^{209}Bi(^{3}He,3nγ) 1985Ra21,1978Ad05

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. Chen # and F. G. Kondev	NDS 126, 373 (2015)	30-Sep-2013

1985Ra21: E=19.0-27.6 MeV ^{3}He beams were produced from the 90 cm cyclotron of the Physics Department of Jyvaskyla University (JYFL). Pure ^{209}Bi target was used. γ-rays were detected by medium-sized (6-13% efficiency) Ge(Li) detectors and conversion electrons were detected by the jyfl electron spectrometer. Measured Eγ, Iγ, γ(θ), γ(t), γγ-coin, I(ce), pulsed beam. Deduced levels, J^π, $T_{1/2}$, γ-branchings, γ-ray transition multipolarities, conversion coefficients, configuration.

1978Ad05: E=28 and 26 MeV ^{3}He beams were produced from the U-120 cyclotron of the Nuclear Physics Institute in Rez. A monoisotopic target of about 10 mg/cm^2 thickness was used. γ-rays were detected by Ge(Li) detectors with volumes of 34 and 7 cm^3. Measured Eγ, Iγ, γγ-coin. Deduced levels, J^π.

^{209}At Levels

E(level)†	J^π‡	$T_{1/2}$	Comments
0	9/2⁻		J^π: from Adopted Levels. Additional information 1.
408.29 *9*	7/2⁻		Additional information 2.
577.01 *8*	11/2⁻		configuration=$\pi(1h_{9/2})^{+1}\otimes 2^+$.
725.01 *8*	13/2⁻		configuration=$\pi(1h_{9/2})^{+1}\otimes 2^+$.
745.85 *15*	(9/2)⁻		Additional information 3.
789.09 *22*	(5/2,7/2)⁻		
794.70 *15*	(5/2,7/2)⁻		
1081.49 *22*	(5/2⁻,7/2⁻)		
1097.69 *22*	(5/2⁻,7/2⁻)		
1130.89 *22*	(5/2,7/2)⁻		
1214.24 *13*	(11/2,13/2)⁻		
1242.29 *11*	(13/2⁻)		Additional information 4.
1269.77 *18*	(11/2,13/2)⁻		J^π: 1985Ra21 assigns J^π=15/2⁻ from 692.8γ to 11/2⁻ with mult=pure E2, however, the measured α(K)exp=0.026 *3* in 1985Ra21 gives mult=M1+E2 with δ(E2/M1)=1.3 *3*.
1321.51 *13*	17/2⁻		configuration=$\pi(1h_{9/2})^{+3}$.
1339.51 *22*	(13/2,15/2)⁻		
1393.51 *13*	(13/2,15/2)⁻		
1427.61 *24*	21/2⁻	24 ns *2*	$T_{1/2}$: from 596.5γ(t) and 725.0γ(t) in 1985Ra21. configuration=$\pi(1h_{9/2})^{+3}$.
1516.83 *15*	(13/2⁻,15/2⁻)		
1659.91 *22*			
1772.50 *13*	(15/2⁻)		
1851.6 *3*	23/2⁻		configuration=$\pi(1h^2_{9/2}2f^1_{7/2})^{+3}$.
1907.21 *17*	19/2⁻		
2075.91 *24*	(19/2⁻)		configuration=$\pi(1h^2_{9/2}2f^1_{7/2})^{+3}$.
2086.30 *24*			
2238.3 *3*	25/2⁻		
2429.3 *3*	29/2⁺	860 ns *20*	$T_{1/2}$: from 577.7γ(t) in 1985Ra21. configuration=$\pi(1h^2_{9/2}1i^1_{13/2})^{+3}$.
2605.3 *4*	(25/2⁺)		configuration=$\pi(1h^2_{9/2}1i^1_{13/2})^{+3}$.
2611.9 *4*	(25/2⁻)		
3188.6 *4*	(31/2⁺)		

† From a least-squares fit to γ-ray energies.

‡ From 1985Ra21, based on deduced γ-ray transition multipolarities, unless otherwise noted.

γ(^{209}At)

Additional information 5.

