^{209}Bi(α,3nγ) 1978Ra03,1982Lo18,1972Wi19

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	M. Shamsuzzoha Basunia	NDS 121, 561 (2014)	31-Mar-2014

Others: 1970AbZT, 1970BeZO, 1972Fi16, 1983Ma08.

1972Wi19: E(α)=32-43 MeV. Measured Iγ(prompt vs delayed), $\gamma(\theta)$, excitation functions. The following γ rays have about the same delayed intensities in the time interval 200-500 ns after beam bursts: 644γ, 542γ, 111γ, 675γ, and 576γ. Measured t, γ(t) pulsed beam method.

1978Ra03, 1980RaZM, 1982Lo18: E(α)=35-51 MeV. Measured Eγ, Iγ, $\gamma(\theta)$, conversion electrons. Deduced γ-ray multipolarities.

^{210}At Levels

Several J±1/2 pairs arise when 3p$_{1/2}$ neutron-hole is coupled to Configuration=(π 1h$_{9/2}$)^3. See 1972Wi19, 1980RaZM, 1982Lo18 for E(level) splitting calculation.

Exp g-factors from Iγ(θ,H,t) are corrected for Knight shift (+0.6% 8) and diamagnetism (−1.8% 6).

Branching-ratios are from 1980RaZM, 1982Lo18, unless otherwise noted.

E(level)[†‡]	J$^\pi$[#]	T$_{1/2}$	Comments
0.0	(5)$^+$	8.1 h *4*	Configuration=((π 1h$_{9/2}$9/2$^-$) (ν 3p$_{1/2}$1/2$^-$))5$^+$.
72.5 *4*	(4)$^+$		Configuration=((π 1h$_{9/2}$9/2$^-$) (ν 3p$_{1/2}$1/2$^-$))4$^+$.
507.4 *1*	(6)$^+$		Configuration=((π 1h$_{9/2}$9/2$^-$) (ν 2f$_{5/2}$5/2$^-$))6$^+$. Calc E(level)=490 (1980RaZM).
576.4 *1*	(7)$^+$		Calc E(level)=630 (1980RaZM). Configuration=((π 1h$_{9/2}$9/2$^-$) (ν 2f$_{5/2}$5/2$^-$))7$^+$.
1222.3 *1*			J$^\pi$: (7$^+$) suggested by 1980RaZM.
1251.9 *1*	(9)$^+$		Calc E(level)=1294 (1972Wi19), 1276 (1980RaZM). Configuration=((π 1h$_{9/2}$17/2$^-$) (ν 3p$_{1/2}$1/2$^-$))9$^+$.
1363.2 *2*	(11)$^+$	25.6 ns *17*	T$_{1/2}$: weighted average of 25 ns *5* (1970AbZT), 30 ns *5* (1970BeZO), and 25 ns *2* (1983Ma08). Calc E(level)=1378 (1972Wi19), 1397 (1980RaZM). Configuration=((π 1h$_{9/2}$21/2$^-$) (ν 3p$_{1/2}$1/2$^-$))11$^+$. Corrected g-factor=0.89 *3* (1975ReZU) preliminary and configuration added g-factor=0.93 *1* corresponds.
1402.9 *2*	(8$^+$)		Configuration=((π 1h$_{9/2}$17/2$^-$) (ν 3p$_{1/2}$1/2$^-$))8$^+$. Calc E(level)=1407 (1972Wi19).
1495.0 *2*	(10$^+$)		Configuration=((π 1h$_{9/2}$21/2$^-$) (ν 3p$_{1/2}$1/2$^-$))10$^+$. Calc E(level)=1517 (1972Wi19). Branching: Iγ(243γ)/Iγ(132γ)=2.2 (singles), 1.8 (delayed).
1688.5 *2*	(10$^-$)	15 ns *2*	T$_{1/2}$: from 1980RaZM. Other: 16 ns (1978Ra03). Calc E(level)=1705 (1980RaZM). Configuration=((π 1h$_{9/2}$9/2$^-$) (ν 1i$_{13/2}$13/2$^+$))10$^-$. Branching: Iγ(325γ)/Iγ(193γ)=1.0 (singles), 1.4 (delayed).
1739.9 *2*			
1905.2 *2*	(12)$^+$		Calc E(level)=1883 (1972Wi19), 1955 (1980RaZM). Configuration=((π 1h$_{9/2}$8$^+$) (π 2f$_{7/2}$7/2$^-$) (ν 3p$_{1/2}$1/2$^-$))12$^+$.
1969.9 *2*			
2042.9 *2*	(13)$^+$		Calc E(level)=2088 (1980RaZM). Configuration=((π 1h$_{9/2}$21/2$^-$) (ν 2f$_{5/2}$5/2$^-$))13$^+$. Branching: Iγ(680γ)/Iγ(138γ)=9.5 (singles), 10 (delayed) 1978Ra03.
2467.1 *2*			
2549.6 *2*	(15)$^-$	0.49 μs *1*	T$_{1/2}$: γ(t) pulsed beam method (1983Ma08). Other values: 0.58 μs *5* (1976WeZD,1978Ra03), 0.74 μs *8* (1970BeZO), 0.75 μs *10* (1970AbZT,1972Wi19). Calc E(level)=2578 (1972Wi19), 2583 (1980RaZM). Configuration=((π 1h$_{9/2}$8$^+$) (π 1i$_{13/2}$13/2$^+$) (ν 3p$_{1/2}$1/2$^-$))15$^-$.

