Adopted Levels, Gammas

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, M. S. Basunia, Jun Chen et al. ,	NDS 192,315 (2023)	25-Sep-2023

Q(β^-)=−4860 *90*; S(n)=7808 *13*; S(p)=4620 *60*; Q(α)=8132.6 *29* 2021Wa16
Q(ε)=581 *11*, S(2n)=13629 *17*, S(2p)=7647 *13* (2021Wa16).

1970To07: ^{222}Th produced and identified in ^{208}Pb(^{16}O,2n), E(^{16}O)=10.6 MeV/nucleon at the Yale accelerator facility; measured α-decay and half-life.

1970Va13: ^{222}Th produced and identified in ^{208}Pb(^{18}O,4n); ^{208}Pb(^{20}Ne,α2n); ^{208}Pb(^{22}Ne,α4n); ^{209}Bi(^{19}F,α2n); E=10.3 MeV/nucleon from Berkeley HILAC facility; measured α-decay and half-life.

Later studies of ^{222}Th decay: 1991AnZZ, 1999Ho28, 2000He17, 2001Ku07, 2005Li17, 2016Pa28, 2018Mi11.

Theoretical nuclear structure calculations:

2022Ja07: calculated fragmentation potentials and preformation probabilities as functions of mass and charge distributions, fission σ(E) using dynamical cluster-decay model (DCM), including quadrupole β_2 and octupole β_3 deformations of fission fragments.

2020Ca18: calculated deformation parameters β_2, β_3, octupole deformation energies, proton moments Q_{20} and Q_{30} for octupole-deformed nuclei using Skyrme energy density functionals, and covariant energy density functionals.

2020No13: calculated potential energy surface in (β_2,β_3) plane, energies of yrast positive-parity and negative-parity states, energy splitting between positive- and negative-parity yrast bands, B(E1), B(E2), B(E3), transition quadrupole and octupole moments using interacting boson model (IBM).

2018Ah03: calculated levels, J^π, bands using IBM-1, Bohr-Mottelson, and IVBM models.

2018Ry04: calculated deformation energy relative to (β_{20},β_{30}) plane, quadrupole and octupole deformation of the mean-field minimum, excitation energies of rotational states using cranked HFB approach; deduced sudden change in configuration and shape of the observed yrast states from large octupole deformation at low spin to small octupole deformation at high spin.

2017Xi15: calculated levels, J^π, B(E1), B(E2), B(E3), electric dipole moments, deformation energy surface in (β_2,β_3) plane, states of reflection-asymmetric nuclei using microscopic quadrupole-octupole collective Hamiltonian (QOCH) based on relativistic PC-PK1 energy density functionals.

2017Ne02: calculated potential energy surface, deformation, g.s. and superdeformed quadrupole moments using Fourier shape parameterization.

2013No07: calculated levels, J^π, bands, potential energy surfaces, B(E2), B(E1) using microscopic framework based on nuclear density functional theory.

2008Fr03: calculated energy differences between positive and negative parity yrast sequences, and energies of aligned octupole multiphonon bands for heart-shaped nuclei.

2005Bo18: calculated g.s. and vibrational bands, level energies, B(E1), B(E2), shape transitions using analytic quadrupole octupole axially symmetric model.

2000Bo34: calculated octupole bands transition energies, beat patterns using algebraic models.

1995Jo11: calculated alternating-parity ground state bands level energies, octupole correlations, rotational spectra.

1989Eg02: calculated octupole barrier energies, pairing energy, deformations using microscopic model.

1987Na10: calculated levels, J^π, routhians, rotational bands, shapes, B(E1)/B(E2) ratios using the cranking model.

1986Le05: calculated B(E1)/B(E2) branching ratio, shell effects on collective E1 excitations, adiabatic isovector and isoscalar deformations.

1984Fr06: calculated quasiparticle routhians for pear-shaped rotating nuclei, octupole-quadrupole deformed axial Woods-Saxon potential.

1984Na08: calculated β_2, β_3 deformation parameters using Woods-Saxon-Bogolyubov cranking theory.

Other theoretical calculations: 73 primary references for structure, and 75 for decay modes (α, ^{14}C and clusters, SF) retrieved from the NSR database are listed as 'document' records in this dataset.

Additional information 1.

Adopted Levels, Gammas (continued)

^{222}Th Levels

The $K^{\pi}=0^+$ g.s. band and the $K^{\pi}=0^-$ band at 246 keV have been interpreted as octupole parity-doublet bands.

