^{204}Pb(^{12}C,4nγ) 1986Ko01,2018Pa04

History

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

2018Pa04: the nuclei of interest were produced in the ^{204}Pb(^{12}C,4n)^{212}Ra fusion evaporation reaction at the Heavy Ion Accelerator Facility at the Australian National University, Canberra. The 5.4-mg/cm^2 thick ^{204}Pb targets were enriched to 99.6% purity. The 81 MeV ^{12}C beam was provided by the 14UD accelerator in ~1 ns long pulses separated by 1712 ns. Prompt and delayed γ rays were detected with the CAESAR HPGe array. Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, γ(t), and α(tot) were measured.

2004He25: the nuclei of interest were produced in the ^{204}Pb(^{12}C,4n)^{212}Ra fusion evaporation reaction with E(^{12}C)=103 MeV. Recoil products selected by the velocity filter SHIP. Measured Eγ, Iγ, implant-γ(t) using an HPGe detector. Deduced $T_{1/2}$ of 1958 level.

1986Ko01: E(^{12}C)=70-90 MeV. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma(\theta)$, γ(lin pol), γ(t) using Ge(Li) detectors. Measured E_{ce}, I_{ce} using Si(Li) detector and superconducting solenoid. Observed level scheme up to a J=16 state at 3929 keV. Proposed level scheme is in good agreement with that of 2018Pa04 up to the J$^\pi$=13$^-$ level at 3404 keV. Above that there are 4 levels and 4 depopulating γ rays that are alternatively placed in 2018Pa04.

The level scheme is that proposed in 2018Pa04. The configurations are assigned based on semiempirical shell-model calculations. Some details are filled from the earlier study 1986Ko01 as indicated.

α: Additional information 1.

^{212}Ra Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
0.0	0$^+$		Nominal configuration $\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2}$.
629.30 *10*	2$^+$		J$^\pi$: from 1986Ko01. 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.
1454.30 *14*	4$^+$		J$^\pi$: from 1986Ko01.
1895.10 *17*	6$^+$		J$^\pi$: from 1986Ko01. Configuration $\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2}$.
1958.4 *20*	8$^+$	9.6 μs *13*	μ=7.104 *72* μ: from g-factor=0.888 *9*, stroboscopic method (1986Ko01). J$^\pi$: Configuration $(\pi h^6_{9/2}\otimes\nu p^{-2}_{1/2})_{8+}$ supported by the measured g-factor 1986Ko01. $T_{1/2}$: unweighted average of 10.9 μs *4* from γ(t) (1986Ko01) and 8.3 μs *3* (2004He25) obtained from a weighted average of 8.3 μs *3* from 440γ(t), 8.6 μs *6* from 629γ(t), and 8.0 μs *7* from 825γ(t). J$^\pi$: from 1986Ko01.
2108.4 *20*	8$^+$		Configuration $\pi h^5_{9/2}f_{7/2}\otimes\nu p^{-2}_{1/2}$.
2577.2 *20*	10$^+$		
2613.3 *20*	11$^-$	0.85 μs *13*	μ=12.01 *25* μ: from the measured g-factor=1.092 *22*, stroboscopic method (1986Ko01). J$^\pi$: 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 1986Ko01, which was confirmed in 2018Pa04, but no numerical value obtained due to maximum beam pulse separation of 1.7 μs.
2699.7 *20*	12$^+$		
3121.6 *20*	12$^-$		
3404.2 *20*	13$^-$		
3602.4 *20*			
3631.8 *20*	(13$^-$)		
3949.0 *20*	(14$^-$)		
4107.2 *20*	15$^-$		
4197.8 *20*	(16$^-$)		
4350.9 *20*	(17$^-$)		
4552.6 *20*	(18$^-$)		
5043.5 *20*	(19$^+$)	21.5 ns *21*	$T_{1/2}$: from 491γ(t) (2018Pa04). Configuration $\pi h^4_{9/2}i^2_{13/2}\otimes\nu p^{-2}_{1/2}$.

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$^{204}Pb(^{12}C,4n\gamma)$ 1986Ko01,2018Pa04 (continued)

^{212}Ra Levels (continued)

E(level)[†]
5125.0 *20*
5414.7 *20*
5877.2 *20*
6137.8 *20*
6370.3 *20*

[†] From a least-squares fit to Eγ, by evaluators.
[‡] The assignments are those proposed by 2018Pa04, unless specified otherwise.

$\gamma(^{212}Ra)$

All γ-ray data are from 2018Pa04, unless indicated otherwise.
Internal conversion coefficients are deduced from an intensity balance across the levels in 2018Pa04.
A_2 value obtained with A_4 set to zero in fitting the angular distributions. Data were collected in γγ coincidence mode, with coincident gates set of known ΔJ=2 E2 transitions. Expected values, taking alignment σ/J=0.3 were −0.2 for ΔJ=1 dipole, +0.28 for ΔJ=2 quadrupole and +0.46 for ΔJ=3 octupole.