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^{209}Bi(α,3nγ) 1978Ra03,1982Lo18,1972Wi19 (continued)

^{210}At Levels (continued)

E(level)[†‡]	J$^\pi$[#]	$T_{1/2}$	Comments
			g-factor=1.056 *20* (1972Fi16), 1.038 *10* (1976WeZD) are compatible with configuration added g-factor=1.066 *10*.
2572.0 *2*	(14$^-$)	≤1 ns	Configuration=((π 1h$_{9/2}$8$^+$) (π 1i$_{13/2}$13/2$^+$) (ν 3p$_{1/2}$1/2$^-$))14$^-$. $T_{1/2}$: from 1982Lo18.
2683.7 *2*			
2783.4 *2*			
3107.2 *2*	(16)$^-$		Configuration=((π 1h$_{9/2}$8$^+$) (π 1i$_{13/2}$13/2$^+$) (ν 2f$_{5/2}$5/2$^-$))16$^-$.
3112.0 *2*			
3542.4 *2*	(17)$^-$		Calc E(level)=3550 (1980RaZM). Configuration=((π 1h$_{9/2}$8$^+$) (π 1i$_{13/2}$13/2$^+$) (ν 2f$_{5/2}$5/2$^-$))17$^-$.
3551.8 *2*			
3655.3 *2*	(16)$^-$		Configuration=((π 1h$_{9/2}$8$^+$) (π 2f$_{7/2}$7/2$^-$) (ν 2g$_{9/2}$9/2$^+$))16$^-$. Branching: Iγ(1106γ)/Iγ(103γ)=2.1 (singles), 3.3 (delayed).
3774.5 *2*			
4027.7 *2*	(19)$^+$	4.0 μs *17*	$T_{1/2}$: from 1978Ra03. Others:≈1 μs (1975BeXL), 3.6 μs *6* (1976WeZD). Calc E(level)=4096 (1980RaZM). Configuration=((π 1h$_{9/2}$8$^+$) (π 1i$_{13/2}$13/2$^+$) (ν 2g$_{9/2}$9/2$^+$))19$^+$. g-factor=0.731 *23* (1976WeZD), 0.737 *25* (1978Ra03) are compatible with configuration added g-factor=0.74 *1*. Branching: Iγ(372γ)/Iγ(485γ)=1.4 (singles), 1.2 (delayed), 1.3 (delayed) 1978Ra03.
4078.0 *2*			

† From γ-ray energies of 1980RaZM, 1982Lo18, using ΔE=0.1 keV.
‡ Excited states of ^{210}At were calculated using exp E(levels) of adjacent nuclei for appropriate configuration; see 1972Wi19, 1978Ra03, 1980RaZM. Calc energies agree well with exp values.
# From Adopted Levels.