E_γ [‡]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	δ [&]	α [†]	Comments
106.1[#] *2*	9 *1*	1427.61	$21/2^-$	1321.51	$17/2^-$	E2		6.03 *10*	α(K)=0.393 *6*; α(L)=4.17 *7*; α(M)=1.119 *19*; α(N+..)=0.351 *6* α(N)=0.289 *5*; α(O)=0.0566 *10*; α(P)=0.00572 *10* Mult.: from 1975Be39 in (α,4nγ). Also, A_2=+0.08 *1*, A_4=+0.02 *2* (1985Ra21), $T_{1/2}$ =24 ns *2* rules out mult=pure M2. Additional information 6.
147.9[#] *2*	7.0 *7*	725.01	$13/2^-$	577.01	$11/2^-$	M1		3.97	α(K)=3.21 *5*; α(L)=0.575 *9*; α(M)=0.1362 *20*; α(N+..)=0.0439 *7* α(N)=0.0353 *6*; α(O)=0.00756 *11*; α(P)=0.001043 *16* Mult.: α(L)exp=0.52 *5*, A_2=−0.11 *1*, A_4=+0.01 *2* (1985Ra21).
247.1 *2*	1.0 *2*	1516.83	$(13/2^-,15/2^-)$	1269.77	$(11/2,13/2)^-$				
313.8 *2*	2.0 *4*	2086.30		1772.50	$(15/2^-)$				
337.6[#] *2*	5.0 *5*	745.85	$(9/2)^-$	408.29	$7/2^-$	M1(+E2)	<0.4	0.378 *22*	α(K)=0.305 *20*; α(L)=0.0553 *20*; α(M)=0.0131 *5*; α(N+..)=0.00422 *14* α(N)=0.00340 *11*; α(O)=0.00073 *3*; α(P)=9.9×10^{-5} *5* Mult.,δ: α(K)exp=0.33 *3*, A_2=+0.11 *5*, A_4=+0.05 *8* (1985Ra21).
380.8[#] *2*	5.0 *5*	789.09	$(5/2,7/2)^-$	408.29	$7/2^-$	M1(+E2)	<0.4	0.272 *16*	α(K)=0.220 *14*; α(L)=0.0396 *16*; α(M)=0.0094 *4*; α(N+..)=0.00302 *12* α(N)=0.00243 *9*; α(O)=0.000520 *20*; α(P)=7.1×10^{-5} *4* Mult.,δ: α(K)exp=0.24 *3*, A_2=+0.02 *5*, A_4=+0.01 *8* (1985Ra21).
386.4 *2*	≈2[a]	794.70	$(5/2,7/2)^-$	408.29	$7/2^-$	(M1+E2)[a]		0.17 *11*	α(K)=0.13 *10*; α(L)=0.029 *11*; α(M)=0.0071 *23*; α(N+..)=0.0023 *8* α(N)=0.0018 *6*; α(O)=0.00039 *14*; α(P)=5.0×10^{-5} *22* I_γ: from Iγ(386γ)/Iγ(795γ)=0.61 in ε decay.
386.6 *2*	≈5[a]	2238.3	$25/2^-$	1851.6	$23/2^-$	(M1+E2)[a]		0.17 *11*	α(K)=0.13 *10*; α(L)=0.029 *11*; α(M)=0.0071 *23*; α(N+..)=0.0023 *8* α(N)=0.0018 *6*; α(O)=0.00039 *14*; α(P)=5.0×10^{-5} *22* I_γ: from Iγ for the doublet and Iγ(386.4γ) determined from branching in ε decay. 4 *2* for 386.3γ in 1978Ad05.
408.3[#] *1*	36.0 *4*	408.29	$7/2^-$	0	$9/2^-$	E2		0.0557	α(K)=0.0348 *5*; α(L)=0.01558 *22*; α(M)=0.00399 *6*; α(N+..)=0.001267 *18* α(N)=0.001033 *15*; α(O)=0.000210 *3*; α(P)=2.43×10^{-5} *4* Mult.: α(K)exp=0.035 *2*, A_2=−0.03 *1*, A_4=−0.01 *1* (1985Ra21).