Additional high-spin levels, decaying by a single transition each, with no J^{π} assignments, are proposed only by 1988ScZF at 1477.2, 1502.4, 1541.4, 1593.3, 1612.6, 1774.6, 1906.2, 1926.2, 1935.2, 2035.8, 2304.8, 2312.6 and 2404.0 keV. These are not listed in this dataset, as evaluators consider these as unconfirmed, but can be found in the ^{208}Pb(^{18}O,4nγ) dataset.

Cross Reference (XREF) Flags

A ^{226}U α decay (268 ms)
B ^{208}Pb(^{18}O,4nγ)

E(level)[†]	J$^{\pi}$[‡]	T$_{1/2}$[#]	XREF	Comments
0.0[@]	0$^+$	1.964 ms *2*	AB	%α=100 %ε<1.3×10^{-8}, estimated by evaluators from a possible ε branch to ^{222}Ac g.s., with log *ft*>5.9. Theoretical partial T$_{1/2}$>100 s for ^{222}Th ε decay (2019Mo01) gives %ε<0.002, and theoretical partial T$_{1/2}\approx 8\times10^{+4}$ s of 1973Ta30 gives %$\varepsilon\approx 3\times10^{-6}$. T$_{1/2}$: from 2016Pa28 (recoil-$\alpha$ decay, authors used the RITU separator and measured $\alpha\gamma$-coin and Eα). Others: 2.3 ms *+8−5* (2018Mi11); 2.4 ms *3* (2005Li17), 2.237 ms *13* (2001Ku07, recoil-α decay curve), 2.0 ms *1* (2000He17), 4.2 ms *5* (1999Ho28), 2.2 ms *2* (1991AnZZ), 2.8 ms *3* (1970Va13), 4 ms *1* (1970To07). Precise values from 2001Ku07 (conference report), and 1999Ho28 are in severe disagreement with that from 2016Pa28, the former differing by ≈20 standard deviations, and the latter larger by a factor of two. The three measurements (2016Pa28, 2001Ku07, 1999Ho28) are from the same laboratory, with several of the same authors. For this reason, values from 2001Ku07 and 1999Ho28 are not considered in the averaging procedure. Other values agree with the adopted value within about two σ, but are too imprecise to be considered in the averaging procedure.
182.9[@] *2*	2$^+$	240 ps *20*	AB	
246[&] *20*	(1$^-$)		A	E(level): from Eα and Q(α). J$^{\pi}$: proposed by 2000He17, based on systematics of 1$^-$ states in neighboring nuclei.
439.2[@] *3*	4$^+$	46 ps *6*	B	
466.6[&] *6*	(3$^-$)		B	
650.4[&] *4*	5$^-$		B	
749.3[@] *4*	6$^+$	<51 ps	B	T$_{1/2}$: <45 ps *6* (1985Bo32). B(E1)/B(E2)=0.00016 *3* (1983Wa20), 0.00011 *2* (1985Bo32).
922.6[&] *4*	7$^-$		B	B(E1)/B(E2)=0.00018 *7* (1983Wa20), 0.00011 *3* (1985Bo32).
1092.8[@] *5*	8$^+$		B	B(E1)/B(E2)=0.00015 *3* (1983Wa20), 0.00025 *5* (1985Bo32).
1254.2[&] *5*	9$^-$		B	B(E1)/B(E2)=0.00014 *3* (1983Wa20), 0.00014 *3* (1985Bo32).
1460.8[@] *5*	10$^+$		B	B(E1)/B(E2)=0.00029 *16* (1983Wa20), 0.00026 *6* (1985Bo32).
1622.0[&] *5*	11$^-$		B	B(E1)/B(E2)=0.00021 *6* (1983Wa20), 0.00026 *7* (1985Bo32).
1850.6[@] *5*	12$^+$		B	B(E1)/B(E2)=0.00022 *11* (1983Wa20), 0.00019 *3* (1985Bo32).
2015.1[&] *6*	13$^-$		B	B(E1)/B(E2)=0.00019 *5* (1983Wa20), 0.00026 *5* (1985Bo32).
2259.7[@] *6*	14$^+$		B	B(E1)/B(E2)=0.00009 *3* (1983Wa20), 0.00022 *4* (1985Bo32).
2431.7[&] *6*	15$^-$		B	B(E1)/B(E2)=0.00020 *6* (1983Wa20), 0.00034 *8* (1985Bo32).
2688.0[@] *6*	16$^+$		B	B(E1)/B(E2)=0.00008 *3* (1983Wa20).
2873.1[&] *6*	17$^-$		B	B(E1)/B(E2)=0.00022 *8* (1983Wa20).
3133.9[@] *6*	18$^+$		B	
3340.9[&] *7*	19$^-$		B	

