Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	K. Auranen and E. A. Mccutchan	NDS 168,117 (2020)	1-Aug-2020

Q(β^-)=−7480 *50*; S(n)=9102 *14*; S(p)=3348 *16*; Q(α)=7031.7 *17* 2017Wa10
S(2n)=16784 *14*; S(2p)=5172 *12*; Q(εp)=1267 *13* (2017Wa10).
2018Ro14: mass measurement, mass excess = −198.1 keV *248* compared with −199.0 keV *113* in AME-2016 (2017Wa10).
α: Additional information 1.

^{212}Ra Levels

The adopted level scheme and γ-ray data is largely that proposed and observed in 2018Pa04. It is based on Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, γ(t), and α(tot) measurements. The configurations are assigned based on semiempirical shell-model calculations. Some details are supplemented by data from the earlier studies, as indicated.

Cross Reference (XREF) Flags

A	^{216}Th α decay (26.0 ms)
B	^{216}Th α decay (133 μs)
C	^{204}Pb(^{12}C,4nγ)

E(level)†	J$^\pi$‡	T$_{1/2}$	XREF	Comments
0.0	0$^+$	13.0 s *2*	ABC	%ε+%β^+<15; %α>85 Nominal configuration $\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2}$. Measured α decay: 2003He06, 2001HeZY, 2014Ya19. T$_{1/2}$: from 1974Ho27. Others: 13 s *1* (1982Bo04), 15 s *2* (1968Lo15), 13 s *2* (1967Va22), 11.8 s *+13−10* (2000Ni02), 9.9 s *+46−24* (2014Ya19). %α,%ε+%β^+: theoretical partial β decay half-life of >100 s in 2019Mo01 yields %ε+%β^+<13. The $\varepsilon+\beta^+$ decay mode has not been observed. RMS charge radius $<r^2>^{1/2}$=5.599 fm *18* (2013An02).
629.30 *10*	2$^+$		ABC	Possible configuration $\pi h^6_{9/2}\otimes\nu p^{-1}_{1/2}f^{-1}_{5/2}$, but the shell model level energy is 600 keV above the experimental one, possibly indicating configuration mixing. J$^\pi$: E2 629γ to 0$^+$ g.s.
1454.30 *22*	4$^+$		BC	J$^\pi$: E2 825γ to 2$^+$ state.
1895.10 *24*	6$^+$		BC	Configuration $\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2}$. J$^\pi$: E2 441$\gamma$ to 4$^+$ state.
1958.4 *20*	8$^+$	9.3 μs *9*	BC	μ=7.104 *72* (1986Ko01) XREF: B(1967). J$^\pi$: from g-factor and supported by configuration assignment. configuration=$(\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2})_{8+}$. T$_{1/2}$: weighted average of 9.6 μs *13* from γ(t) in ^{204}Pb(^{12}C,4nγ) and 9.1 μs *9* from 2006He17 in ^{174}Yb(^{40}Ar,2nγ). Other: 7.1 *2* from 2013Ba29 in ^{9}Be(^{238}U,X). μ: from g-factor=0.888 *9* (1986Ko01, stroboscopic observation of perturbed angular distributions). Other: 1993Ne04.
2108.4 *20*	8$^+$		C	J$^\pi$: E3 505γ from 11$^-$ state. Configuration $\pi h^5_{9/2}f_{7/2}\otimes\nu p^{-2}_{1/2}$.
2577.2 *20*	10$^+$		C	J$^\pi$: E2 γ to 8$^+$ state.
2613.3 *20*	11$^-$	0.85 μs *13*	C	μ=12.01 *25* (1986Ko01) J$^\pi$: E3 655γ to 8$^+$ state. Configuration $\pi h^5_{9/2}i_{13/2}\otimes\nu p^{-2}_{1/2}$ supported by the measured g-factor. T$_{1/2}$: from ^{204}Pb(^{12}C,4nγ). Other: 0.48 μs *4* from 2013Ba29 in ^{9}Be(^{238}U,X). μ: from the measured g-factor=1.092 *22* (1986Ko01, stroboscopic observation of perturbed angular distributions).

