Adopted Levels, Gammas

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

Q(β^-)=−884 *6*; S(n)=6023 *5*; S(p)=3499 *5*; Q(α)=9254 *5* 2021Wa16

Assignment: daughter of ^{229}Np, ^{225}Pa, ^{221}Ac, and ^{217}Fr (1968Ha14,1970Bo13).

Induced fission data from ^{209}Bi(α,f) reaction were taken, and fission barrier parameters were deduced by 1982Gr21, 1982Gr24, 1983Gr17, 1984Gr06, 1984Gr13, 1984Ig01, 1984It01, 1985It01, 1986Be20, 1986It01, 1987It03, and 1988Gr16.

2020De36: ^{238}U(^{48}Ca,X), E=233.3 MeV; measured multi-nucleon transfer reaction cross section $\sigma_{cumulative}$=54.0 nb/sr *12* for ^{213}At.

2015Ba20: ^{136}Xe + ^{208}Pb, E(c.m.)=450 MeV, measured multi-nucleon transfer reaction cross section $\sigma_{cumulative\ yield}$=0.384 mb *77* and $\sigma_{independent\ yield}$=0.384 mb *77* for ^{213}At.

See 1972Mo10, 1973Ba19, 1974Ba87, 1977Ha41, 1977Pr10, 1979Ad07, 1979Ig04, 1980Ig02, 1983Br06, 1983Br15, 1984Ni09, and 1984Ro23 for calculations of fission barriers and probabilities for decay by fission. Effective moment of inertia was calculated by 1982Ad01.

^{213}At Levels

Cross Reference (XREF) Flags

- A ^{217}Fr α decay
- B ^{208}Pb(^{7}Li,2nγ),^{209}Bi(^{18}O,^{14}Cγ)
- C ^{209}Bi(^{7}Li,p2nγ),^{209}Bi(^{8}He,4nγ)

E(level)†	J$^\pi$‡	$T_{1/2}$	XREF	Comments
0.0	9/2$^-$	125 ns *6*	ABC	%α=100 Possible %ε decay to ^{213}Po g.s. is expected to be <2.5×10^{-12} from log *ft*>5.1. J$^\pi$: favored α decay to ^{209}Bi g.s. (J$^\pi$=9/2$^-$). Configuration: π ($h^{+1}_{9/2}$). $T_{1/2}$: from 1981Bo29. Other measurements: <2 s (1968Ha14), 110 ns (1975LiZH), 110 ns *20* (1970Bo13, 1976Da18). Probability for decay by ^{8}Be emission relative to α emission was calculated by 1986Pi11. See 1973Ma52 for theoretical calculations of α-decay probabilities. See also 1976De25 for absolute reduced $\Gamma(\alpha)$ obtained by analyzing ^{209}Bi(α) reaction cross sections. α clustering effects were studied by 1982Ka37. Eα=9080 *5* (1988Hu08), 9080 *12* (1970Bo13), 9060 *20* (1968Ha14).
340.5 *3*	(7/2$^-$,9/2$^-$)	≤5.5& ns	B	J$^\pi$: 340.5γ (M1,E2) to 9/2$^-$ state. Dominant π ($f^{+1}_{7/2}$) with possible π ($h^{+1}_{9/2}$)⊗2$^+$ admixture.
724.6 *3*	(13/2$^-$)	≤5.5& ns	BC	J$^\pi$: 724.6γ (E2) to 9/2$^-$ state. Possible configuration: π ($h^{+1}_{9/2}$)⊗2$^+$.
1111.3 *5*	(15/2$^-$)	≤5.5& ns	BC	J$^\pi$: 386.7γ (M1+E2) to (13/2$^-$) state.
1129.7 *5*	(17/2$^-$)	≤5.5& ns	BC	J$^\pi$: 405γ (E2) to (13/2$^-$) state. Possible configuration: π ($h^{+1}_{9/2}$)⊗4$^+$.
1318.1 *6*	(19/2$^-$)	≤5.5& ns	BC	J$^\pi$: 188.4γ D to (17/2$^-$) state.
1318.1+x		110 ns *17*	B	E(level),J$^\pi$: 1358 *23* (2021Ko07 − NUBASE) and 25/2$^-$ from systematics (2021Ko07 − NUBASE). $T_{1/2}$: from 386.7γ(t) in ^{208}Pb(^{7}Li,2nγ) (1980Sj01 − also 113 ns *10* from 405γ(t) measurements).
1318.1+y	(27/2$^-$)#	85@ ns	C	
1681+y	(29/2$^+$)#		C	
1838+y	(33/2$^+$)#	82@ ns	C	
2194+y	(35/2$^-$)#		C	

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Adopted Levels, Gammas (continued)

