^{209}Bi(α,nγ) 1982Lo01

History

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

1982Lo01: E(α)=18.0-20.8 MeV. Measured Eγ, Iγ, Ice, γγ, Xγ, γ(E(α)), γ(θ), γ(t) using large coaxial Ge(Li) detectors and a small Ge x-ray detector for γ-rays and a Si(Li) detector combined with a magnetic lens for electrons.

The level scheme proposed by 1979Sj01 from the ^{208}Pb(^{7}Li,3nγ) reaction has been confirmed and several additional cascades have been added. The following results of γ(t) experiments have been considered in building the level scheme: 1) 45γ and 160γ have both delayed ($T_{1/2}$=32 ns) and prompt components; 2) 70γ and 184γ have no prompt components (70γ $T_{1/2}$=32 ns, 184γ $T_{1/2}$=20 ns); 3) 55γ has no delayed component. The intensity of the 160γ requires its feeding to the g.s. in order to establish a balance between Iγ in ^{212}At and the I(62.9 γ) in ^{208}Bi fed by ^{212}At α decay.

Other: 1980Di09: ^{209}Bi(α,n) E=45-172.5 MeV; measured excit, isomer ratio by detecting α groups from α decay. Deduced that the reaction is dominated by preequilibrium processes.

α: Additional information 1.

^{212}At Levels

E(level)†	J^{π}‡	$T_{1/2}$#	Comments
0.0	1^-@		
55.0	0^-	<1 ns	J^{π}: 1982Lo01 suggest J^{π}=0^- (of the configuration=((π $h_{9/2})^{+2}_{0+}$(π $h_{9/2}$)(ν $g_{9/2}$)) multiplet) for this level in analogy with ^{210}Bi. However, since gammas of mixed multipolarity feed this level, J=0 is not allowed.
160.4	2^-@		
205.6	3^-@		
222.9	(9^-)@	0.121 s *2*	E(level),$T_{1/2}$,J^{π}: From Adopted Levels.
275.5	5^-@	32 ns *1*	
328.1	8^-@	<1 ns	
345.7	1^-		
363.7	2^-		
622.6	$(1,2)^-$		
635.3	$(1,2)^-$		
701.6	10^-		configuration=($\pi h_{9/2\ 0+}$)($\pi h_{9/2}$)($\nu i_{11/2}$).
748.1	$(1,2,3,4)^-$		
769.0	$(1,2,3,4)^-$		
779.2	$(1,2,3,4)^-$		
783.5	(3^-)		
840.0	$(1,2,3,4)^-$		
843.0	7^-		
845.8	$(1,2,3,4)^-$		
885.5	11^+	20 ns *4*	configuration=($\pi h_{9/2\ 0+}$)($\pi i_{13/2}$)($\nu g_{9/2}$). $T_{1/2}$: from 184γ(t).
890.4	3^-		
920.8	4^-		
1082.6	(6^-)		
1117.7	(5)		
1209.6	(6^-)		
1262.7	12^+		
1283.1	12^+		
1321.1	(11^+)		
1429.8 *4*	11^-		
1457.5	(5^+)		
1540.8	13^-		
1604.7	(15^-)		configuration=$(\pi h_{9/2})^3$($\nu g_{9/2}$). E(level): this level is placed at 1616-keV in 1982Lo02, based on a tentatively placed

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^{209}Bi(α,nγ) 1982Lo01 (continued)

^{212}At Levels (continued)

E(level)†	J$^{\pi}$‡	Comments
		75-keV depopulating transition. In subsequent studies in ^{208}Pb(^{7}Li,3nγ) (1999Ba30), this level is found to decay by a 63.9γ resulting in a level energy of 1605 keV. As 1999Ba30 provide more support for the 63.9γ, we adopt the 63.9γ and the associated 1605-keV level.
1651.2	13^{+}	
1827.6	12^{+}	
1933.2	13^{+}	

† Deduced by evaluators from Eγ data.

‡ As proposed by 1982Lo01 based on multipolarities deduced from γ(θ) and α(K)exp measurements along with comparison to shell model calculations.

From γ(t) in 1982Lo01.

@ Dominant component configuration=$((\pi\ h_{9/2})^{+2}_{0+}(\pi\ h_{9/2})(\nu\ g_{9/2}))$.

