^{204}Pb(^{13}C,4nγ) 2018Pa04,2021Ge07

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia	NDS 181, 475 (2022)	1-Jan-2022

Combined 2021Ge07 data with the XUNDL dataset of 2018Pa04, compiled by B. Singh (McMaster), Feb 8, 2018.

2018Pa04: E(^{13}C)=80 MeV pulsed beam. Target=5.4 mg/cm^2 thick, 99.6% enriched ^{204}Pb. Prompt and delayed (out-of-beam) γ rays were detected using CAESAR array of nine Compton-suppressed HPGe detectors, and two LEPS Ge detectors for low-energy γ radiation. Measured Eγ, Iγ, γγ-coin, γ(θ). Deduced high-spin levels, J^π, lifetime of a new isomer, total conversion coefficients of low-energy γ rays, multipolarities, configurations.

2021Ge07 (same lab and research group of 2018Pa04): E(^{13}C)=80 MeV pulsed beam. Target=5.4 mg/cm^2 thick, 99.6% enriched ^{204}Pb. Emitted γ rays were measured using the CAESAR array of six Compton-suppressed $LaBr_3$ detectors, three suppressed HPGe and one unsuppressed LEPS Ge detector. Measured Eγ, γγ-coin, γγ time difference spectra. Deduced lifetime for the 5/2$^-$ state at 546 keV.

^{213}Ra Levels

Nominal configurations are as given in 2018Pa04 in their Table V.

E(level)†	J$^\pi$‡	T$_{1/2}$	Comments
0.0	1/2$^-$		Configuration: $\pi(h^6_{9/2})_{0+}\otimes\nu p^{-1}_{1/2}$.
546.35 *5*	(5/2$^-$)	21.5 ps *28*	Configuration: $\pi(h^6_{9/2})_{0+}\otimes\nu f^{-1}_{5/2}$. T$_{1/2}$: From τ=31 ps *4* (2021Ge07), from γ gated time difference measurements by Generalised Centroid Difference method.
1608.85 *21*	(9/2$^-$)		Configuration: $\pi(h^6_{9/2})_{4+}\otimes\nu p^{-1}_{1/2}$.
1769.72 *22*	(13/2$^-$)		Configuration: $\pi(h^6_{9/2})_{6+}\otimes\nu p^{-1}_{1/2}$.