E_γ	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ	α	Comments
(29.4[a])		3631.8	(13⁻)	3602.4					
(36.1[a])	15.5 *20*	2613.3	11⁻	2577.2	10⁺	[E1]		1.668	α(L)=1.257 *18*; α(M)=0.312 *5*; α(N)=0.0800 *12*; α(O)=0.01661 *24*; α(P)=0.00228 *4* α(Q)=7.95×10⁻⁵ *12* I_γ: deduced by the evaluator from the intensity balance of the 2577 keV level assuming no direct population 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 Iγ(36)=15.3 *38* was obtained from the intensity balance of the 2613 keV level.
63.3 *20*		1958.4	8⁺	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* E_γ: observed ce(L) and ce(M) in 1986Ko01 experiment, energy uncertainty not given, ±2 keV assumed by the evaluator for further fitting.
(90.6[a])		4197.8	(16⁻)	4107.2	15⁻				
122.5 *1*		2699.7	12⁺	2577.2	10⁺	E2		4.03	α(exp)=4.7 *10* 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*
150.0 *2*	4.9 *6*	2108.4	8⁺	1958.4	8⁺				
153.1 *2*	5.9 *14*	4350.9	(17⁻)	4197.8	(16⁻)	M1		4.65	α(exp)=5.0 *3* 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* A_2=+1.0 *4*.

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^{204}Pb(^{12}C,4nγ) 1986Ko01,2018Pa04 (continued)

γ(^{212}Ra) (continued)

E_γ	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ	α	Comments
201.7 *1*	7.9 *16*	4552.6	(18⁻)	4350.9	(17⁻)	M1+E2	0.43 +*12*−*13*	1.89 *13*	α(exp)=1.89 *11* α(K)=1.47 *12*; α(L)=0.315 *5*; α(M)=0.0766 *12*; α(N)=0.0202 *3*; α(O)=0.00457 *7* α(P)=0.000778 *14*; α(Q)=5.4×10^{-5} *5* A_2=+0.3 *2*. δ: from γ(θ).
248.8 *1*	35.8 *40*	4197.8	(16⁻)	3949.0	(14⁻)	E2		0.275	α(exp)=0.31 *4* 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* A_2=+0.24 *14*.
260.6 *1*	24.9 *30*	6137.8		5877.2					A_2=+0.45 *23*.
282.5 *1*	23.1 *31*	3404.2	13⁻	3121.6	12⁻	M1		0.837	α(exp)=0.98 *5* 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* A_2=−0.66 *17*.
289.7 *1*	14.0 *23*	5414.7		5125.0					A_2=−0.6 *3*.
317.3 *1*	7.5 *18*	3949.0	(14⁻)	3631.8	(13⁻)	M1		0.608	α(exp)=0.65 *13* 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*
371.1 *1*	13.2 *24*	5414.7		5043.5	(19⁺)				
440.8[b]		1895.10	6⁺	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* E_γ: other: 440.2 *6* (2004He25).
462.4 *1*	17.6 *33*	5877.2		5414.7					A_2=−0.3 *4*.
475.2 *2*	10.4 *24*	4107.2	15⁻	3631.8	(13⁻)				
490.9 *1*	30.3 *45*	5043.5	(19⁺)	4552.6	(18⁻)	D			A_2=−0.23 *18*.
493.1 *2*	9.1 *22*	6370.3		5877.2					
504.9 *2*	27.4 *22*	2613.3	11⁻	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*
508.3 *1*	51.1 *58*	3121.6	12⁻	2613.3	11⁻	D+Q			A_2=−0.85 *10*.
544.8 *1*	41.5 *52*	3949.0	(14⁻)	3404.2	13⁻	D			A_2=−0.07 *15*.
618.8 *1*	48.9 *35*	2577.2	10⁺	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*
629.3[b]		629.30	2⁺	0.0	0⁺	E2[&]		0.0230	α(K)=0.01624 *23*; α(L)=0.00504 *7*;

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^{204}Pb(^{12}C,4nγ) 1986Ko01,2018Pa04 (continued)

γ(^{212}Ra) (continued)