^{213}At Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	T$_{1/2}$	XREF	Comments
2570+y	(37/2$^-$)[#]		C	
2620+y	(43/2$^-$)[#]	34.7[@] ns	C	possible configuration: π ([h$^{+2}_{9/2}$,f$^{+1}_{7/2}$]$_{23/2^-}$) ν ([(g$^{+1}_{9/2}$,i$^{+1}_{11/2}$]$_{10^+}$) (2003LaZZ). T$_{1/2}$: A low-energy (50-keV) unobserved transition was postulated to explain the observed isomer (2003LaZZ – (^{7}Li,p2nγ)).
2926+y	(49/2$^+$)[#]	45 μs *4*	C	E(level): 2998 *27* (2021Ko07 – NUBASE). possible configuration: π ([h$^{+2}_{9/2}$,i$^{+1}_{13/2}$]$_{29/2^+}$) ν ([g$^{+1}_{9/2}$,i$^{+1}_{11/2}$]$_{10^+}$) (2003LaZZ). 306γ [E3] to 43/2$^-$ state. T$_{1/2}$: From 306γ(t) (2003LaZZ – (^{7}Li,p2nγ)).

[†] From Eγ. Energy levels at 1318.1+y keV and above are from ^{209}Bi(^{7}Li,p2nγ). These level energies are about 235 keV less than the level energy presented in 2003LaZZ. Evaluator labeled these levels with '+y', because placement of some highly converted low energy γ-lines between (27/2$^-$) and 19/2$^-$ states are not clear and the evaluator placed those gammas as unplaced in the ^{209}Bi(^{7}Li,p2nγ),^{209}Bi(^{8}He,4nγ) dataset.

[‡] From γ transition multipolarity, deduced from measured γ-ray angular distribution in ^{208}Pb(^{7}Li,2nγ), except otherwise noted.

[#] From 2003LaZZ (^{7}Li,p2nγ), detailed arguments are not available. It appears that the assignment was based on the placement of gamma transitions in the level scheme following the decay of 2626+y isomer (J$^{\pi}$=(49/2$^+$)), shell model calculations, and comparison with a comparable isomer at 4771.4 (J$^{\pi}$=(25$^-$)), T$_{1/2}$=152 μs *5*, in ^{212}At.

[@] From time-difference spectra by gating on γ-ray transition above and below the level of interest in ^{209}Bi(^{7}Li,p2nγ) (2003LaZZ).

[&] From ^{208}Pb(^{7}Li,2nγ),^{209}Bi(^{18}O,^{14}Cγ) (1980Sj01).

γ(^{213}At)

E$_i$(level)	J$_i^{\pi}$	E$_{\gamma}$[†]	I$_{\gamma}$	E$_f$	J$_f^{\pi}$	Mult.[#]	α[@]	Comments
340.5	(7/2$^-$,9/2$^-$)	340.5 *3*	100	0.0	9/2$^-$	(M1,E2)	0.24 *15*	α(K)=0.18 *14*; α(L)=0.043 *14*; α(M)=0.0104 *28* α(N)=0.00270 *72*; α(O)=5.7×10^{-4} *17*; α(P)=7.3×10^{-5} *28*
724.6	(13/2$^-$)	724.6 *3*	100	0.0	9/2$^-$	(E2)	0.01473	α(K)=0.01106 *16*; α(L)=0.00278 *4*; α(M)=0.000683 *10* α(N)=0.0001766 *25*; α(O)=3.67×10^{-5} *6*; α(P)=4.64×10^{-6} *7*
1111.3	(15/2$^-$)	386.7 *3*	100	724.6	(13/2$^-$)	(M1+E2)	0.17 *11*	α(K)=0.132 *93*; α(L)=0.029 *11*; α(M)=0.0071 *23* α(N)=0.00183 *59*; α(O)=3.8×10^{-4} *14*; α(P)=5.0×10^{-5} *22*
1129.7	(17/2$^-$)	(18.4)		1111.3	(15/2$^-$)			Transition was not observed. Its existence is inferred from the observed (188.4)(386.7γ) coincidences. Intensity balance at 1111.3 level yields I(γ+ce)(18.4)/Iγ(405.1γ)<1.2 *4*.
		405.1 *3*	100	724.6	(13/2$^-$)	(E2)	0.0568	α(K)=0.0354 *5*; α(L)=0.01600 *23*; α(M)=0.00410 *6* α(N)=0.001061 *16*; α(O)=0.000215 *3*; α(P)=2.49×10^{-5} *4*
1318.1	(19/2$^-$)	188.4 *3*	100	1129.7	(17/2$^-$)	D		
1681+y	(29/2$^+$)	363[‡]	100	1318.1+y	(27/2$^-$)			
1838+y	(33/2$^+$)	156[‡]		1681+y	(29/2$^+$)			

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Adopted Levels, Gammas (continued)