$^{209}_{85}$At$_{124}$-2

γ(^{209}At) (continued)

E_γ[‡]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[&]	α[†]	Comments
424.0[#] *1*	25.0 *3*	1851.6	23/2⁻	1427.61	21/2⁻	M1		0.215	α(K)=0.1750 *25*; α(L)=0.0307 *5*; α(M)=0.00725 *11*; α(N+..)=0.00234 *4* α(N)=0.00188 *3*; α(O)=0.000402 *6*; α(P)=5.56×10^{-5} *8* Mult.: α(K)exp=0.183, A_2=−0.21 *2*, A_4=−0.03 *2* (1985Ra21).
489.2 *2*	3.0 *6*	1214.24	(11/2,13/2)⁻	725.01	13/2⁻	M1(+E2)	<0.3	0.142 *5*	α(K)=0.115 *5*; α(L)=0.0204 *6*; α(M)=0.00481 *14*; α(N+..)=0.00155 *5* α(N)=0.00125 *4*; α(O)=0.000267 *8*; α(P)=3.68×10^{-5} *12* Mult.,δ: α(K)exp=0.14 *2* (1985Ra21).
517.2[#] *2*	3.0 *6*	1242.29	(13/2⁻)	725.01	13/2⁻	(E2)		0.0310	α(K)=0.0214 *3*; α(L)=0.00724 *11*; α(M)=0.00183 *3*; α(N+..)=0.000581 *9* α(N)=0.000472 *7*; α(O)=9.68×10^{-5} *14*; α(P)=1.164×10^{-5} *17* Mult.: α(K)exp=0.03 *2* (1985Ra21).
530.2[#] *1*	10.0 *5*	1772.50	(15/2⁻)	1242.29	(13/2⁻)	M1+E2	0.57 *5*	0.097 *4*	α(K)=0.078 *3*; α(L)=0.0143 *4*; α(M)=0.00341 *9*; α(N+..)=0.00110 *3* α(N)=0.000883 *23*; α(O)=0.000188 *5*; α(P)=2.56×10^{-5} *8* Mult.,δ: α(K)exp=0.078 *2*, A_2=−0.30 *3*, A_4=−0.00 *5* (1985Ra21).
577.0[#] *1*	95 *1*	577.01	11/2⁻	0	9/2⁻	M1+E2	0.71 *11*	0.071 *5*	α(K)=0.057 *5*; α(L)=0.0107 *6*; α(M)=0.00254 *14*; α(N+..)=0.00082 *5* α(N)=0.00066 *4*; α(O)=0.000140 *8*; α(P)=1.90×10^{-5} *12* Mult.,δ: from α(K)exp=0.055 *3*, A_2=−0.25 *1*, A_4=+0.01 *1* for 577.0+577.7 and I(577.0γ)/I(577.7γ)=95/11 given mult(577.7γ) is E3 from 1975Be39 in (α,4nγ). α(K)exp=0.55 in 1985Ra21 is a typographical error.
577.7[#] *1*	11.0 *6*	2429.3	29/2⁺	1851.6	23/2⁻	E3		0.0749	α(K)=0.0417 *6*; α(L)=0.0247 *4*; α(M)=0.00647 *9*; α(N+..)=0.00206 *3* α(N)=0.001682 *24*; α(O)=0.000343 *5*; α(P)=4.00×10^{-5} *6* Mult.: from 1975Be39 in (α,4nγ).
585.7[#] *1*	11.0 *6*	1907.21	19/2⁻	1321.51	17/2⁻	M1+E2	1.8 *3*	0.039 *5*	α(K)=0.030 *5*; α(L)=0.0069 *6*; α(M)=0.00167 *13*; α(N+..)=0.00053 *5* α(N)=0.00043 *4*; α(O)=9.1×10^{-5} *8*; α(P)=1.17×10^{-5} *11* Mult.,δ: from α(K)exp=0.030 *3*, but A_2=−0.33 *4* and A_4=+0.04 *5* imply a stretched dipole (1985Ra21).
596.5[#] *1*	77 *1*	1321.51	17/2⁻	725.01	13/2⁻	E2		0.0224	α(K)=0.01609 *23*; α(L)=0.00474 *7*; α(M)=0.001182 *17*; α(N+..)=0.000377 *6* α(N)=0.000306 *5*; α(O)=6.31×10^{-5} *9*; α(P)=7.76×10^{-6} *11* Mult.: α(K)exp=0.017 *1*, A_2=+0.10 *1*, A_4=−0.01 *1* (1985Ra21).
614.5 *2*	6.0 *6*	1339.51	(13/2,15/2)⁻	725.01	13/2⁻	M1+E2	0.48 *14*	0.069 *6*	α(K)=0.056 *5*; α(L)=0.0100 *7*; α(M)=0.00238 *15*; α(N+..)=0.00077 *5* α(N)=0.00062 *4*; α(O)=0.000131 *9*; α(P)=1.80×10^{-5} *13* Mult.: α(K)exp=0.056 *4*, A_2=+0.06 *8*, A_4=−0.06 *11* (1985Ra21).