γ(^{212}At)

The experimental conversion coefficients are given relative to the M1 coefficient for the 476.8γ. It appears, however, that the 476.8γ is not a pure M1 transition (from γ(θ) in both this experiment and in the ^{208}Pb(^{7}Li,3nγ) study of 1979Sj01). Thus, the actual α(K) may be smaller than the α(K)(M1) used for normalization, and as a result, all α(K)exp given in this data set may be somewhat higher than their true value. In fact, all α(K)exp for M1 transitions given below are somewhat higher than the corresponding theoretical values. Because of the uncertainty in the α(K)exp, E2 admixture cannot be ruled out in transitions listed as M1.

Eγ	Iγ†	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	Mult.	α	Comments
45.1	15.7	205.6	3^{-}	160.4	2^{-}	(M1)‡	23.8	α(L)=18.1 *3*; α(M)=4.30 *6*; α(N)=1.113 *16*; α(O)=0.238 *4*; α(P)=0.0329 *5* Mult.: γ(t) shows a prompt component suggesting M1 multipolarity (1982Lo01).
55.1	10.2	55.0	0^{-}	0.0	1^{-}	(M1)‡	13.21	α(L)=10.06 *14*; α(M)=2.38 *4*; α(N)=0.618 *9*; α(O)=0.1323 *19*; α(P)=0.0183 *3* Mult.: γ(t) shows only a prompt component suggesting M1 multipolarity.
63.9		1604.7	(15^{-})	1540.8	13^{-}			Eγ: From Adopted Gammas. Tentative Eγ=75.0 keV observed in γγ coin spectrum with (278.1γ, 377.2γ) (1982Lo01) was not seen in ^{208}Pb(^{7}Li,3nγ) (1999Ba30).
69.9	3.7	275.5	5^{-}	205.6	3^{-}			
105.1	2.9	328.1	8^{-}	222.9	(9^{-})	(D+Q)		Mult.: γ(θ) rules out ΔJ=0,2 Q and ΔJ=1 pure D. A_2=0.10 *3*, A_4≈0.
160.4	100	160.4	2^{-}	0.0	1^{-}	(M1)‡	3.15	α(K)=2.55 *4*; α(L)=0.457 *7*; α(M)=0.1081 *16*; α(N)=0.0280 *4*; α(O)=0.00600 *9* α(P)=0.000828 *12* Eγ: excit shows that this γ feeds the ground state. Mult.: γ(θ) rules out ΔJ=0,2; α(L)exp≈0.7 indicates M1. A_2=−0.06 *1*, A_4=−0.01 *2*.
183.8	7.9	885.5	11^{+}	701.6	10^{-}	(E1)	0.1032	α(K)=0.0828 *12*; α(L)=0.01551 *22*; α(M)=0.00368 *6*; α(N)=0.000942 *14*; α(O)=0.000195 *3* α(P)=2.45×10^{-5} *4* Mult.: α(L)exp≈0.03; γ(θ) rules out ΔJ=2 Q and ΔJ=0

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^{209}Bi(α,nγ) 1982Lo01 (continued)

γ(^{212}At) (continued)