γ(^{213}At) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ	E_f	J_f^π	Mult.[#]	α[@]	Comments
1838+y	(33/2$^+$)	520[‡]		1318.1+y	(27/2$^-$)			
2194+y	(35/2$^-$)	356[‡]	100	1838+y	(33/2$^+$)			
2570+y	(37/2$^-$)	376[‡]	100	2194+y	(35/2$^-$)			
2620+y	(43/2$^-$)	(50)		2570+y	(37/2$^-$)			E_γ: A low-energy (50-keV) unobserved γ transition was postulated to explain the observed isomer (2003LaZZ – (^{7}Li,p2nγ)).
2926+y	(49/2$^+$)	306[‡]	100	2620+y	(43/2$^-$)	[E3]	0.707	B(E3)(W.u.)=23 *2* α(K)=0.1716 *24*; α(L)=0.393 *6*; α(M)=0.1075 *15* α(N)=0.0280 *4*; α(O)=0.00558 *8*; α(P)=0.000600 *9* The large B(E3)(W.u) value implies ΔJ=ΔL=3 transition, which is consistent with the π ($i^{+1}_{13/2}$) → π ($f^{+1}_{7/2}$) orbitals change.

[†] From ^{208}Pb(^{7}Li,2nγ), except otherwise noted.
[‡] From ^{209}Bi(^{7}Li,p2nγ),^{209}Bi(^{8}He,4nγ).
[#] From ^{208}Pb(^{7}Li,2nγ) (1980Sj01), based on γ(θ) and RUL, except where otherwise noted.
[@] Additional information 1.

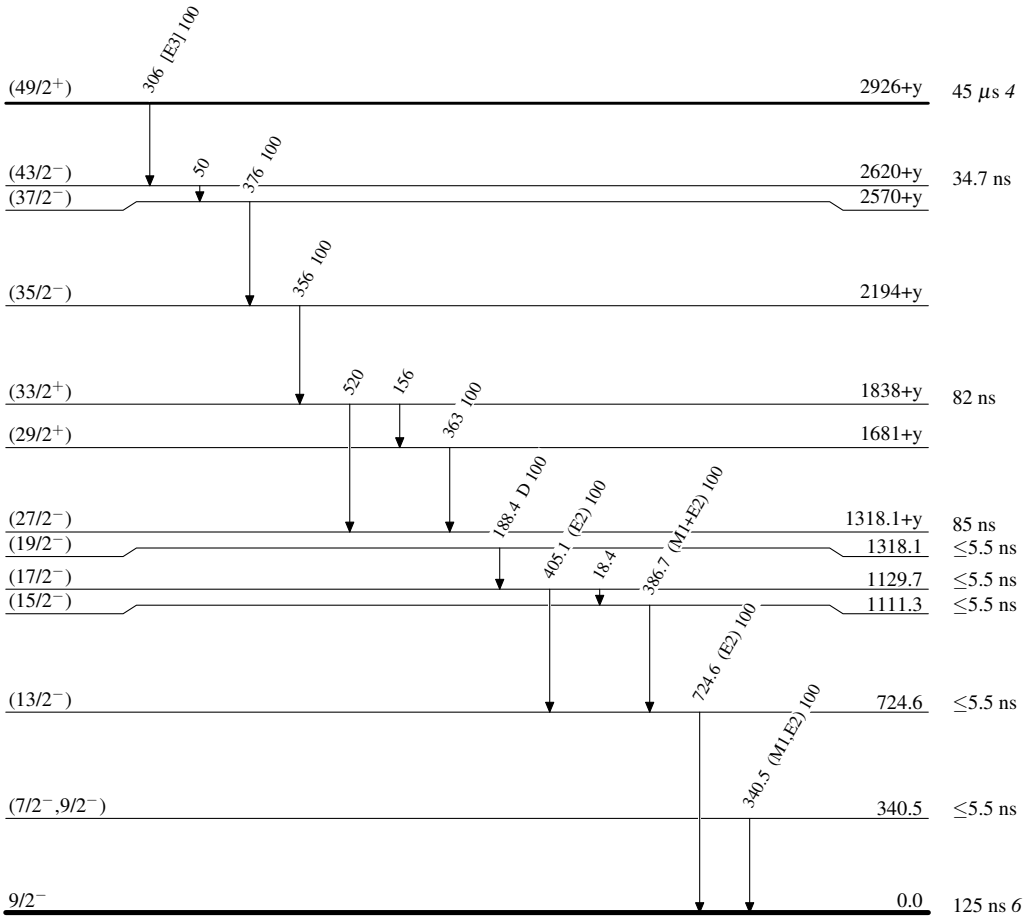
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

- - - - - - ► γ Decay (Uncertain)



$^{213}_{85}At_{128}$