From ENSDF

γ(^{209}At) (continued)

E_γ[‡]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ[&]	α[†]	Comments
637.2[#] 2	6.0 6	1214.24	(11/2,13/2)$^-$	577.01	11/2$^-$	M1(+E2)	<0.3	0.0707 25	α(K)=0.0575 21; α(L)=0.0100 3; α(M)=0.00237 7; α(N+..)=0.000763 23 α(N)=0.000614 18; α(O)=0.000131 4; α(P)=1.81×10^{-5} 6 Mult.,δ: α(K)exp=0.062 5, A_2=+0.02 7, A_4=0.0 1 (1985Ra21).
665.3 1	18 1	1242.29	(13/2$^-$)	577.01	11/2$^-$	D			Mult.: A_2=−0.07 1, A_4=−0.02 2 (1985Ra21).
668.5 1	11.0 6	1393.51	(13/2,15/2)$^-$	725.01	13/2$^-$	M1(+E2)	<0.2	0.0634 13	α(K)=0.0516 11; α(L)=0.00896 17; α(M)=0.00211 4; α(N+..)=0.000681 13 α(N)=0.000548 10; α(O)=0.0001173 22; α(P)=1.62×10^{-5} 3 Mult.,δ: α(K)exp=0.057 4 (1985Ra21).
673.2 2	1.0 2	1081.49	(5/2$^-$,7/2$^-$)	408.29	7/2$^-$				
689.4 2	3.0 6	1097.69	(5/2$^-$,7/2$^-$)	408.29	7/2$^-$				
692.8[#] 2	12 1	1269.77	(11/2,13/2)$^-$	577.01	11/2$^-$	M1+E2	1.3 3	0.032 6	α(K)=0.025 5; α(L)=0.0050 7; α(M)=0.00121 16; α(N+..)=0.00039 5 α(N)=0.00031 4; α(O)=6.6×10^{-5} 9; α(P)=8.8×10^{-6} 13 Mult.: α(K)exp=0.026 3 (1985Ra21), mult=pure E2 assigned by 1985Ra21.
722.6 2	4.0 8	1130.89	(5/2,7/2)$^-$	408.29	7/2$^-$	M1(+E2)	≤0.9		α(K)=0.040 12; α(L)=0.0070 17; α(M)=0.0017 4; α(N+..)=0.00053 13 α(N)=0.00043 10; α(O)=9.2×10^{-5} 22; α(P)=1.3×10^{-5} 4 Mult.,δ: α(K)exp=0.04 1 (1985Ra21).
725.0[#] 1	100	725.01	13/2$^-$	0	9/2$^-$	E2		0.01472	α(K)=0.01105 16; α(L)=0.00277 4; α(M)=0.000682 10; α(N+..)=0.000218 3 α(N)=0.0001764 25; α(O)=3.67×10^{-5} 6; α(P)=4.64×10^{-6} 7 Mult.: α(K)exp=0.011 1, A_2=+0.11 1, A_4=−0.03 1 (1985Ra21).
745.8[#] 2	7.0 7	745.85	(9/2)$^-$	0	9/2$^-$	M1(+E2)	<0.3	0.0468 16	α(K)=0.0382 13; α(L)=0.00662 20; α(M)=0.00156 5; α(N+..)=0.000503 15 α(N)=0.000404 12; α(O)=8.7×10^{-5} 3; α(P)=1.20×10^{-5} 4 Mult.: α(K)exp=0.040 2 (1985Ra21).
753.7 2	4.0 8	2605.3	(25/2$^+$)	1851.6	23/2$^-$	(E1)[b]		0.00475	α(K)=0.00393 6; α(L)=0.000629 9; α(M)=0.0001467 21; α(N+..)=4.69×10^{-5} 7 α(N)=3.78×10^{-5} 6; α(O)=8.03×10^{-6} 12; α(P)=1.086×10^{-6} 16 Additional information 7.
754.4 2	3.0 6	2075.91	(19/2$^-$)	1321.51	17/2$^-$	(M1)[b]		0.0468	α(K)=0.0382 6; α(L)=0.00659 10; α(M)=0.001554 22; α(N+..)=0.000500 7 α(N)=0.000402 6; α(O)=8.62×10^{-5} 12; α(P)=1.193×10^{-5} 17
759.3 2	2.0 4	3188.6	(31/2$^+$)	2429.3	29/2$^+$	(M1)[c]		0.0461	α(K)=0.0376 6; α(L)=0.00648 9; α(M)=0.001528 22; α(N+..)=0.000492 7 α(N)=0.000395 6; α(O)=8.47×10^{-5} 12; α(P)=1.173×10^{-5} 17
760.3 2	3.0 6	2611.9	(25/2$^-$)	1851.6	23/2$^-$	(M1)[c]		0.0459	α(K)=0.0374 6; α(L)=0.00646 9; α(M)=0.001522 22; α(N+..)=0.000490 7 α(N)=0.000394 6; α(O)=8.44×10^{-5} 12; α(P)=1.169×10^{-5} 17

