^{158}Gd(^{7}Li,p4nγ) 2002Ju08

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 176, 1 (2021)	1-May-2021

Additional information 1.

Reaction channels include (^{7}Li,d3nγ) and (^{7}Li,t2nγ), from an incomplete-fusion reaction induced by ^{7}Li ions.

Data set based on the XUNDL compilation produced by M. Lee and B. Singh (McMaster University), August 28, 2002.

Previous reports of various aspects of these data are given in 1998Ha66 and 2001Ju08.

Incomplete-fusion reaction induced by ^{7}Li ions on ^{158}Gd target. E(^{7}Li)=35-67 MeV, with most measurements at 56 MeV, chosen in a separate experiment designed to determine the optimal energy for population of ^{160}Dy. ^{158}Gd target 3.7 mg/cm^{2} thick. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma\gamma(\theta)$(DCO), (particle)-γ coin., using the GASP array comprised of 40 Compton-suppressed Ge detectors, the 80-element BGO inner ball, and ISIS, consisting of 40 Si ΔE-E telescopes arranged in the same geometry as the Ge crystals in the GASP spectrometer.

^{160}Dy Levels

E(level)[†]	J$^{\pi}$[#]	Comments
0[@]	0^{+}	
86.7877[@] *3*	2^{+}	
283.58[@] *20*	4^{+}	
580.6[@] *3*	6^{+}	
966.1[@] *3*	8^{+}	
1288.2[a] *4*	5^{+}	
1386.0[d] *4*	4^{-}	
1408.1[c] *4*	5^{-}	
1427.3[@] *3*	10^{+}	
1437.9[b] *3*	6^{+}	
1554.2?[e] *11*	4^{-}	E(level): 1987Ri08, (α,2nγ), place this 4^{-} band member at 1536. From ^{160}Ho ε decay, 2002Ad34 place the 4^{-} member of this band at 1535 and do not report a level at this energy. Since this 1554 level is supported by only one feeding γ, about which there is some question, the evaluator has shown it as uncertain.
1593.9[d] *3*	6^{-}	
1613.2[c] *4*	7^{-}	
1616.5[a] *4*	7^{+}	
1694.6[‡g]	4^{+}	
1787.2[e] *5*	6^{-}	E(level): this level was proposed to deexcite via 252.2 and 498.6 γ's by 1987Ri08, (α,2nγ). No 192.6 and 233 γ's were reported by 1987Ri08.
1799.8[b] *3*	8^{+}	
1803.0[‡g]	5^{+}	
1881.6[d] *3*	8^{-}	
1897.5[f] *4*	7^{-}	
1900.2[c] *3*	9^{-}	
1929.8[‡g]	6^{+}	
1949.6[@] *3*	12^{+}	
2020.6[a] *4*	9^{+}	
2075.0[‡g]	(7^{+})	
2111.0[e] *4*	8^{-}	
2220.9[b] *3*	10^{+}	
2241.3[d] *3*	10^{-}	
2263.1[f] *4*	9^{-}	
2263.6[c] *4*	11^{-}	

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^{158}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

^{160}Dy Levels (continued)

