^{208}Pb(^{50}Ti,2nγ) 2012Gr12,2009Je01,2011Ro20

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 141,327 (2017)	22-Mar-2017

2012Gr12: E=242 MeV ^{50}Ti beam produced in an ECR ion source using the MIVOC (metallic Ions from volatile compounds) method. Target=446 μg/cm^2 ^{208}Pb. γ rays were detected using the JUROGAM-II array consisting of 24 clover and 15 tapered Ge detectors with Compton suppression shields. Fission tagging technique. Measured Eγ, Iγ, $\gamma\gamma$, energy loss, time-of-flight, recoils, fission products, (fission fragments)γ coin. Deduced g.s. rotational band, kinematic and dynamic moments of inertia. No significant deformed shell gap at Z=104.

2011Ro20: ^{50}Ti beam, E=242.5 MeV produced at the Argonne ATLAS facility. Target=^{208}Pb about 0.5 mg/cm^2 thick on a rotating target wheel. Recoiling nuclei identified in the Argonne Fragment Mass Analyzer (FMA) using a position-sensitive parallel grid avalanche counter (PGAC) located in the focal plane based on A/Q, time of arrival and energy-loss signals. Isomeric electron and fission events where detected in the same pixel of a 140 μm thick double-sided Si strip detector that the recoiling nucleus was implanted. γ-rays were detected using four large clover Ge detectors, each consisting of four crystals. Measured electron energies and in coincidence with fission and gamma events, deduced isomer half-life. A total of 783 ^{256}Rf nuclei were identified from SF decay. No candidates for isomeric transitions were detected within the gamma spectrum in coincidence with the electrons. No evidence was found for a 2-qp isomer in ^{256}Rf. A predicted 2-qp isomer may decay by SF mode with a half-life close to that of the ground state, thus making its identification difficult. 2011Ro20 discuss in detail many discrepancies with the work of 2009Je01 on the observation of isomers in ^{256}Rf.

2013Ri07: E(^{50}Ti)=238, 243 and 258 MeV. Measured recoil implants and fission correlations at LBNL cyclotron facility using the Berkeley Gas-filled Separator. 2013Ri07 assigned (5$^-$) to a 25−μs isomer at 1120 keV, and (8$^-$) to a 17−μs isomer at 1400 keV, both first reported in their earlier paper 2009Je01 and described as 2-qp states. Note that in 2011Ro20, only one weakly populated isomer of 17 μs was found and described as possible 4-qp state.

2010Be16: E(^{50}Ti)=238 MeV. Measured Eγ, ce, Eα, (recoils)(ce)(α), using a DSSD for particles and electrons, and an HPGe clover detector for γ rays at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory using the Berkeley Gas-filled Separator. Half-lives of two isomers measured as 13.2 μs *33* and 36.5 μs *86* from recoil- electron-electron-fission(from ^{256}Rf) correlated events.

2009Je01: E=243 MeV ^{50}Ti beam provided by 88-Inch Cyclotron at Lawrence Berkeley National Laboratory. Evaporation residues were separated in the Berkeley Gas Separator and identified by coincident signals in the Multi-Wire Proportional Counter and the double-sided Si strip detector. γ rays were detected with a Clover germanium detector. Measured delayed γ rays and conversion electrons, ce-γ coincidence, half-lives of isomeric states. Deduced configurations. See also 2013Ri07 where configurations are reassigned based on data for ^{257}Rf.

2008Dr05: E=4.6-4.8 MeV/nucleon beam provided by 88-Inch cyclotron at LBNL. Detected charged particles using a focal plane detector and a double-sided silicon strip detector. Half-life measured based on the subsequent α-decay of ^{256}Rf.