γ(^{210}At)

Eγ, Iγ(singles), Ice measured at Eα=43 MeV,Ge(Li) (1980RaZM).
α(K)exp=ce(K)/Iγ normalized to α(K)(644γ)=0.0334 (E3 theory).
Angular distributions studied at Eα=39,48 MeV, θ=90°−150°. A_2 coef from 1980RaZM, 1982Lo18, Eα=39 MeV. Other: 1978Ra03.
γ-placement is based on $\gamma\gamma$-coin, Iγ(prompt vs delayed), and γ-ray excit.

E$_\gamma$[#]	I$_\gamma$[†]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[‡]	α[a]	Comments
69.2[&] *3*		576.4	(7)$^+$	507.4	(6)$^+$	[M1]	6.78 *13*	α(L)=5.16 *10*; α(M)=1.224 *24* α(N)=0.317 *6*; α(O)=0.0679 *13*; α(P)=0.00937 *18*
72.5[&] *5*		72.5	(4)$^+$	0.0	(5)$^+$	M1	5.92 *15*	α(L)=4.51 *12*; α(M)=1.07 *3* α(N)=0.277 *7*; α(O)=0.0592 *15*; α(P)=0.00818 *21* Mult.: from Adopted Gammas.
103.5	2	3655.3	(16)$^-$	3551.8				A_2=−0.23 *11*.
111.3	13	1363.2	(11)$^+$	1251.9	(9)$^+$	E2	4.91	α(K)=0.398 *6*; α(L)=3.34 *5*; α(M)=0.896 *13* α(N)=0.231 *4*; α(O)=0.0454 *7*; α(P)=0.00459 *7* A_2=0.12 *2*.
131.7	1.2	1495.0	(10$^+$)	1363.2	(11)$^+$	[M1][@]	5.52	α(K)=4.47 *7*; α(L)=0.802 *12*; α(M)=0.190 *3* α(N)=0.0492 *7*; α(O)=0.01053 *15*; α(P)=0.001454 *21* A_2=−0.13 *2*.
137.6	1	2042.9	(13)$^+$	1905.2	(12)$^+$	[M1][@]	4.87	α(K)=3.94 *6*; α(L)=0.707 *10*; α(M)=0.1674 *24* α(N)=0.0434 *6*; α(O)=0.00929 *13*; α(P)=0.001283 *18* A_2=−0.26 *11*.

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^{209}Bi(α,3nγ) 1978Ra03,1982Lo18,1972Wi19 (continued)

γ(^{210}At) (continued)