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Adopted Levels, Gammas (continued)

^{212}Ra Levels (continued)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	XREF	Comments
2699.7 *20*	12$^+$		C	J$^\pi$: E2 122.5γ to 10$^+$ state.
3121.6 *20*	12$^-$		C	J$^\pi$: M1 283γ from 13$^-$ state.
3404.2 *20*	13$^-$		C	J$^\pi$: E2 791γ to 11$^-$ state.
3602.4 *20*			C	
3631.8 *20*	(13$^-$)		C	J$^\pi$: M1 317γ from (14$^-$) state.
3949.0 *20*	(14$^-$)		C	J$^\pi$: D 545γ to 13$^-$ state, negative parity proposed in 2018Pa04.
4107.2 *20*	15$^-$		C	J$^\pi$: E2 703γ to 13$^-$ state.
4197.8 *20*	(16$^-$)		C	J$^\pi$: E2 249γ to (14$^-$) state.
4350.9 *20*	(17$^-$)		C	J$^\pi$: M1 153γ to (16$^-$) state.
4552.6 *20*	(18$^-$)		C	J$^\pi$: M1+E2 202γ to (17$^-$) state.
5043.5 *20*	(19$^+$)	21.5 ns *21*	C	T$_{1/2}$: from 491γ(t) in ^{204}Pb(^{12}C,4nγ). Configuration $\pi h^4_{9/2} i^2_{13/2} \otimes \nu p^{-2}_{1/2}$. J$^\pi$: D 491$\gamma$ to (18$^-$) state, π from configuration assignment.
5125.0 *20*			C	
5414.7 *20*			C	
5877.1 *20*			C	
6137.8 *20*			C	
6370.3 *20*			C	

† From a least square fit to the Eγ data.
‡ From excited levels, based on measured multipolarities of transitions. For states populated in ^{204}Pb(^{12}C,4nγ) reaction there is the assumption of increasing spin with increasing excitation energy.

γ(^{212}Ra)

E$_i$(level)	J$^\pi_i$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$^\pi_f$	Mult.[‡]	α	Comments
629.30	2$^+$	629.3[#] *1*	100	0.0	0$^+$	E2	0.0230	α(K)=0.01624 *23*; α(L)=0.00504 *7*; α(M)=0.001273 *18*; α(N)=0.000336 *5*; α(O)=7.43×10^{-5} *11* α(P)=1.208×10^{-5} *17*; α(Q)=5.78×10^{-7} *8*
1454.30	4$^+$	825.0[#] *2*	100	629.30	2$^+$	E2	0.01311	α(K)=0.00985 *14*; α(L)=0.00245 *4*; α(M)=0.000607 *9*; α(N)=0.0001599 *23*; α(O)=3.57×10^{-5} *5* α(P)=5.93×10^{-6} *9*; α(Q)=3.40×10^{-7} *5*
1895.10	6$^+$	440.8[#] *1*	100	1454.30	4$^+$	E2	0.0526	α(K)=0.0323 *5*; α(L)=0.01508 *22*; α(M)=0.00391 *6*; α(N)=0.001032 *15*; α(O)=0.000226 *4* α(P)=3.55×10^{-5} *5*; α(Q)=1.205×10^{-6} *17*
1958.4	8$^+$	63.3 *20*	100	1895.10	6$^+$	[E2]	84 *14*	α(L)=61 *11*; α(M)=17 *3*; α(N)=4.4 *8*; α(O)=0.93 *16*; α(P)=0.134 *23*; α(Q)=0.00032 *5* B(E2)(W.u.)=0.0094 *+30−20* E$_\gamma$: 1986Ko01 observed ce(L) and ce(M), energy uncertainty not given, ±2 keV assumed by the evaluator for further fitting.
2108.4	8$^+$	150.0 *2*	100	1958.4	8$^+$			
2577.2	10$^+$	618.8 *1*	100	1958.4	8$^+$	E2	0.0238	α(K)=0.01676 *24*; α(L)=0.00529 *8*; α(M)=0.001337 *19*; α(N)=0.000353 *5*; α(O)=7.80×10^{-5} *11* α(P)=1.266×10^{-5} *18*; α(Q)=5.98×10^{-7} *9*
2613.3	11$^-$	(36.1[@])	57 *7*	2577.2	10$^+$	[E1]	1.67 *5*	α(L)=1.26 *4*; α(M)=0.312 *9*; α(N)=0.0800 *22*; α(O)=0.0166 *5*; α(P)=0.00228 *6* α(Q)=7.95×10^{-5} *18* B(E1)(W.u.)=7.6×10^{-7} *+15−12* I$_\gamma$: Deduced by the evaluator from the intensity balance of the 2577 keV level assuming no direct

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Adopted Levels, Gammas (continued)

$\gamma(^{212}Ra)$ (continued)