E(level)[†]	J$^{\pi}$[#]	E(level)[†]	J$^{\pi}$[#]	E(level)[†]	J$^{\pi}$[#]	E(level)[†]	J$^{\pi}$[#]
2484.8[a] *4*	11^{+}	3187.4[f] *5*	13^{-}	4160.3[&] *4*	18^{+}	5240.5[a] *5*	21^{+}
2513.0[@] *4*	14^{+}	3191.9[c] *4*	15^{-}	4256.3[d] *5*	18^{-}	5527.5[d] *7*	22^{-}
2519.2[e] *4*	10^{-}	3219.6[b] *4*	14^{+}	4277.9[@] *4*	20^{+}	5601.6[b] *11*	22^{+}
2593.1[&] *4*	12^{+}	3507.6[a] *4*	15^{+}	4316.2[f] *8*	17^{-}	5646.8[@] *5*	24^{+}
2665.6[d] *4*	12^{-}	3509.8[e] *5*	14^{-}	4347.3[c] *5*	19^{-}	5704.5[c] *6*	23^{-}
2695.5[f] *5*	11^{-}	3526.1[&] *4*	16^{+}	4349.4[b] *4*	18^{+}	5915.9[a] *6*	23^{+}
2696.7[c] *4*	13^{-}	3669.1[@] *4*	18^{+}	4617.7[a] *4*	19^{+}	6219.1[d] *8*	24^{-}
2707.2[b] *4*	12^{+}	3680.6[d] *5*	16^{-}	4871.9[d] *6*	20^{-}	6412.0[@] *7*	26^{+}
2984.0[e] *5*	12^{-}	3729.8[f] *7*	15^{-}	4874.6[&] *4*	20^{+}	6457.3[c] *8*	25^{-}
2988.1[a] *4*	13^{+}	3743.8[c] *4*	17^{-}	4935.1[@] *5*	22^{+}	6642.1[a] *7*	25^{+}
3007.0[&] *4*	14^{+}	3767.1[b] *4*	16^{+}	4936.0[f] *9*	19^{-}	6965.6[d] *9*	26^{-}
3089.0[@] *4*	16^{+}	4043.6[a] *4*	17^{+}	4974.5[b] *5*	20^{+}	7229.8[@] *8*	28^{+}
3147.8[d] *4*	14^{-}	4077.5[e] *7*	16^{-}	5000.8[c] *5*	21^{-}		

[†] From least-squares fit to the listed Eγ values. The use of the uncertainties of 2002Ju08 in this fit gives a poor result, with 24 Eγ's deviating by more than 3 times the Δ(Eγ) given by 2002Ju08. In the least-squares fit used here, the evaluator assumed Δ(Eγ) values twice those given here, except for those where 1 keV was assigned. This procedure gives a reasonably good fit, with only 6 Eγ's out of a total of 127 deviating by more than 3σ.

[‡] From 1987Ri08, (α,2nγ). 2002Ju08 state that this level, established in other studies, is also observed in their work. However, they give no other information about it.

[#] From the Adopted Levels. For those levels seen only in this reaction, these values are based on multipolarities from DCO ratios and expected energy-level spacings within rotational bands.

[@] Band(A): Yrast band. Below the band crossing, this is the g.s. band.

[&] Band(B): Yrare band. Below the crossing with the g.s. band, this is the S, or “Stockholm”, or “Super”, band.

[a] Band(C): γ-vibrational band, signature=1 component.

[b] Band(c): γ-vibrational band, signature=0 component.

[c] Band(D): K$^{\pi}$=2^{-} octupole-vibrational band, signature=1 component.

[d] Band(d): K$^{\pi}$=2^{-} octupole-vibrational band, signature=0 component.

[e] Band(E): K$^{\pi}$=1^{-} octupole-vibrational band, signature=0 component.

[f] Band(e): K$^{\pi}$=1^{-} octupole-vibrational band, signature=1 component.

[g] Band(F): K$^{\pi}$=4^{+} band.

γ(^{160}Dy)

2002Ju08 state that the DCO ratios are $\approx$1 for stretched quadrupole transitions and $\approx$0.5 for pure dipole transitions in a stretched quadrupole transition gate; and $\approx$2 for stretched quadrupole transitions and $\approx$1 for pure dipole transitions in a stretched dipole transition gate. As the nature of the gates is not stated on a case by case basis no γ ray multipolarities are adopted by the evaluator from the DCO values listed in the table.

E$_{\gamma}$[†]	I$_{\gamma}$[‡]	E$_{i}$(level)	J$^{\pi}_{i}$	E$_{f}$	J$^{\pi}_{f}$	Comments
86.7877 *3*		86.7877	2^{+}	0	0^{+}	E$_{\gamma}$: value from the evaluation of 2000He14, from ^{160}Tb decay. γ not reported by 2002Ju08.
185.5 *2*	<0.5	1593.9	6^{-}	1408.1	5^{-}	
192.6 *2*	<0.5	1787.2	6^{-}	1593.9	6^{-}	E$_{\gamma}$: γ not reported by 1987Ri08.
196.8 *1*	100.0	283.58	4^{+}	86.7877	2^{+}	

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^{158}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