E_γ[#]	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	α[a]	Comments
151.0	1.5	1402.9	(8$^+$)	1251.9	(9)$^+$	[M1][@]	3.74	α(K)=3.03 *5*; α(L)=0.542 *8*; α(M)=0.1284 *18* α(N)=0.0333 *5*; α(O)=0.00712 *10*; α(P)=0.000983 *14* A_2=−0.32 *15*.
193.5	2.1	1688.5	(10$^-$)	1495.0	(10$^+$)	(E1)	0.0910	α(K)=0.0732 *11*; α(L)=0.01360 *19*; α(M)=0.00322 *5* α(N)=0.000826 *12*; α(O)=0.0001712 *24*; α(P)=2.16×10^{-5} *3* A_2=0.36 *6*. B(E1)(W.u.)=8.3×10^{-7}.
211.5	3.5	2783.4		2572.0	(14$^-$)			A_2=0.28 *3*.
243.1	2.7	1495.0	(10$^+$)	1251.9	(9)$^+$	[M1][@]	0.983	α(K)=0.797 *12*; α(L)=0.1416 *20*; α(M)=0.0335 *5* α(N)=0.00867 *13*; α(O)=0.00186 *3*; α(P)=0.000257 *4* A_2=−0.03 *10*.
325.3	2.2	1688.5	(10$^-$)	1363.2	(11)$^+$	(E1)	0.0269	α(K)=0.0219 *3*; α(L)=0.00381 *6*; α(M)=0.000897 *13* α(N)=0.000230 *4*; α(O)=4.83×10^{-5} *7*; α(P)=6.30×10^{-6} *9* A_2=−0.07 *5*. B(E1)(W.u.)=1.8×10^{-7}.
372.4	6.5	4027.7	(19)$^+$	3655.3	(16)$^-$	E3	0.323	α(K)=0.1106 *16*; α(L)=0.1569 *22*; α(M)=0.0424 *6* α(N)=0.01103 *16*; α(O)=0.00221 *3*; α(P)=0.000243 *4* α(K)exp=0.10 *2*, K/L=0.7 *1*. A_2≈0. B(E3)(W.u.)=45.
434.7[&] *6*		507.4	(6)$^+$	72.5	(4)$^+$	[E2]	0.0474	α(K)=0.0305 *5*; α(L)=0.01262 *19*; α(M)=0.00322 *5* α(N)=0.000833 *13*; α(O)=0.0001695 *25*; α(P)=1.98×10^{-5} *3*
435.2	13	3542.4	(17)$^-$	3107.2	(16)$^-$	M1	0.201	α(K)=0.1632 *23*; α(L)=0.0286 *4*; α(M)=0.00676 *10* α(N)=0.001749 *25*; α(O)=0.000375 *6*; α(P)=5.18×10^{-5} *8* α(K)exp=0.16 *3*, K/L=4.9 *8*. A_2=−0.14 *4*.
436.6[b]	<1	1688.5	(10$^-$)	1251.9	(9)$^+$	[E1]	0.01411	α(K)=0.01156 *17*; α(L)=0.00195 *3*; α(M)=0.000457 *7* α(N)=0.0001177 *17*; α(O)=2.48×10^{-5} *4*; α(P)=3.28×10^{-6} *5* Weak peak in delayed γ spectrum.
485.3	4.6	4027.7	(19)$^+$	3542.4	(17)$^-$	M2	0.433	α(K)=0.333 *5*; α(L)=0.0750 *11*; α(M)=0.0184 *3* α(N)=0.00479 *7*; α(O)=0.001021 *15*; α(P)=0.0001388 *20* α(K)exp=0.44 *8*, K/L=2.8 *4*. A_2≈0. B(M2)(W.u.)=0.0026 from Configuration=(ν $2g_{9/2}$)^1 to Configuration=(ν $2f_{5/2}$)$^{-1}$.
507.4	30	507.4	(6)$^+$	0.0	(5)$^+$	E2	0.0324	α(K)=0.0222 *4*; α(L)=0.00768 *11*; α(M)=0.00194 *3* α(N)=0.000501 *7*; α(O)=0.0001028 *15*; α(P)=1.232×10^{-5} *18* α(K)exp=0.023 *4*, K/L=3.4 *6*. A_2=0.14 *8* (1978Ra03), 0.04 *3* (1980RaZM).
517.6	2.6	1739.9		1222.3				
529.1	13	2572.0	(14$^-$)	2042.9	(13)$^+$	(E1)	0.00947	α(K)=0.00779 *11*; α(L)=0.001287 *18*; α(M)=0.000302 *5* α(N)=7.76×10^{-5} *11*; α(O)=1.641×10^{-5} *23*; α(P)=2.19×10^{-6} *3* Mult.: dipole from A_2 coef coupled with relatively weak ce(K) peak. A_2=−0.23 *4*.