E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Mult.‡	δ‡	α	Comments
									feeding and that I(γ+ce)(123)=I(γ+ce)(932), i.e. I(γ+ce)(36) = I(γ+ce)(618)−I(γ+ce)(1025)−I(γ+ce)(932). Similar, but less precise value of I(γ)(36)=56 *14* was obtained from the intensity balance of the 2613 keV level.
2613.3	11⁻	504.9 *2*	100 *8*	2108.4	8⁺	E3		0.1352	α(K)=0.0617 *9*; α(L)=0.0541 *8*; α(M)=0.01454 *21*; α(N)=0.00386 *6*; α(O)=0.000842 *12* α(P)=0.0001312 *19*; α(Q)=3.47×10^{-6} *5* B(E3)(W.u.)=18 *4*
		654.9 *2*	86 *8*	1958.4	8⁺	E3		0.0625	α(K)=0.0358 *5*; α(L)=0.0198 *3*; α(M)=0.00521 *8*; α(N)=0.001381 *20*; α(O)=0.000304 *5* α(P)=4.83×10^{-5} *7*; α(Q)=1.734×10^{-6} *25* B(E3)(W.u.)=2.5 *5*
2699.7	12⁺	122.5 *1*	100	2577.2	10⁺	E2		4.03	α(K)=0.309 *5*; α(L)=2.74 *4*; α(M)=0.745 *11*; α(N)=0.197 *3*; α(O)=0.0419 *6*; α(P)=0.00609 *9* α(Q)=2.87×10^{-5} *4*
3121.6	12⁻	508.3 *1*	100	2613.3	11⁻	D+Q			
3404.2	13⁻	282.5 *1*	58 *8*	3121.6	12⁻	M1		0.837	α(K)=0.673 *10*; α(L)=0.1237 *18*; α(M)=0.0295 *5*; α(N)=0.00779 *11*; α(O)=0.001777 *25* α(P)=0.000310 *5*; α(Q)=2.43×10^{-5} *4*
		791.0 *1*	100 *15*	2613.3	11⁻	E2		0.01426	α(K)=0.01063 *15*; α(L)=0.00273 *4*; α(M)=0.000677 *10*; α(N)=0.0001784 *25* α(O)=3.98×10^{-5} *6*; α(P)=6.59×10^{-6} *10*; α(Q)=3.69×10^{-7} *6*
3602.4		1025.2 *2*	100	2577.2	10⁺				
3631.8	(13⁻)	(29.4@)		3602.4					
		932.0 *1*		2699.7	12⁺				
3949.0	(14⁻)	317.3 *1*	18 *4*	3631.8	(13⁻)	M1		0.608	α(K)=0.490 *7*; α(L)=0.0897 *13*; α(M)=0.0214 *3*; α(N)=0.00565 *8*; α(O)=0.001288 *18* α(P)=0.000225 *4*; α(Q)=1.760×10^{-5} *25*
		544.8 *1*	100 *13*	3404.2	13⁻	D			
4107.2	15⁻	475.2 *2*	63 *15*	3631.8	(13⁻)				
		703.1 *1*	100 *24*	3404.2	13⁻	E2		0.0182	α(K)=0.01321 *19*; α(L)=0.00371 *6*; α(M)=0.000929 *13*; α(N)=0.000245 *4*; α(O)=5.45×10^{-5} *8* α(P)=8.94×10^{-6} *13*; α(Q)=4.64×10^{-7} *7*
4197.8	(16⁻)	(90.6@)		4107.2	15⁻				
		248.8 *1*		3949.0	(14⁻)	E2		0.275	α(K)=0.1045 *15*; α(L)=0.1257 *18*; α(M)=0.0337 *5*; α(N)=0.00889 *13*; α(O)=0.00191 *3* α(P)=0.000287 *4*; α(Q)=4.37×10^{-6} *7*
4350.9	(17⁻)	153.1 *2*	100	4197.8	(16⁻)	M1		4.65	α(K)=3.73 *6*; α(L)=0.694 *10*; α(M)=0.1658 *24*; α(N)=0.0437 *7*; α(O)=0.00997 *15* α(P)=0.00174 *3*; α(Q)=0.0001363 *20*

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Adopted Levels, Gammas (continued)

$\gamma(^{212}Ra)$ (continued)

E_i(level)	J^π_i	E_γ †	I_γ †	E_f	J^π_f	Mult.‡	δ‡	α	Comments
4552.6	(18⁻)	201.7 *1*	100	4350.9	(17⁻)	M1+E2	0.43 *+12−13*		
5043.5	(19⁺)	490.9 *1*	100	4552.6	(18⁻)	(E1)		0.01224	α(K)=0.00998 *14*; α(L)=0.001719 *24*; α(M)=0.000407 *6*; α(N)=0.0001066 *15* α(O)=2.40×10^{-5} *4*; α(P)=4.08×10^{-6} *6*; α(Q)=2.87×10^{-7} *4* B(E1)(W.u.)=7.4×10^{-8} *8* D from $\gamma(\theta)$, $\Delta\pi$ from level scheme.
5125.0		774.1 *1*	100	4350.9	(17⁻)				
5414.7		289.7 *1*	100 *16*	5125.0					
		371.1 *1*	94 *17*	5043.5	(19⁺)				
5877.1		462.4 *1*	89 *17*	5414.7					
		833.7 *1*	100 *22*	5043.5	(19⁺)				
6137.8		260.6 *1*	100	5877.1					
6370.3		493.1 *2*	100	5877.1					

† From $^{204}Pb(^{12}C,4n\gamma)$, except where noted.