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Adopted Levels, Gammas (continued)

^{222}Th Levels (continued)

E(level)†	Jπ‡	XREF	E(level)†	Jπ‡	XREF
3596.8@ 7	20^+	B	4348.5& 7	23^-	B
3836.0& 7	21^-	B	4579.2@ 7	24^+	B
4078.6@ 7	22^+	B	4882.1?& 8	(25^-)	B
			5099.2?@ 9	(26^+)	B

† From ^{208}Pb(^{18}O,4nγ), based on least-squares fit to Eγ data. Exceptions are noted.
‡ From transition multipolarities measured in ^{208}Pb(^{18}O,4nγ) from conversion electron measurements and γ(θ) for selected γ rays, and g.s. yrast band, and octupole rotational band, as assigned in 1995Sm06 and 1988ScZF.
# For excited states, values are from measurement in ^{208}Pb(^{18}O,4nγ) (1985Bo32) using recoil-shadow method for conversion electrons.
@ Band(A): $K^\pi=0^+$ g.s. band.
& Band(B): $K^\pi=0^-$ octupole-vibrational band.

γ(^{222}Th)

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.‡	α#	Comments
182.9	2^+	182.9 *2*	100	0.0	0^+	E2	0.920 *14*	B(E2)(W.u.)=75 *6*
439.2	4^+	256.3 *2*	100	182.9	2^+	E2	0.278 *4*	B(E2)(W.u.)=109 *15*
466.6	(3^-)	283.7	100	182.9	2^+	[E1]	0.0421 *7*	
650.4	5^-	211.1 *3*	100	439.2	4^+	E1	0.0831 *12*	
749.3	6^+	98.7 *3*	80 *7*	650.4	5^-	(E1)	0.1215 *20*	B(E1)(W.u.)>0.0013
		310.2 *3*	100 *10*	439.2	4^+	E2	0.1524 *22*	B(E2)(W.u.)>22
922.6	7^-	173.1 *3*	100 *10*	749.3	6^+	E1	0.1329 *19*	
		272.4 *3*	1.4 *4*	650.4	5^-	(E2)	0.2280 *33*	
1092.8	8^+	170.1 *3*	100 *10*	922.6	7^-	E1	0.1385 *20*	
		343.6 *3*	18 *6*	749.3	6^+	E2	0.1131 *16*	
1254.2	9^-	161.2 *3*	100 *11*	1092.8	8^+	E1	0.1575 *23*	
		331.6 *3*	23 *7*	922.6	7^-	E2	0.1252 *18*	
1460.8	10^+	206.4 *3*	100 *10*	1254.2	9^-	E1	0.0876 *13*	
		368.1 *3*	15 *5*	1092.8	8^+	E2	0.0932 *13*	
1622.0	11^-	161.1 *3*	100 *20*	1460.8	10^+	E1	0.1577 *23*	
		367.8 *3*	54 *17*	1254.2	9^-	E2	0.0934 *13*	
1850.6	12^+	228.5 *3*	100 *20*	1622.0	11^-	E1	0.0691 *10*	
		389.8 *3*	13 *4*	1460.8	10^+	(E2)	0.0798 *11*	
2015.1	13^-	164.4 *3*	100 *21*	1850.6	12^+	(E1)	0.1503 *22*	
		393.2 *3*	45 *15*	1622.0	11^-	(E2)	0.0780 *11*	
2259.7	14^+	244.6 *3*	100 *19*	2015.1	13^-	E1	0.0590 *8*	
		409.2 *3*	10 *4*	1850.6	12^+	(E2)	0.0702 *10*	
2431.7	15^-	171.7 *3*	100 *21*	2259.7	14^+	[E1]	0.1355 *20*	
		416.6 *3*	47 *16*	2015.1	13^-	(E2)	0.0670 *9*	
2688.0	16^+	256.2 *3*	100 *28*	2431.7	15^-	[E1]	0.0531 *8*	
		428.5 *3*	26 *8*	2259.7	14^+	(E2)	0.0624 *9*	
2873.1	17^-	185.1 *3*	100 *21*	2688.0	16^+	(E1)	0.1133 *16*	
		441.3 *3*	35 *11*	2431.7	15^-	(E2)	0.0579 *8*	
3133.9	18^+	260.6 *3*	100 *21*	2873.1	17^-	(E1)	0.0511 *7*	
		446.0 *3*	40 *12*	2688.0	16^+	[E2]	0.0564 *8*	
3340.9	19^-	206.9 *3*	100 *19*	3133.9	18^+	[E1]	0.0871 *13*	
		468.0 *3*	41 *12*	2873.1	17^-	(E2)	0.0500 *7*	
3596.8	20^+	256.0 *3*	100 *28*	3340.9	19^-	[E1]	0.0532 *8*	
		462.8 *3*	37 *11*	3133.9	18^+	(E2)	0.0514 *7*	
3836.0	21^-	239.2 *3*	100 *30*	3596.8	20^+	[E1]	0.0622 *9*	