E_γ	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α	Comments
								D,Q transitions, A_4=0.13 5 indicates ΔJ=1 D+Q transition. A_2=−0.11 3, A_4=0.123 5.
196.9	<30	1117.7	(5)	920.8	4⁻			I_γ: contaminated line. A_2=0.11 2, A_4=−0.09 3.
239.6	≤10.6	1082.6	(6⁻)	843.0	7⁻			Mult.: γ(θ) rules out ΔJ=1 pure D and ΔJ=0,1 pure Q. A_2=0.18 5, A_4=−0.04 9.
ˣ251.0	2.9							
278.1	4.6	1540.8	13⁻	1262.7	12⁺			Mult.: α(K)exp=0.13 6; γ(θ) rules out ΔJ=1,2 Q, ΔJ=0 D transitions. A_2=−0.25 9, A_4=−0.3 2. Mult.: 1982Lo01 assign E1, however, α(K) is more consistent with M1.
290.7	9.0	345.7	1⁻	55.0	0⁻	(M1(+E2))	0.37 23	Mult.: from α(K)exp=0.60 15; γ(θ) shows ΔJ=1 with A_4=0.09 2 suggesting Q admixture. A_2=−0.10 2, A_4=0.09 2.
ˣ300.0	≈1							
308.9	3.9	363.7	2⁻	55.0	0⁻	(M1+E2)	0.31 20	Mult.: from α(K)exp=0.34 15.
363.6	14.5	363.7	2⁻	0.0	1⁻	(M1)	0.326	α(K)=0.265 4; α(L)=0.0466 7; α(M)=0.01102 16; α(N)=0.00285 4; α(O)=0.000611 9 α(P)=8.44×10^{-5} 12 Mult.: α(K)exp=0.35 5 suggests M1; γ(θ) rules out ΔJ=2 Q or ΔJ=0 D transitions. A_2=−0.04 4, A_4=0.04 6.
366.6	5.5	1209.6	(6⁻)	843.0	7⁻	(M1+E2)	0.20 13	α(K)=0.15 11; α(L)=0.034 12; α(M)=0.0083 25; α(N)=0.00215 64; α(O)=4.5×10^{-4} 15 α(P)=5.9×10^{-5} 24 Mult.: α(K)exp=0.26 4. A_2=0.09 11, A_4=0.2 2.
377.2	5.7	1262.7	12⁺	885.5	11⁺	(M1)	0.295	α(K)=0.240 4; α(L)=0.0422 6; α(M)=0.00997 14; α(N)=0.00258 4; α(O)=0.000553 8 α(P)=7.64×10^{-5} 11 Mult.: α(K)exp=0.43 5; γ(θ) rules out ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.04 2, A_4=−0.2 3.
397.6	5.0	1283.1	12⁺	885.5	11⁺	(M1)	0.256	α(K)=0.208 3; α(L)=0.0365 6; α(M)=0.00863 12; α(N)=0.00224 4; α(O)=0.000479 7 α(P)=6.62×10^{-5} 10 Mult.: α(K)exp=0.24 4; γ(θ) rules out ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.29 15, A_4=0.3 2.
419.8	4.5	783.5	(3⁻)	363.7	2⁻	(M1)	0.221	α(K)=0.180 3; α(L)=0.0315 5; α(M)=0.00745 11; α(N)=0.00193 3; α(O)=0.000413 6 α(P)=5.71×10^{-5} 8 Mult.: α(K)exp=0.26 7; γ(θ) rules out ΔJ=2 Q or ΔJ=0 D transition. A_2=−0.1 2, A_4=0.2 3.
435.6	4.4	1321.1	(11⁺)	885.5	11⁺	(M1)	0.200	α(K)=0.1628 23; α(L)=0.0285 4; α(M)=0.00674 10; α(N)=0.001745 25; α(O)=0.000374 6 α(P)=5.17×10^{-5} 8 Mult.: from α(K)exp=0.20 5. A_2=0.4 4, A_4=−0.2 5.
ˣ442.0	2							
478.6	20.7	701.6	10⁻	222.9	(9⁻)	[M1][#]	0.1556	α(K)=0.1266 18; α(L)=0.0221 3; α(M)=0.00523 8; α(N)=0.001353 19; α(O)=0.000290 4 α(P)=4.01×10^{-5} 6

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^{209}Bi(α,nγ) 1982Lo01 (continued)

γ(^{212}At) (continued)