1770 *5*	(17/2$^-$)	2.18 ms *5*	Additional information 1. E(level),T$_{1/2}$: From Adopted Levels. Configuration: $\pi(h^6_{9/2})_{8+}\otimes\nu p^{-1}_{1/2}$.
2287.50 *10*	21/2$^-$		Configuration: $\pi(h^6_{9/2})_{8+}\otimes\nu f^{-1}_{5/2}$.
2609.90 *14*	23/2$^+$	18.7 ns *21*	Configuration: $\pi[(h^5_{9/2})_{9/2}i_{13/2}]_{11-}\otimes\nu p^{-1}_{1/2}$. T$_{1/2}$: from τ=27 ns *3* (^{13}C,4nγ) – 2018Pa04) – based on (455γ+731γ)(322γ)(Δt) measurements.
3065.3 *4*	25/2$^+$		Configuration: $\pi[(h^5_{9/2})_{9/2}i_{13/2}]_{10-}\otimes\nu f^{-1}_{5/2}$.
3136.6 *3*	25/2$^-$		Configuration: $\pi(h^6_{9/2})_{12+}\otimes\nu p^{-1}_{1/2}$.
3281.1 *5*	25/2$^-$		Configuration: $\pi[(h^5_{9/2})_{17/2}f_{7/2}]_{12+}\otimes\nu p^{-1}_{1/2}$.
3340.4 *4*	27/2$^+$		Configuration: $\pi[(h^5_{9/2})_{9/2}i_{13/2}]_{11-}\otimes\nu f^{-1}_{5/2}$.
3345.60 *22*	25/2$^-$		Configuration: $\pi(h^6_{9/2})_{10+}\otimes\nu f^{-1}_{5/2}$.
3433.2 *3*	27/2$^-$		Configuration: $\pi[(h^5_{9/2})_{21/2}f_{7/2}]_{13+}\otimes\nu p^{-1}_{1/2}$.
3441.4 *5*	29/2$^-$		Configuration: $\pi[(h^5_{9/2})_{21/2}f_{7/2}]_{14+}\otimes\nu p^{-1}_{1/2}$.
3863.8 *8*	27/2$^+$		Configuration: $\pi[(h^5_{9/2})_{13/2}i_{13/2}]_{13-}\otimes\nu p^{-1}_{1/2}$.
3878.0 *6*	29/2$^+$		Configuration: $\pi[(h^5_{9/2})_{17/2}i_{13/2}]_{14-}\otimes\nu p^{-1}_{1/2}$.
4006.9 *5*	31/2$^+$		Configuration: $\pi[(h^5_{9/2})_{17/2}i_{13/2}]_{15-}\otimes\nu p^{-1}_{1/2}$.
4047.7 *6*	33/2$^+$	34.7 ns *21*	Configuration: $\pi[(h^5_{9/2})_{21/2}i_{13/2}]_{16-}\otimes\nu p^{-1}_{1/2}$. T$_{1/2}$: from τ=50 ns *3* ((^{13}C,4nγ) – 2018Pa04) – based on (455γ+731γ)(322γ)(Δt) measurements. Lifetime measured by (beam pulse)(566γ and 667γ)(t) showed no difference.
4047.7+x?	(35/2$^+$)		Additional information 2.
4506.2+x?	(37/2$^+$)		Additional information 3.