^{256}Rf Levels

E(level)[†]	J$^\pi$	T$_{1/2}$	Comments
0[#]	0$^+$	6.67 ms *10*	T$_{1/2}$: from Adopted Levels. Production σ=17 nb *3* (2012Gr12), 15.8 nb *2* (2008Dr05).
44[#] *1*	(2$^+$)		E(level): ≈46 (2009Je01).
148[#] *2*	(4$^+$)		
309[#] *2*	(6$^+$)		
527[#] *2*	(8$^+$)		
799[#] *2*	(10$^+$)		
≈946	(3$^-$)		E(level),J$^\pi$: from (electron)(900γ) (2009Je01), member of K^π=2$^-$ band.
≈1120[‡]	(5$^-$)	25[‡] μs *2*	%IT=?; %SF=? J$^\pi$: assigned by 2013Ri07 as K^π=(5$^-$) with possible 2-qp configuration=(π1/2[521]⊗π9/2[624])$_{5-}$. T$_{1/2}$: 2011Ro20 state that their observed isomer of 17 μs *5* (half-life from time distribution of conversion electrons and maximum likelihood method) may correspond to the 25−μs *2* isomer in 2009Je01, although, the isomer population ratio of ≈5% *2* (with respect to that

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^{256}Rf Levels (continued)

E(level)[†]	J$^\pi$	T$_{1/2}$	Comments
			of ^{256}Rf g.s.) is much smaller than ≈27% deduced by 2011Ro20 from data in 2009Je01. Due to its low population and several other arguments against its assignment as a 2-qp isomer, 2011Ro20 suggest that their observed 17−μs isomer is more likely a 4-qp state.
1122[#] *3*	(12$^+$)		
≈1400[‡]	(8$^-$)	17[‡] μs *2*	%IT=?; %SF=? E(level): isomer not found in 2011Ro20, perhaps due to low statistics. T$_{1/2}$: others: 13.2 μs *33* (2010Be16). J$^\pi$: assigned by 2013Ri07 as K^π=(8$^-$) with possible 2-qp configuration=(π7/2[514]⊗π9/2[624])$_{8-}$.
1493[#] *3*	(14$^+$)		
1910[#] *4*	(16$^+$)		
>2200[‡]		27[‡] μs *5*	%IT=?; %SF=? E(level): isomer not found in 2011Ro20, perhaps due to low statistics. T$_{1/2}$: other: 36.5 μs *86* (2010Be16). Possible 4-qp state (2009Je01,2013Ri07).
2369[#] *4*	(18$^+$)		
2868[#] *5*	(20$^+$)		

[†] From Eγ data in 2012Gr12, unless otherwise stated.
[‡] From 2009Je01. Level energy deduced from (electron)(900γ) coin. Half-life from recoil-electron-electron-electron-fission(t). Isomers at ≈1120 and ≈1400 keV interpreted by 2009Je01 as possible 2-qp states, while the one at >2000 keV is interpreted as possible 4-qp state. See also 2011Ro20 where only one isomer of 17 μs *5* was seen and interpreted as possible 4-qp state.
[#] Band(A): g.s. band. Band assignment from 2012Gr12.

γ(^{256}Rf)

E$_\gamma$[‡]	I$_\gamma$[‡]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.	α[#]	Comments
(44[†] *1*)		44	(2$^+$)	0	0$^+$	[E2]	1.83×10^3 *22*	
(104[†] *1*)		148	(4$^+$)	44	(2$^+$)	[E2]	31.5 *15*	
161 *1*	100 *30*	309	(6$^+$)	148	(4$^+$)	[E2]	4.51 *14*	
218 *1*	80 *20*	527	(8$^+$)	309	(6$^+$)	[E2]	1.33 *3*	
272 *1*	53 *12*	799	(10$^+$)	527	(8$^+$)	[E2]	0.589 *12*	
323 *1*	49 *11*	1122	(12$^+$)	799	(10$^+$)	[E2]	0.333 *6*	
371 *1*	22 *8*	1493	(14$^+$)	1122	(12$^+$)	[E2]	0.218 *4*	
417 *2*	20 *7*	1910	(16$^+$)	1493	(14$^+$)			
459 *2*	18 *7*	2369	(18$^+$)	1910	(16$^+$)			
499 *2*	16 *7*	2868	(20$^+$)	2369	(18$^+$)			
900 *1*		≈946	(3$^-$)	44	(2$^+$)			E$_\gamma$: from 2009Je01.