γ(^{209}At) (continued)

E_γ[‡]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	α[†]	Comments
791.8 *2*	3.0 *6*	1516.83	(13/2⁻,15/2⁻)	725.01	13/2⁻			
794.7 *2*	3.0 *6*	794.70	(5/2,7/2)⁻	0	9/2⁻			
810.8[#] *4*	7.0 *7*	2238.3	25/2⁻	1427.61	21/2⁻	E2	0.01170	α(K)=0.00895 *13*; α(L)=0.00208 *3*; α(M)=0.000508 *8*; α(N+..)=0.0001624 *23* α(N)=0.0001314 *19*; α(O)=2.75×10^{-5} *4*; α(P)=3.52×10^{-6} *5* Mult.: α(K)exp=0.008 *2*, A_2=+0.21 *6*, A_4=+0.06 *9* (1985Ra21).
934.9 *2*	3.0 *6*	1659.91		725.01	13/2⁻			
939.8 *2*	2.0 *4*	1516.83	(13/2⁻,15/2⁻)	577.01	11/2⁻			
1047.5 *2*	2.0 *4*	1772.50	(15/2⁻)	725.01	13/2⁻			
1214.3 *2*	3.0 *6*	1214.24	(11/2,13/2)⁻	0	9/2⁻			

[†] Additional information 8.

[‡] From 1985Ra21, unless otherwise noted. 1985Ra21 states that the uncertainties in Eγ are 0.1-0.2 keV. The evaluators have assigned uncertainties for Eγ from 1985Ra21 of 0.1 keV where Iγ is ≥10 and 0.2 keV for Iγ<10. 1985Ra21 states that uncertainties in Iγ range from 1-20%. The evaluators have assigned uncertainties for Iγ from 1985Ra21 as follows: 1% for Iγ≥20, 5% for Iγ≥10, 10% for Iγ≥5 and 20% for Iγ<5. Iγ is normalized to I(725γ)=100.

[#] Weighted average of values from 1985Ra21 and 1978Ad05.

[@] From Iγ and I(ce(K)) data in 1985Ra21 (except I(ce(L)) for the 148γ), normalized to M1 value 0.183 for the 424γ. unless otherwise noted.

[&] From measured ce data using the BrIccMixing program.