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^{209}Bi(α,3nγ) 1978Ra03,1982Lo18,1972Wi19 (continued)

γ(^{210}At) (continued)

Eγ[#]	Iγ[†]	Ei(level)	J^{π}_{i}	Ef	J^{π}_{f}	Mult.[‡]	α[a]	Comments
535.6	3	4078.0		3542.4	(17)⁻			
540.0	6.9	3112.0		2572.0	(14⁻)			
542.0	50	1905.2	(12)⁺	1363.2	(11)⁺	M1	0.1118	α(K)=0.0910 *13*; α(L)=0.01585 *23*; α(M)=0.00374 *6* α(N)=0.000969 *14*; α(O)=0.000208 *3*; α(P)=2.87×10^{-5} *4* α(K)exp=0.096 *15*, K/L=6.2 *9*. A_2=−0.40 *5*.
557.6	15	3107.2	(16)⁻	2549.6	(15)⁻	M1	0.1037	α(K)=0.0844 *12*; α(L)=0.01470 *21*; α(M)=0.00347 *5* α(N)=0.000898 *13*; α(O)=0.000192 *3*; α(P)=2.66×10^{-5} *4* α(K)exp=0.059 *10*, K/L=4.6 *8*. A_2=−0.44 *8*.
561.9	5	2467.1		1905.2	(12)⁺			A_2=−0.32 *7*.
567.0	7	1969.9		1402.9	(8⁺)			A_2=0.20 *8*.
576.4	96	576.4	(7)⁺	0.0	(5)⁺	E2	0.0242	α(K)=0.01721 *24*; α(L)=0.00523 *8*; α(M)=0.001309 *19* α(N)=0.000338 *5*; α(O)=6.98×10^{-5} *10*; α(P)=8.53×10^{-6} *12* α(K)exp=0.028 *4* (composite ce(K)), K/L=4.6 *7*. A_2=0.16 *1*.
644.4	32	2549.6	(15)⁻	1905.2	(12)⁺	E3	0.0549	α(K)=0.0329 *5*; α(L)=0.01641 *23*; α(M)=0.00426 *6* α(N)=0.001106 *16*; α(O)=0.000226 *4*; α(P)=2.69×10^{-5} *4* K/L=2.0 *3*. A_2=0.28 *3*. B(E3)(W.u.)=15.9.
662.5	5	3774.5		3112.0				
675.5	100	1251.9	(9)⁺	576.4	(7)⁺	E2	0.01708	α(K)=0.01264 *18*; α(L)=0.00335 *5*; α(M)=0.000828 *12* α(N)=0.000214 *3*; α(O)=4.44×10^{-5} *7*; α(P)=5.56×10^{-6} *8* α(K)exp=0.016 *3*, K/L=3.9 *6*. A_2=0.22 *3*.
679.7	9.5	2042.9	(13)⁺	1363.2	(11)⁺	E2	0.01686	α(K)=0.01249 *18*; α(L)=0.00329 *5*; α(M)=0.000814 *12* α(N)=0.000210 *3*; α(O)=4.37×10^{-5} *7*; α(P)=5.47×10^{-6} *8* α(K)exp=0.014 *3*. A_2=0.31 *10*.
714.9	5.1	1222.3		507.4	(6)⁺			
768.4	4.6	3551.8		2783.4				
778.5	3.9	2683.7		1905.2	(12)⁺			
1105.7	4.1	3655.3	(16)⁻	2549.6	(15)⁻	M1	0.01736	α(K)=0.01419 *20*; α(L)=0.00242 *4*; α(M)=0.000570 *8* α(N)=0.0001475 *21*; α(O)=3.16×10^{-5} *5*; α(P)=4.38×10^{-6} *7*; α(IPF)=3.40×10^{-7} *5* α(K)exp=0.015 *5*.

[†] Photon intensity relative to Iγ(675γ)=100, ΔIγ range from 2% to 10% (1980RaZM).
[‡] Based on α(K)exp, K/L, A_2 coef (1978Ra03,1980RaZM,1982Lo18).
[#] ΔE<0.1 keV (1980RaZM).
[@] Dipole from A_2<0.
[&] From 1972Wi19.
[a] Additional information 1.
[b] Placement of transition in the level scheme is uncertain.