† From least-squares fit to Eγ data.

‡ Up to 1770 from Adopted Levels, above assignments are from 2018Pa04, based on proposed γ multipolarity from measured γ(θ) data and deduced total conversion coefficients.

γ(^{213}Ra)

A_2 values are from 2018Pa04, with A_4 set to zero. These data were obtained in γγ-coin mode, with coincident gates placed on known ΔJ=2, E2 transitions. Typical A_2 values, based on alignment σ/J=0.3, were expected as −0.2 for ΔJ=1, dipole, +0.28 for ΔJ=2, quadrupole (E2), and +0.46 for ΔJ=3, octupole (E3) transitions.

The α(total)expt values are from 2018Pa04, based on intensity balance arguments in γγ-coin mode.

E_γ	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ[@]	α[&]	Comments
y[a]		4047.7+x?	(35/2$^+$)	4047.7	33/2$^+$				
(8.2[†])		3441.4	29/2$^-$	3433.2	27/2$^-$	[M1]		1213 *17*	α(M)=908 *13* α(N)=240.5 *34*; α(O)=54.9 *8*; α(P)=9.56 *13*; α(Q)=0.754 *11*
(14.2[†])		3878.0	29/2$^+$	3863.8	27/2$^+$	[M1]		236.8 *33*	α(M)=177.3 *25* α(N)=46.8 *7*; α(O)=10.68 *15*; α(P)=1.861 *26*; α(Q)=0.1466 *21* E_γ: 14.4 in 2018Pa04.
(40.8[†])		4047.7	33/2$^+$	4006.9	31/2$^+$	[M1]		42.8 *6*	α(L)=32.4 *5*; α(M)=7.76 *11* α(N)=2.046 *29*; α(O)=0.467 *7*; α(P)=0.0814 *11*; α(Q)=0.00641 *9* E_γ: 40.9 in 2018Pa04.
87.6 *4*		3433.2	27/2$^-$	3345.60	25/2$^-$	[M1]		4.56 *9*	α(L)=3.46 *7*; α(M)=0.827 *16* α(N)=0.218 *4*; α(O)=0.0498 *10*; α(P)=0.00868 *17*; α(Q)=0.000682 *13*
152.1 *5*	2.3 *2*	3433.2	27/2$^-$	3281.1	25/2$^-$	M1+E2	0.7 *3*	3.7 *6*	α(exp)=3.7 *5* (2018Pa04) α(K)=2.6 *7*; α(L)=0.81 *6*; α(M)=0.205 *21* α(N)=0.054 *6*; α(O)=0.0120 *11*; α(P)=0.00195 *11*; α(Q)=9.8×10^{-5} *24* α for δ(E2/M1)=0.7 (deduced by 2018Pa04 from α(total)exp).
160.87[‡] *5*		1769.72	(13/2$^-$)	1608.85	(9/2$^-$)				
169.7 *3*	4.4 *2*	4047.7	33/2$^+$	3878.0	29/2$^+$	E2		1.079 *17*	α(exp)=1.3 *2* (2018Pa04) α(K)=0.2176 *31*; α(L)=0.634 *10*; α(M)=0.1717 *28* α(N)=0.0454 *7*; α(O)=0.00969 *16*; α(P)=0.001426 *23*; α(Q)=1.139×10^{-5} *17*
[x]204									γ in coin with 297, 314, 377, 397/398, 416, 447, 518, 849, 994 and 1058 γ rays.
275.0 *4*	4.2 *2*	3340.4	27/2$^+$	3065.3	25/2$^+$	M1+E2	0.64 *2*	0.697 *14*	α(exp)=0.99 *8* (2018Pa04); A_2=−0.41 *16* α(K)=0.539 *11*; α(L)=0.1190 *19*; α(M)=0.0291 *4* α(N)=0.00768 *12*; α(O)=0.001730 *27*; α(P)=0.000293 *5*; α(Q)=1.96×10^{-5} *4* δ: Deduced using the α(exp) datum and BriccMixing code.
296.6 *2*	12.3 *3*	3433.2	27/2$^-$	3136.6	25/2$^-$	M1		0.732 *10*	α(exp)=0.96 *9* (2018Pa04); A_2=−0.73 *4* α(K)=0.589 *8*; α(L)=0.1081 *15*; α(M)=0.0258 *4* α(N)=0.00680 *10*; α(O)=0.001552 *22*; α(P)=0.000271 *4*; α(Q)=2.121×10^{-5} *30* δ: 0.00 *16* from the α(exp) datum and BriccMixing code.
304.8 *8*	1.8 *2*	3441.4	29/2$^-$	3136.6	25/2$^-$	[E2]		0.1450 *23*	α(K)=0.0686 *10*; α(L)=0.0565 *10*; α(M)=0.01499 *26*

γ(^{213}Ra) (continued)