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Adopted Levels, Gammas (continued)

$\gamma(^{222}Th)$ (continued)

E_i(level)	J_i^π	E_γ [†]	I_γ [†]	E_f	J_f^π	Mult.[‡]	α [#]
3836.0	21^-	494.9 *3*	29 *9*	3340.9	19^-	(E2)	0.0437 *6*
4078.6	22^+	242.3 *3*	100 *29*	3836.0	21^-	[E1]	0.0603 *9*
		482.0 *3*	21 *7*	3596.8	20^+	(E2)	0.0466 *7*
4348.5	23^-	269.8 *3*	100 *29*	4078.6	22^+	[E1]	0.0472 *7*
		512.6 *3*	60 *19*	3836.0	21^-	[E2]	0.0402 *6*
4579.2	24^+	230.7 *3*	100 *30*	4348.5	23^-	[E1]	0.0676 *10*
		500.7 *3*	34 *11*	4078.6	22^+	(E2)	0.0425 *6*
4882.1?	(25^-)	304 [@]		4579.2	24^+		
		533.3	100	4348.5	23^-	[E2]	0.0367 *5*
5099.2?	(26^+)	217 [@]		4882.1?	(25^-)		
		520.0	100	4579.2	24^+	[E2]	0.0389 *6*

[†] From $^{208}Pb(^{18}O,4n\gamma)$.
[‡] From ce and $\gamma(\theta)$ data in $^{208}Pb(^{18}O,4n\gamma)$.
[#] 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.