‡ From $\gamma(\theta)$ and α(exp) in $^{204}Pb(^{12}C,4n\gamma)$, except where noted.

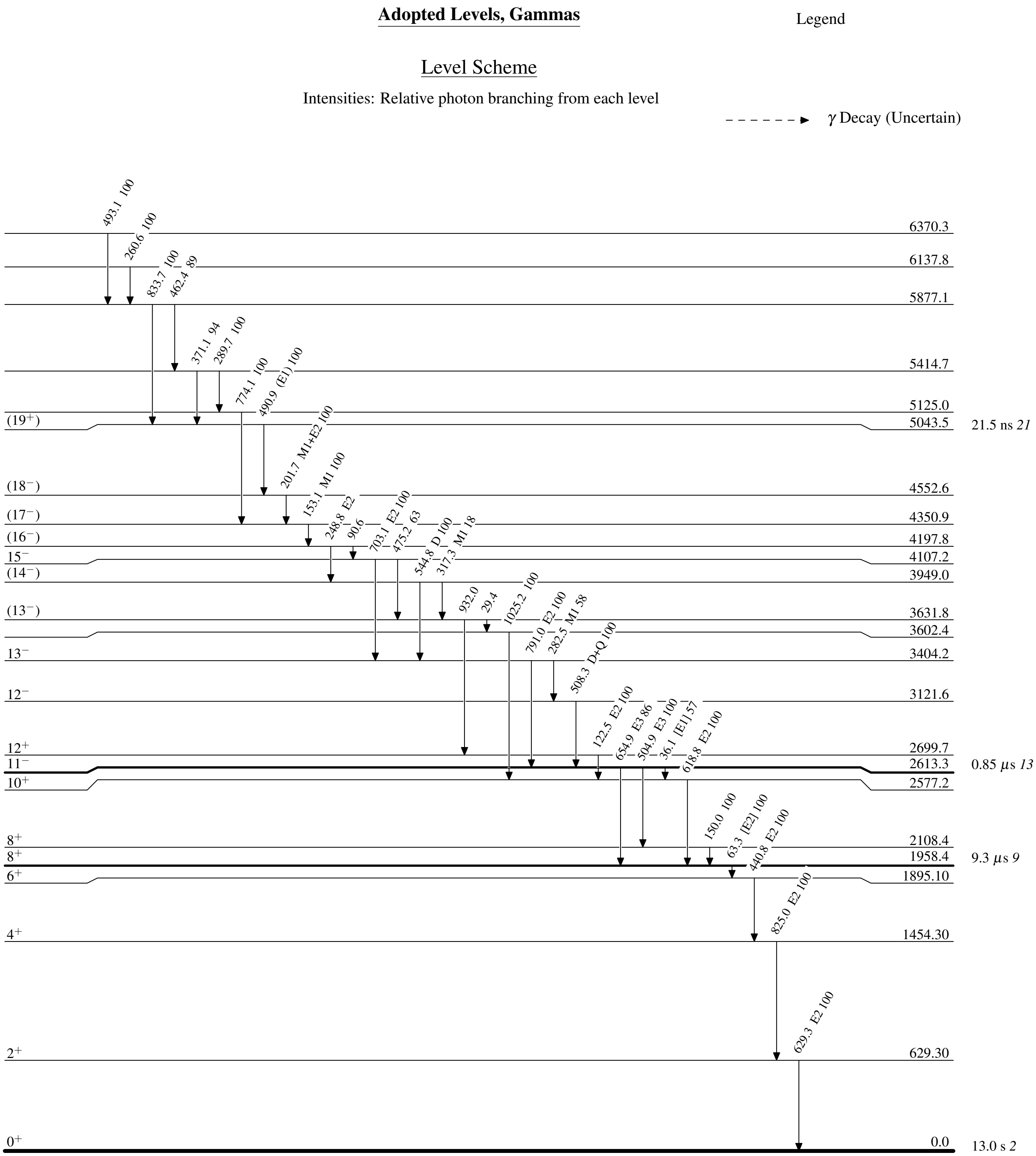
From ^{216}Th α decay (133 μs).

@ Transition not observed, but suggested by the $\gamma\gamma$-coincidence analysis of 2018Pa01. Eγ deduced by the evaluators from level energy differences.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{212}_{88}Ra_{124}$