E_γ	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	α[&]	Comments
								α(N)=0.00396 *7*; α(O)=0.000856 *15*; α(P)=0.0001305 *22*; α(Q)=2.72×10^{-6} *4*
[x]314								γ in coin with 204, 297, 377, 397/398, 416, 447, 518, 849, 994 and 1058 γ rays.
322.4 *1*	44.6 *6*	2609.90	23/2$^+$	2287.50	21/2$^-$	E1	0.0299 *4*	α(exp)=0.11 *5* (2018Pa04); A_2=−0.31 *5* α(K)=0.02418 *34*; α(L)=0.00438 *6*; α(M)=0.001042 *15* α(N)=0.000273 *4*; α(O)=6.10×10^{-5} *9*; α(P)=1.021×10^{-5} *14*; α(Q)=6.70×10^{-7} *9*
[x]377								γ in coin with 204, 297, 314, 397/398, 416, 447, 518, 849, 994 and 1058 γ rays.
[x]397								γ in coin with 204, 297, 314, 377, 398, 416, 447, 518, 849, 994 and 1058 γ rays.
[x]398								γ in coin with 204, 297, 314, 377, 397, 416, 447, 518, 849, 994 and 1058 γ rays.
[x]416								γ in coin with 204, 297, 377, 397/398, 518, 849, 994 and 1058 γ rays.
436.7 *8*	2.4 *2*	3878.0	29/2$^+$	3441.4	29/2$^-$	[E1]	0.01557 *23*	α(K)=0.01266 *18*; α(L)=0.002211 *32*; α(M)=0.000524 *8* α(N)=0.0001373 *20*; α(O)=3.09×10^{-5} *4*; α(P)=5.22×10^{-6} *8*; α(Q)=3.61×10^{-7} *5*
[x]447								γ in coin with 204, 297, 377, 397/398, 518, 849, 994 and 1058 γ rays.
455.4 *4*	7.1 *3*	3065.3	25/2$^+$	2609.90	23/2$^+$	M1+E2		A_2=−1.06 *6*
458.7[a] *6*		4506.2+x?	(37/2$^+$)	4047.7+x?	(35/2$^+$)			
[x]459								γ in coin with 297, 397/398, 518, 565, 667, 849, 994 and 1058 γ rays.
517.5 *1*	100	2287.50	21/2$^-$	1770	(17/2$^-$)	E2		A_2=+0.26 *1*
537.8 *11*	2.0 *2*	3878.0	29/2$^+$	3340.4	27/2$^+$	M1		A_2=−0.46 *7*
546.35[‡] *5*		546.35	(5/2$^-$)	0.0	1/2$^-$			
565.5 *2*	41.0 *7*	4006.9	31/2$^+$	3441.4	29/2$^-$	E1		A_2=−0.46 *6*
606.3 *5*	5.4 *3*	4047.7	33/2$^+$	3441.4	29/2$^-$	[M2+E3]	0.18 *10*	α(K)=0.13 *9*; α(L)=0.037 *11*; α(M)=0.0094 *24* α(N)=0.0025 *6*; α(O)=5.6×10^{-4} *15*; α(P)=9.4×10^{-5} *30*; α(Q)=6.E−6 *4*
666.5 *4*	10.0 *4*	4006.9	31/2$^+$	3340.4	27/2$^+$	E2		A_2=+0.38 *13*
730.5 *5*	5.8 *3*	3340.4	27/2$^+$	2609.90	23/2$^+$	E2		A_2=+0.38 *17*
798.5 *10*	0.7 *2*	3863.8	27/2$^+$	3065.3	25/2$^+$	[M1+E2]	0.033 *19*	α(K)=0.026 *16*; α(L)=0.0050 *24*; α(M)=0.0012 *6* α(N)=3.2×10^{-4} *15*; α(O)=7.3×10^{-5} *34*; α(P)=1.3×10^{-5} *6*; α(Q)=9.E−7 *6*
849.1 *3*	24.4 *6*	3136.6	25/2$^-$	2287.50	21/2$^-$	E2		A_2=+0.38 *4*
993.6 *7*	3.7 *3*	3281.1	25/2$^-$	2287.50	21/2$^-$	E2		A_2=+0.33 *14*
1058.1 *2*	28.3 *7*	3345.60	25/2$^-$	2287.50	21/2$^-$	E2		A_2=+0.30 *5*
1062.5[‡] *2*		1608.85	(9/2$^-$)	546.35	(5/2$^-$)			

[†] This γ not seen but required from the analysis of γγ-coin data. Energy deduced from level-energy difference.

[‡] From Adopted Gammas.

$^{213}_{88}$Ra$_{125}$-3

γ(^{213}Ra) (continued)

Delayed γ-intensities relative to Iγ(517.5)=100 for 'out-of-beam' data.

@ From 2018Pa04, based on $\gamma(\theta)$ data and α(tot)exp. Multipolarities listed in square brackets are from ΔJ^{π} assigned in their work (see footnote 'a' in Table I of 2018Pa04).