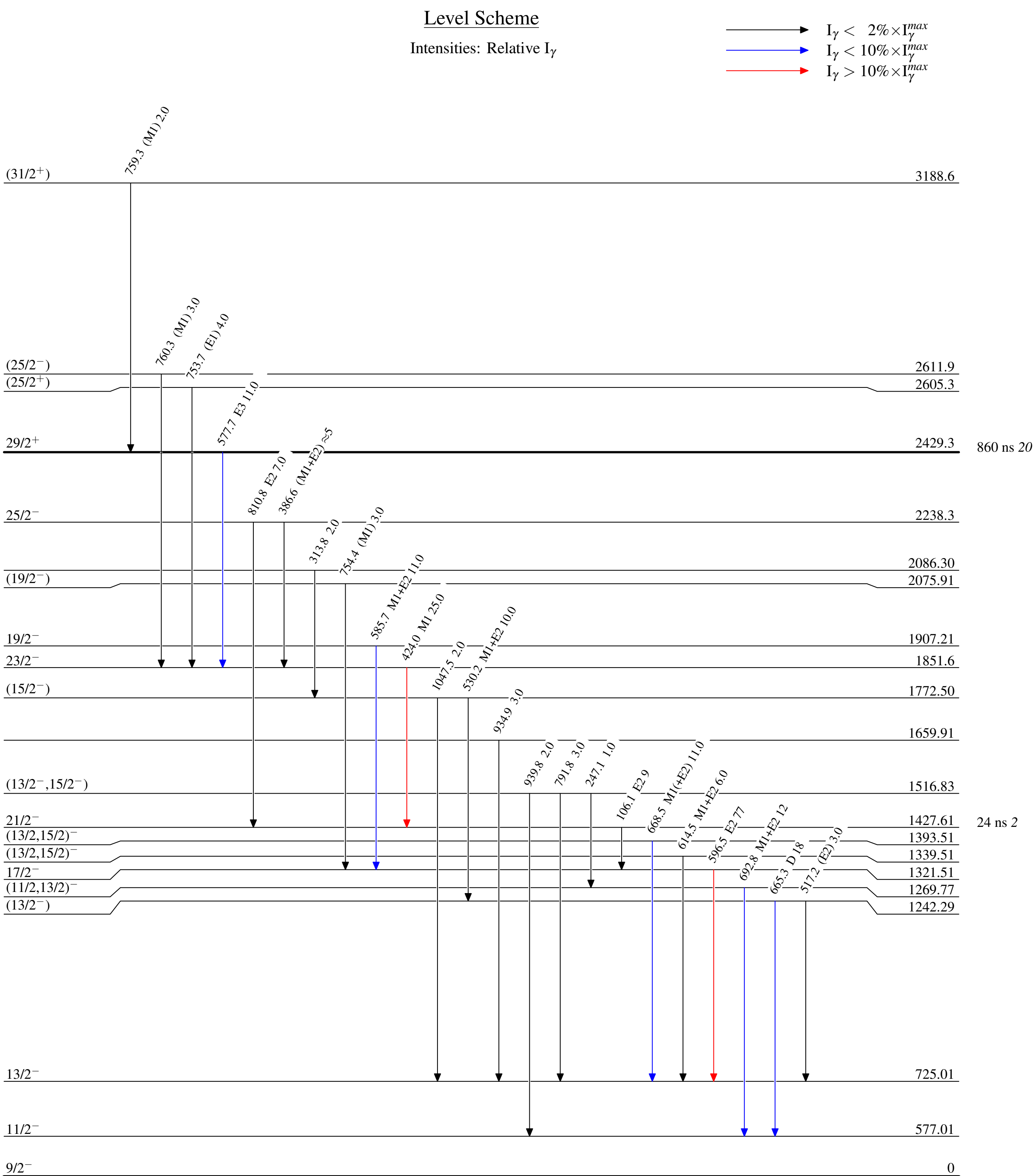
[a] Iγ(386.4+386.6γ′s)=7. A_2=−0.04 *2*, A_4=−0.06 *3*, α(K)exp= 0.10 *4* for 386.4+386.6γ′s (1985Ra21). The intensities were divided by using branching from ε decay.

[b] α(K)exp=0.03 *1* and A_2=−0.38 *5*, A_4=−0.01 *8* from γ(θ) for the 753.7+754.4γ′s (1985Ra21).

[c] α(K)exp=0.05 *1* and A_2=−0.38 *6*, A_4=−0.01 *9* from γ(θ) for the 759.3+760.3γ′s (1985Ra21).

$^{209}_{85}At_{124}$-5

$^{209}Bi(^3He,3n\gamma)$ 1985Ra21,1978Ad05



$^{209}_{85}At_{124}$

$^{209}Bi(^{3}He,3n\gamma)$ 1985Ra21,1978Ad05

Level Scheme (continued)

Intensities: Relative I_γ