82.0870 *22*)	0.70[@] *5*	183.4956	5/2$^+$	101.409	7/2$^+$	M1(+E2)	0.04 *6*	7.47 *23*		%Iγ=1.82×10^{-5} *16*

γ(^{231}Pa) (continued)

E_γ[†]	I_γ[#b]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[a]	δ[a]	α[c]	Comments
									α(L)=5.63 *17*; α(M)=1.36 *5* α(N)=0.365 *12*; α(O)=0.088 *3*; α(P)=0.0167 *5*; α(Q)=0.001377 *22*
84.2140 *22*	6.9 *4*	84.2152	5/2$^+$	0.0	3/2$^-$	E1		2.17 *21*	%Iγ=0.000179 *14* Eγ: 84.2 *1* (1973Br12). Mult.: Anomalous E1 γ ray. Total conversion coefficient from ^{231}Th β^- decay.
89.95[‡d] *2*	<0.07	174?	(5/2$^-$)	84.2152	5/2$^+$	(E1)		0.1598 *23*	%Iγ<1.8×10^{-6} α(L)=0.1205 *17*; α(M)=0.0294 *5* α(N)=0.00777 *11*; α(O)=0.001782 *25*; α(P)=0.000304 *5*; α(Q)=1.467×10^{-5} *21*
93.02[d] *4*	0.10 *5*	102.2687	3/2$^+$	9.2	1/2$^-$	(E1)		0.1463 *21*	%Iγ=2.6×10^{-6} *13* α(L)=0.1103 *16*; α(M)=0.0269 *4* α(N)=0.00711 *10*; α(O)=0.001633 *23*; α(P)=0.000279 *4*; α(Q)=1.363×10^{-5} *20* Eγ: 92.2 *4* (1973Br12, uncertain γ).
(99.2780 *36*)	0.22[@] *2*	183.4956	5/2$^+$	84.2152	5/2$^+$	M1+E2	0.35 *7*	5.2 *4*	%Iγ=5.7×10^{-6} *6* α(L)=3.9 *3*; α(M)=0.97 *8* α(N)=0.261 *20*; α(O)=0.062 *5*; α(P)=0.0113 *7*; α(Q)=0.00072 *3*
102.2700 *24*	0.30 *6*	102.2687	3/2$^+$	0.0	3/2$^-$	(E1)		0.1141 *16*	%Iγ=7.8×10^{-6} *16* α(L)=0.0860 *12*; α(M)=0.0210 *3* α(N)=0.00554 *8*; α(O)=0.001276 *18*; α(P)=0.000220 *3*; α(Q)=1.107×10^{-5} *16* Eγ: 102.2 *4* (1973Br12).
110.8 *4*	0.09 *3*	169.4	11/2$^-$	58.570	7/2$^-$	(E2)		7.60 *11*	%Iγ=2.3×10^{-6} *8* α(L)=5.55 *13*; α(M)=1.53 *4* α(N)=0.414 *9*; α(O)=0.0936 *21*; α(P)=0.0152 *4*; α(Q)=6.79×10^{-5} *13* Eγ: from 1973Br12.
124.927 *18*	0.07 *3*	183.4956	5/2$^+$	58.570	7/2$^-$	(E1)		0.294 *4*	%Iγ=1.8×10^{-6} *8* α(K)=0.226 *6*; α(L)=0.0510 *13*; α(M)=0.0124 *4* α(N)=0.00328 *9*; α(O)=0.000759 *19*; α(P)=0.000133 *4*; α(Q)=7.11×10^{-6} *17* Eγ: 125 *1* (1973Br12).
^{x}126 *2*	0.3 *2*								%Iγ=8×10^{-6} *5* Eγ: from 1973Br12. This γ seems different from the 125γ from 247 level.
(135.670 *11*)	0.026[@] *16*	247.317	7/2$^+$	111.647	(9/2$^+$)	M1(+E2)	0.1 *+4−1*	8.5 *10*	%Iγ=7.E−7 *4* α(K)=6.7 *13*; α(L)=1.32 *17*; α(M)=0.32 *6*

From ENSDF

γ(^{231}Pa) (continued)

E_γ[†]	I_γ[#b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	δ[a]	α[c]	Comments
									α(N)=0.086 *15*; α(O)=0.021 *4*; α(P)=0.0039 *5*; α(Q)=0.00032 *6*
163.1010 *54*	0.05 *3*	247.317	7/2$^+$	84.2152	5/2$^+$	M1(+E2)	0.0 *3*	5.1 *3*	%Iγ=1.3×10^{-6} *8* α(K)=4.0 *4*; α(L)=0.776 *19*; α(M)=0.187 *7* α(N)=0.0502 *19*; α(O)=0.0120 *4*; α(P)=0.00230 *5*; α(Q)=0.000190 *15* E_γ: 165 *1* (1973Br12).
174.15[‡d] *2*	<0.007	174?	(5/2$^-$)	0.0	3/2$^-$	[M1+E2]		2.7 *15*	%Iγ≤1.8×10^{-7} α(K)=1.8 *16*; α(L)=0.68 *4*; α(M)=0.177 *22* α(N)=0.048 *6*; α(O)=0.0111 *11*; α(P)=0.00196 *6*; α(Q)=8.7×10^{-5} *71*
183.489 *20*	0.04 *3*	183.4956	5/2$^+$	0.0	3/2$^-$	(E1)		0.1181 *17*	%Iγ=1.0×10^{-6} *8* α(K)=0.0928 *13*; α(L)=0.0191 *3*; α(M)=0.00463 *7* α(N)=0.001228 *18*; α(O)=0.000287 *4*; α(P)=5.13×10^{-5} *8*; α(Q)=3.05×10^{-6} *5* E_γ: 185 *1* (1973Br12).

[†] From the Adopted Gammas, which are mostly from ^{231}Th β^- decay, as these are most precisely known. Exceptions are noted.
[‡] γ not seen in 1973Br12, only an upper limit is given.
[#] From 1973Br12 per 100 decays of α particles, unless otherwise specified.
[@] From γ-branching ratios in the Adopted Gammas, which are mostly from ^{231}Th β^- decay.
[&] From γ-ray transition intensity balance at 84-, 101-, and 102-keV levels, and γ-ray data from ^{231}Th β^- decay.
[a] From the Adopted Levels, Gammas dataset.
[b] For absolute intensity per 100 decays, multiply by 2.60×10^{-5} *13*.
[c] 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.
[d] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{231}_{91}Pa_{140}$-5

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