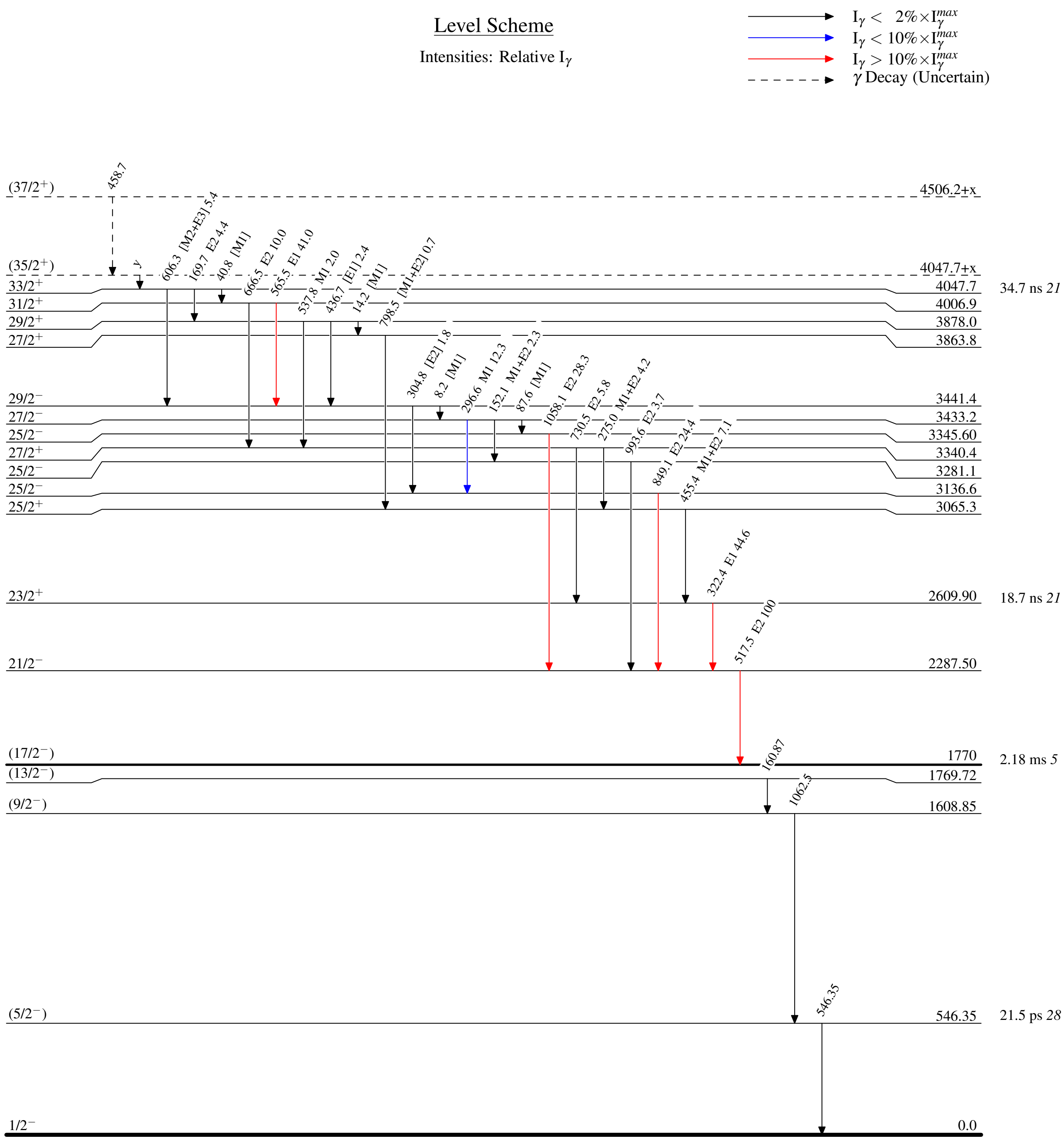
& Additional information 4.

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

[x] γ ray not placed in level scheme.

$^{213}_{88}$Ra$_{125}$-4

^{204}Pb(^{13}C,4nγ) 2018Pa04,2021Ge07



$^{213}_{88}Ra_{125}$