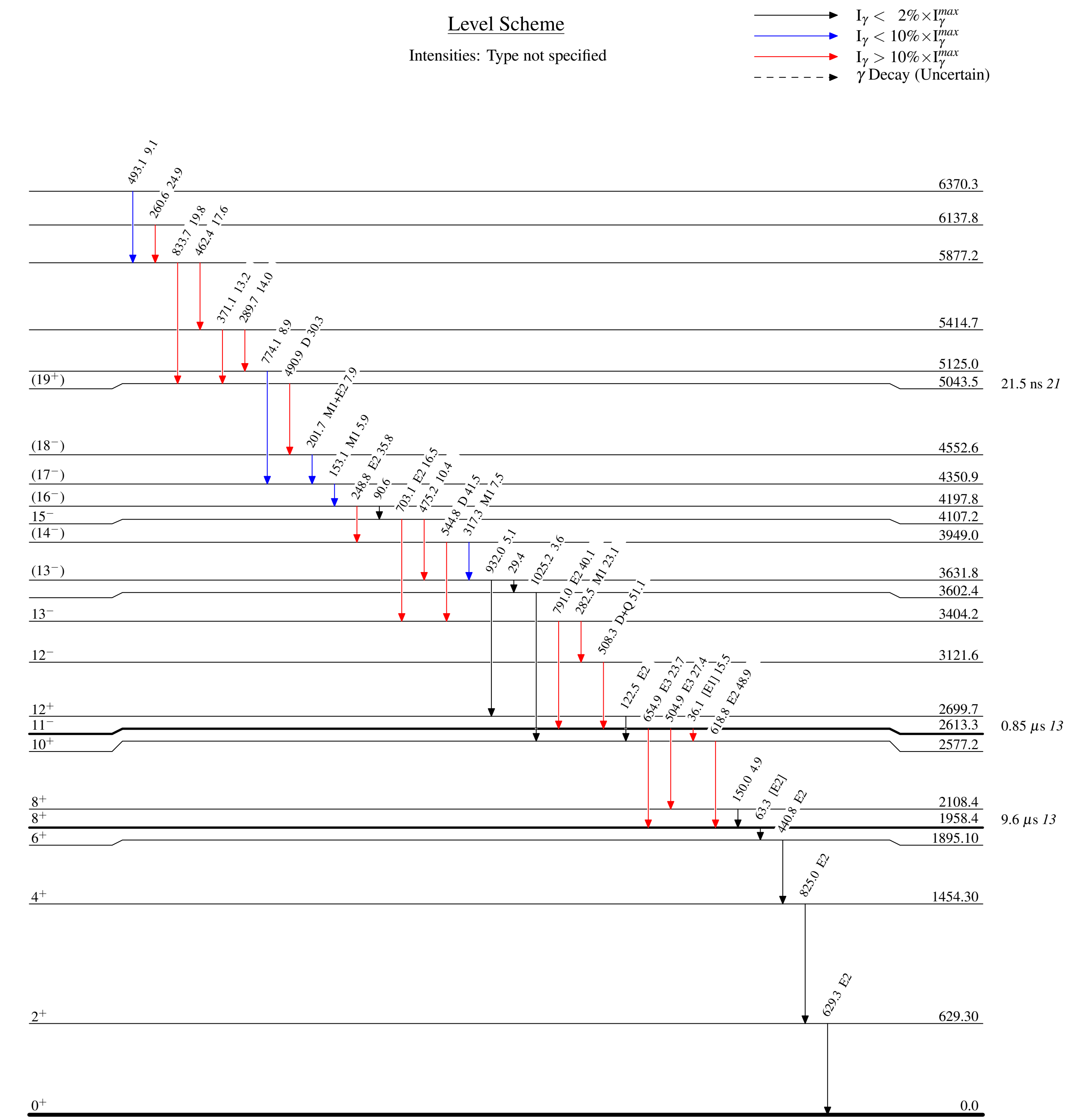
E_γ	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	α	Comments
								α(M)=0.001273 *18*; α(N)=0.000336 *5*; α(O)=7.43×10^{-5} *11* α(P)=1.208×10^{-5} *17*; α(Q)=5.78×10^{-7} *8* E_γ: other: 628.6 *6* (2004He25).
654.9 *2*	23.7 *23*	2613.3	11$^-$	1958.4	8$^+$	E3[#]	0.0625	α(K)=0.0358 *5*; α(L)=0.0198 *3*; 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*
703.1 *1*	16.5 *39*	4107.2	15$^-$	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* A_2=+0.7 *2*.
774.1 *1*	8.9 *26*	5125.0		4350.9	(17$^-$)			
791.0 *1*	40.1 *59*	3404.2	13$^-$	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* A_2=+0.48 *14*.
825.0[b]		1454.30	4$^+$	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* E_γ: other: 824.3 *6* (2004He25).
833.7 *1*	19.8 *44*	5877.2		5043.5	(19$^+$)			
932.0 *1*	5.1 *23*	3631.8	(13$^-$)	2699.7	12$^+$			
1025.2 *2*	3.6 *30*	3602.4		2577.2	10$^+$			

[†] As given in 2018Pa04, normalized to the Iγ(619).
[‡] From γ(θ) and α(exp) in 2018Pa04 , except where noted.
[#] Positive A_2 for γ(θ), $T_{1/2}$(2613.4 level), and measured conversion coefficient suggest E3 (1986Ko01), details not provided by authors.
[@] Measured α suggests E2 (1986Ko01), details not provided by authors.
[&] From γ(θ) and γ(pol) (1986Ko01), details not provided by authors.
[a] Transition not observed in 2018Pa04, but γγ coincidence relations suggest its presence. Energy from level energy difference.
[b] From 1986Ko01. Values are identical in 2018Pa04 and were likely taken from the literature. 0.1 keV uncertainty assumed for least-squares fitting.

$^{204}Pb(^{12}C,4n\gamma)$ 1986Ko01,2018Pa04

Level Scheme

Intensities: Type not specified



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