Eγ	Iγ†	Ei(level)	J_i^π	Ef	J_f^π	Mult.	α	Comments
								Mult.: although the transition is assumed to be M1, A_4=0.20 *4* in γ(θ) suggests some E2 admixture. A_2=0.13 *3*, A_4=0.20 *4*.
514.8	19	843.0	7⁻	328.1	8⁻	(M1)	0.1281	α(K)=0.1043 *15*; α(L)=0.0182 *3*; α(M)=0.00430 *6*; α(N)=0.001112 *16*; α(O)=0.000238 *4* α(P)=3.29×10^{-5} *5* Mult.: α(K)exp≈0.12; γ(θ) rules out ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.18 *8*.
526.7	7.0	890.4	3⁻	363.7	2⁻	(M1)	0.1206	α(K)=0.0981 *14*; α(L)=0.01712 *24*; α(M)=0.00404 *6*; α(N)=0.001046 *15*; α(O)=0.000224 *4* α(P)=3.10×10^{-5} *5* Eγ: Eγ=526.4 given in table 2 (1982Lo01) seems to be a misprint. The value, 526.7 appears on level scheme (fig.7) and agrees with the deduced level energy. Mult.: α(K)exp=0.14 *3* suggests M1; A_4=−0.23 *14* in γ(θ) indicates Q admixture. A_2=−0.02 *9*, A_4=−0.23 *14*.
536.7	4.4	1457.5	(5⁺)	920.8	4⁻	(E1)	0.00920	α(K)=0.00757 *11*; α(L)=0.001249 *18*; α(M)=0.000293 *4*; α(N)=7.53×10^{-5} *11* α(O)=1.593×10^{-5} *23*; α(P)=2.13×10^{-6} *3* Mult.: from α(K)exp=0.017 *5*; γ(θ) rules out ΔJ=0,2 Q and ΔJ=0 D transitions, A_4=0.4 *2* suggests Q admixture. A_2=−0.25 *14*, A_4=0.4 *2*.
567.6	15.4	622.6	(1,2)⁻	55.0	0⁻	(M1)	0.0989	α(K)=0.0805 *12*; α(L)=0.01401 *20*; α(M)=0.00331 *5*; α(N)=0.000856 *12*; α(O)=0.000183 *3* α(P)=2.54×10^{-5} *4* Eγ: Eγ=567.1 given in table 2 in 1982Lo01 is possibly a misprint. The level scheme (fig. 7) gives 567.6 which fits the level energies. Mult.: α(K)exp=0.090 *15*. A_2=−0.01 *8*, A_4=−0.05 *13*.
^{x}570.3	1.9							
580.3	10.6	635.3	(1,2)⁻	55.0	0⁻			α(K)exp≥0.15.
587.7	14.9	748.1	(1,2,3,4)⁻	160.4	2⁻	(M1)	0.0902	α(K)=0.0735 *11*; α(L)=0.01277 *18*; α(M)=0.00301 *5*; α(N)=0.000780 *11* α(O)=0.0001671 *24*; α(P)=2.31×10^{-5} *4* Mult.: α(K)exp=0.086 *15*. A_2=0.00 *10*, A_4=0.04 *15*.
608.6	9.1	769.0	(1,2,3,4)⁻	160.4	2⁻	(M1)	0.0823	α(K)=0.0670 *10*; α(L)=0.01164 *17*; α(M)=0.00275 *4*; α(N)=0.000711 *10* α(O)=0.0001523 *22*; α(P)=2.11×10^{-5} *3* Mult.: α(K)exp=0.080 *10*. A_2=0.07 *8*, A_4=0.10 *13*.
618.8	@	779.2	(1,2,3,4)⁻	160.4	2⁻	@		
620.0	@	843.0	7⁻	222.9	(9⁻)	@		
650.1	2.6	1933.2	13⁺	1283.1	12⁺	(M1+E2)	0.044 *26*	α(K)=0.035 *22*; α(L)=0.0067 *31*; α(M)=0.00161 *70*; α(N)=4.2×10^{-4} *18*; α(O)=8.9×10^{-5} *40* α(P)=1.19×10^{-5} *58* Mult.: α(K)exp≈0.06 suggests M1; γ(θ) rules out pure D (A_4=0.26 *15*), ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.14 *9*, A_4=0.26 *15*.

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^{209}Bi(α,nγ) 1982Lo01 (continued)

γ(^{212}At) (continued)