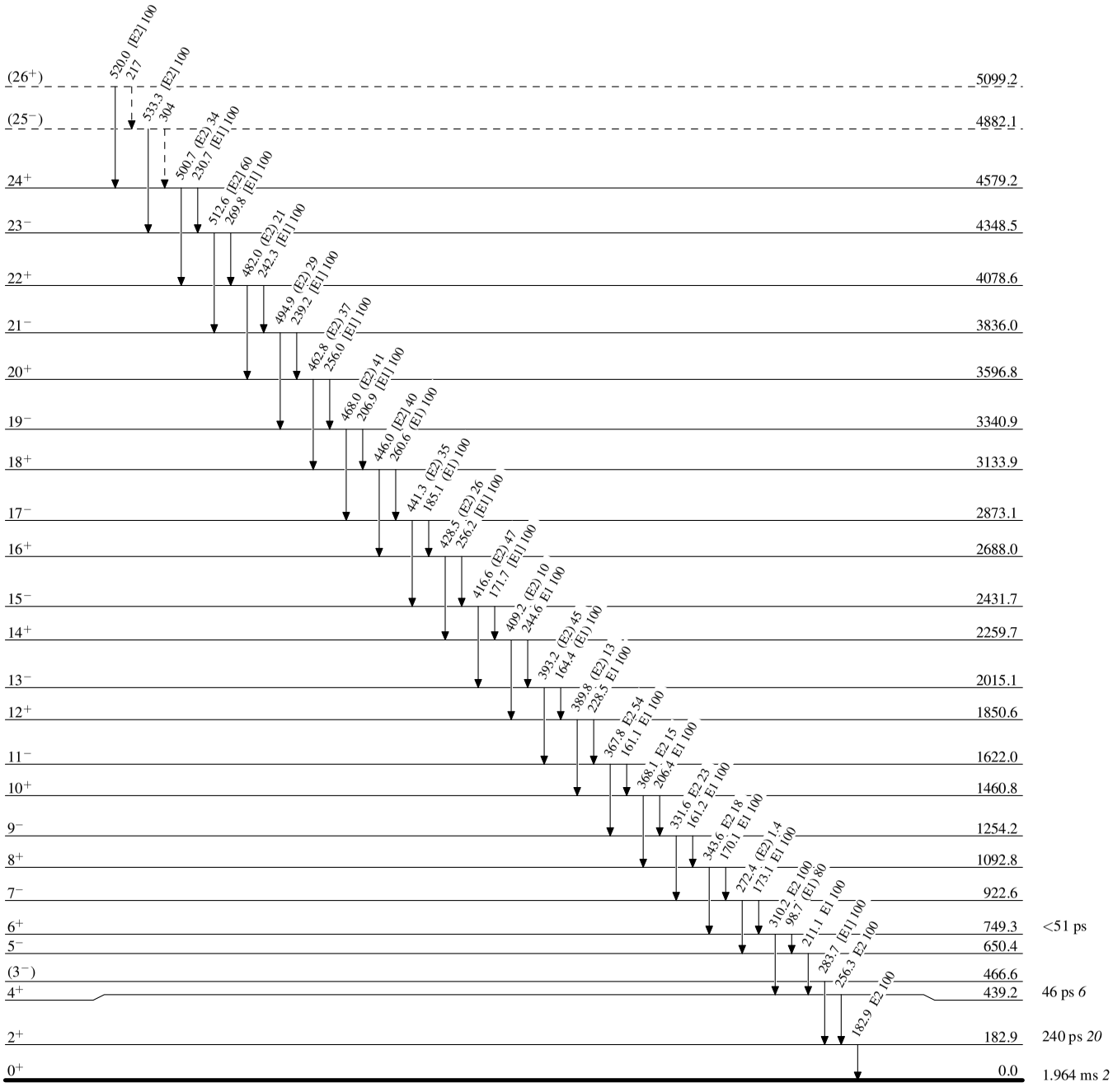
Adopted Levels, Gammas

Legend

Level Scheme

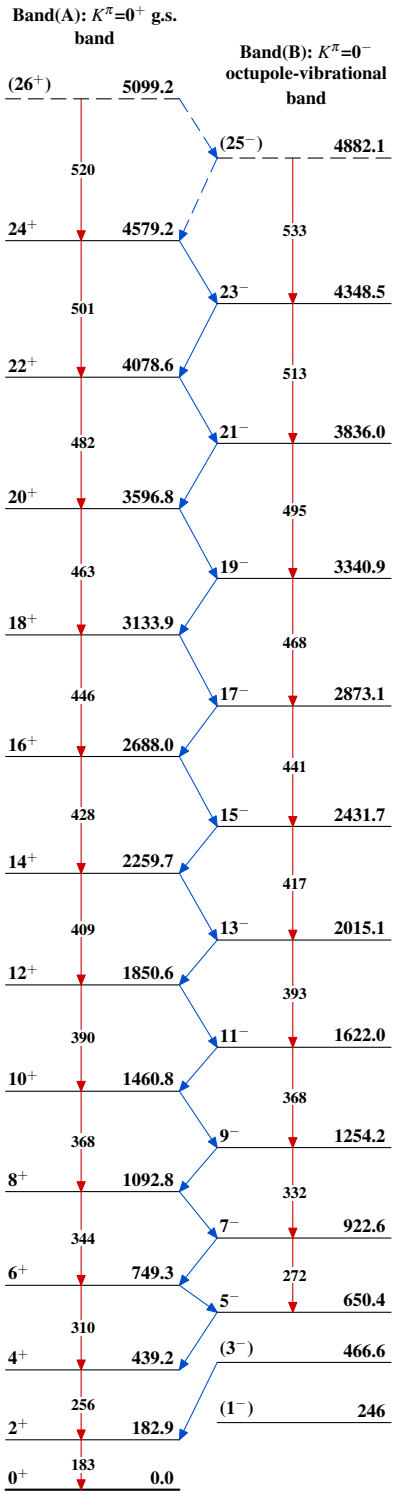
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{222}_{90}Th_{132}$

Adopted Levels, Gammas



$^{222}_{90}Th_{132}$