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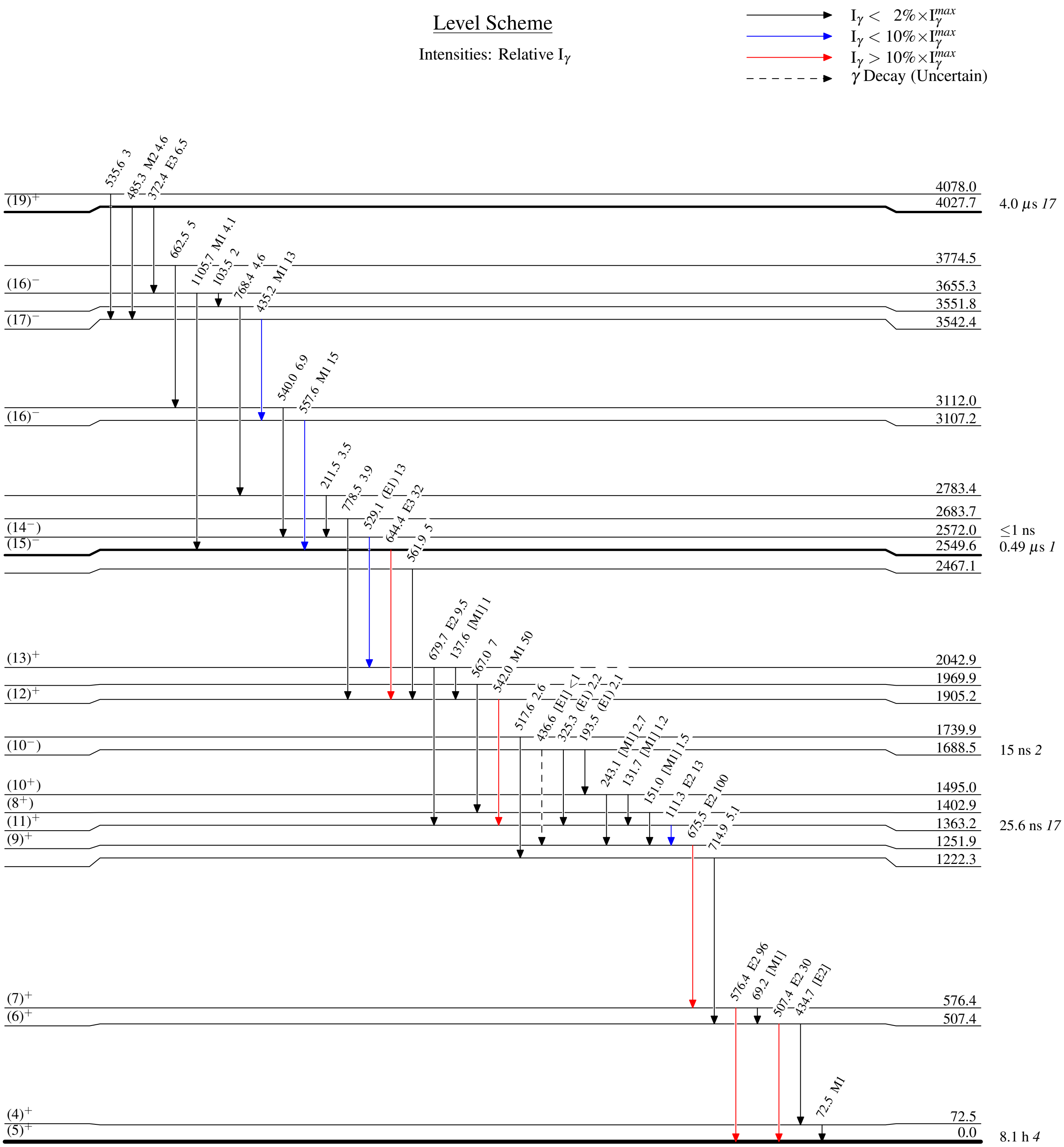
Level Scheme

Intensities: Relative I_γ



$^{210}_{85}At_{125}$