[†] Calculated value from Harris fit in a rotational band.
[‡] From 2012Gr12, unless otherwise stated.
[#] Theoretical values from BrIcc code (2008Ki07) using "Frozen orbital" approximation.

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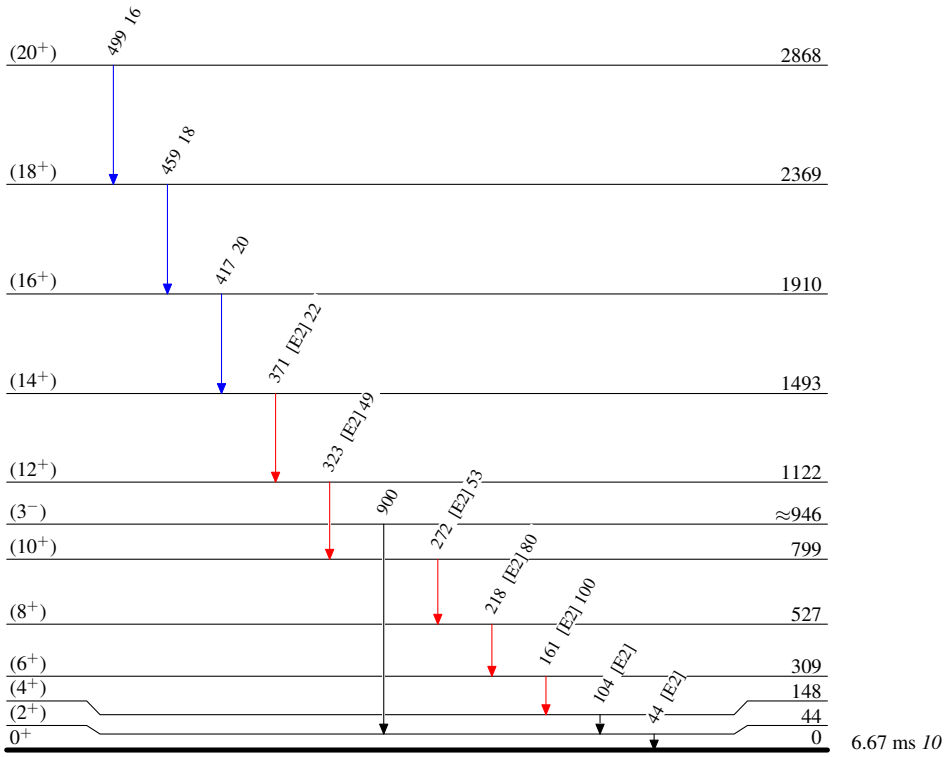
Level Scheme

Intensities: Relative I_γ

Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)



$^{256}_{104}Rf_{152}$

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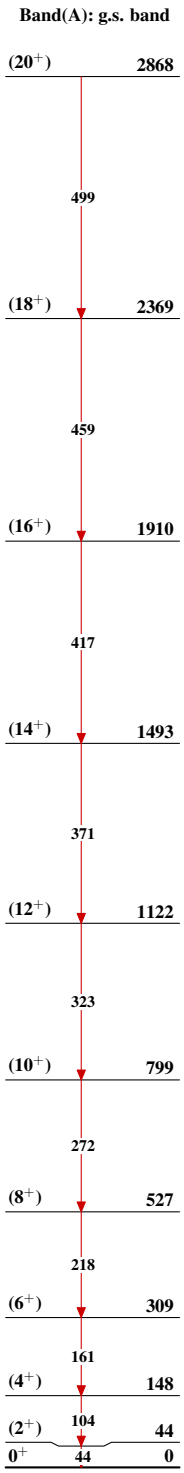

$^{256}_{104}Rf_{152}$