E_γ	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α	Comments
662.5	16.9	885.5	11+	222.9	(9−)	M2	0.1714	α(K)=0.1343 *19*; α(L)=0.0281 *4*; α(M)=0.00681 *10*; α(N)=0.001772 *25*; α(O)=0.000378 *6* α(P)=5.17×10^{-5} *8* Mult.: from α(K)exp=0.17 *5* and γ(θ) (A_4 rules out ΔJ=1). A_2=0.04 *1*, A_4=−0.05 *2*.
^{x}675.0	15.3					(M1+E2)	0.040 *23*	α(K)=0.032 *20*; α(L)=0.0061 *28*; α(M)=0.00146 *63*; α(N)=3.8×10^{-4} *17*; α(O)=8.0×10^{-5} *36* α(P)=1.08×10^{-5} *53*
679.6	11.6	840.0	(1,2,3,4)−	160.4	2−	(M1+E2)	0.039 *23*	α(K)=0.031 *19*; α(L)=0.0060 *27*; α(M)=0.00143 *62*; α(N)=3.7×10^{-4} *16*; α(O)=7.9×10^{-5} *35* α(P)=1.06×10^{-5} *52* Mult.: from α(K)exp=0.068 *15*; γ(θ) rules out a pure Q or D transition. A_2=−0.30 *10*, A_4>0.
685.4	6.9	845.8	(1,2,3,4)−	160.4	2−	(M1)	0.0602	α(K)=0.0491 *7*; α(L)=0.00849 *12*; α(M)=0.00200 *3*; α(N)=0.000518 *8*; α(O)=0.0001111 *16* α(P)=1.537×10^{-5} *22* Mult.: α(K)exp=0.073 *10*; γ(θ) rules out ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.2 *1*, A_4=−0.1 *3*.
715.1	19.6	920.8	4−	205.6	3−	(E2)	0.01515	α(K)=0.01134 *16*; α(L)=0.00287 *4*; α(M)=0.000708 *10*; α(N)=0.000183 *3*; α(O)=3.81×10^{-5} *6* α(P)=4.80×10^{-6} *7* Mult.: from α(K)exp=0.011 *4*; γ(θ) data suggest ΔJ=2 Q or ΔJ=1 D+Q transition. A_2=−0.11 *4*, A_4=−0.01 *6*.
728.2	7.4	1429.8	11−	701.6	10−	(M1)	0.0514	α(K)=0.0419 *6*; α(L)=0.00724 *11*; α(M)=0.001706 *24*; α(N)=0.000442 *7*; α(O)=9.46×10^{-5} *14* α(P)=1.309×10^{-5} *19* Mult.: from α(K)exp=0.061 *15*. A_2=−0.08 *10*, A_4=0.08 *15*.
760.5 *3*	14.2	920.8	4−	160.4	2−	(E2)	0.01333	α(K)=0.01009 *15*; α(L)=0.00245 *4*; α(M)=0.000601 *9*; α(N)=0.0001553 *22*; α(O)=3.24×10^{-5} *5* α(P)=4.11×10^{-6} *6* Mult.: from α(K)exp=0.0086 *20*; γ(θ) rules out ΔJ=0,1 Q transition. A_2=0.21 *10*, A_4=0.04 *15*.
765.7	4.9	1651.2	13+	885.5	11+	(E2)	0.01315	α(K)=0.00996 *14*; α(L)=0.00241 *4*; α(M)=0.000590 *9*; α(N)=0.0001525 *22*; α(O)=3.18×10^{-5} *5* α(P)=4.05×10^{-6} *6* Mult.: from α(K)exp=0.012 *5*; γ(θ) rules out ΔJ=0,1 Q and ΔJ=1 D transitions. A_2=0.4 *3*, A_4=0.2 *5*.
942.1	11.0	1827.6	12+	885.5	11+	(M1+E2)	0.0175 *88*	α(K)=0.0141 *74*; α(L)=0.0026 *12*; α(M)=6.1×10^{-4} *26*; α(N)=1.57×10^{-4} *67*; α(O)=3.4×10^{-5} *15* α(P)=4.6×10^{-6} *21* Mult.: α(K)exp≈0.02 suggests M1+E2; γ(θ) rules out ΔJ=2 Q and ΔJ=0 D transitions. A_2=−0.3 *2*, A_4=−0.3 *3*.

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^{209}Bi(α,nγ) 1982Lo01 (continued)

γ(^{212}At) (continued)

† From singles spectrum at E(α)=20.6 MeV; ΔI_γ not given.

‡ From shell model the low-lying levels in ^{212}At are expected to have negative parity, therefore E1 transitions are not expected between these levels.

This 478.6, 10^- to 9^- transition was assumed to be M1; its α(K)exp was used to normalize the ce-spectra to the γ-spectra in order to calculate the experimental conversion coefficients. The value of α(K)(478.6γ) used for normalization is not given.

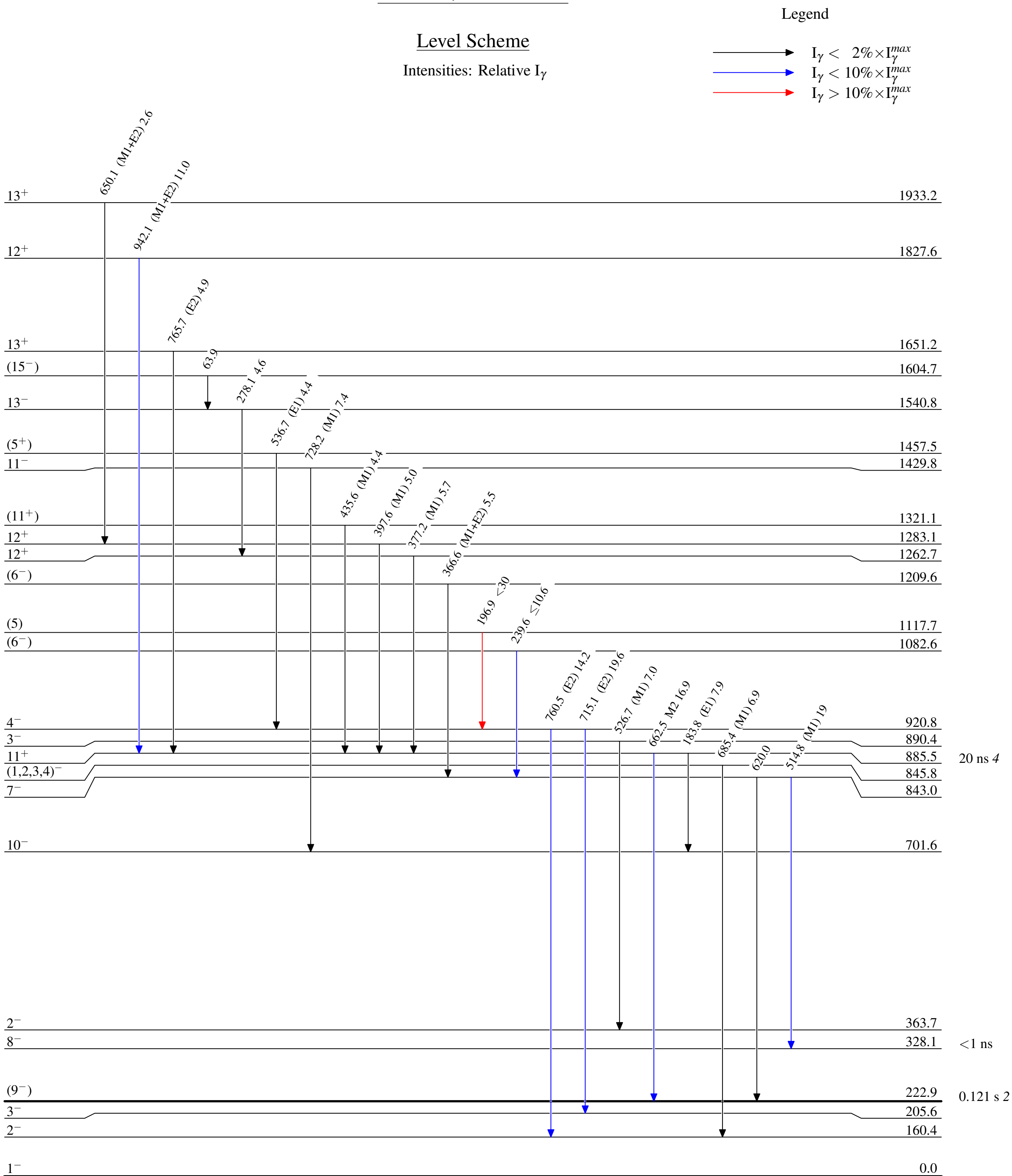
@ Iγ(618.8γ+620.0γ)=15.5. α and γ(θ) show that the 618.8γ + 620.0γ peak is a mixture of M1 and E2 multipolarities.

^{x} γ ray not placed in level scheme.

^{209}Bi(α,nγ) 1982Lo01

Level Scheme

Intensities: Relative I_γ



$^{212}_{85}At_{127}$

^{209}Bi(α,nγ) 1982Lo01

Level Scheme (continued)

Intensities: Relative I_γ