γ(^{160}Dy) (continued)

E_γ †	I_γ ‡	E_i(level)	J^π_i	E_f	J^π_f	Comments
207.9 2	<0.5	1593.9	6−	1386.0	4−	
230.0 2	<0.5	2111.0	8−	1881.6	8−	
233 1	<0.5	1787.2	6−	1554.2?	4−	E_γ: γ not reported by 1987Ri08.
268.5 2	<0.5	1881.6	8−	1613.2	7−	
278.2 2	<0.5	2519.2	10−	2241.3	10−	
286.9 2	<0.5	1900.2	9−	1613.2	7−	
287.8 1	2.6 1	1881.6	8−	1593.9	6−	DCO=1.12 6.
297.0 1	84# 3	580.6	6+	283.58	4+	DCO=1.12 1.
318.2 2	<0.5	2984.0	12−	2665.6	12−	
323.2 2	<0.5	2111.0	8−	1787.2	6−	
328.3 1	0.5 1	1616.5	7+	1288.2	5+	
341.2 2	<0.5	2241.3	10−	1900.2	9−	
359.8 1	4.4 2	2241.3	10−	1881.6	8−	DCO=1.11 5.
362.0 1	0.7 1	1799.8	8+	1437.9	6+	
363.4 1	1.0 1	2263.6	11−	1900.2	9−	
365.3 2	<0.5	2263.1	9−	1897.5	7−	
385.5 1	69# 3	966.1	8+	580.6	6+	DCO=1.07 1.
404.2 1	1.4 1	2020.6	9+	1616.5	7+	DCO=1.03 11.
408.1 2	<0.5	2519.2	10−	2111.0	8−	
414.3 2	<0.5	3007.0	14+	2593.1	12+	
421.6 1	0.9 1	2220.9	10+	1799.8	8+	
424.4 1	4.6 2	2665.6	12−	2241.3	10−	DCO=1.00 3.
432.4 2	<0.5	2695.5	11−	2263.1	9−	
433.0 1	2.1 1	2696.7	13−	2263.6	11−	DCO=1.03 6.
437.4 2	<0.5	3526.1	16+	3089.0	16+	DCO=0.79 4.
461.4 1	51# 3	1427.3	10+	966.1	8+	DCO=1.03 1.
464.3 1	3.7 2	2484.8	11+	2020.6	9+	DCO=1.12 7.
465.0 2	<0.5	2984.0	12−	2519.2	10−	
475 1	<0.5	2988.1	13+	2513.0	14+	
482.2 1	3.1 2	3147.8	14−	2665.6	12−	DCO=0.96 4.
486.1 1	0.5 1	2707.2	12+	2220.9	10+	
490.6 2	<0.5	4160.3	18+	3669.1	18+	
491.9 1	0.6 1	3187.4	13−	2695.5	11−	
493.7 1	1.3 1	3007.0	14+	2513.0	14+	
495.4 1	4.2 2	3191.9	15−	2696.7	13−	
503.3 1	2.2 1	2988.1	13+	2484.8	11+	
512.2 1	0.7 1	3219.6	14+	2707.2	12+	
517.2 2	<0.5	3526.1	16+	3007.0	14+	E_γ: Note: level-energy difference=519.1. A poor energy fit.
519.7 1	2.3 1	3507.6	15+	2988.1	13+	DCO=1.28 8.
522.6 1	36# 3	1949.6	12+	1427.3	10+	DCO=1.01 2.
525.8 1	0.6 1	3509.8	14−	2984.0	12−	
532.8 1	2.1 1	3680.6	16−	3147.8	14−	DCO=1.01 5.
534.7 2	<0.5	2484.8	11+	1949.6	12+	DCO=0.72 6.
536.1 1	1.1 1	4043.6	17+	3507.6	15+	DCO=0.72 6.
542.4 2	<0.5	3729.8	15−	3187.4	13−	
547.1 2	<0.5	3767.1	16+	3219.6	14+	
551.5 1	3.0 2	3743.8	17−	3191.9	15−	DCO=0.82 4.
563.3 1	22.6 11	2513.0	14+	1949.6	12+	DCO=1.01 2.
567.7 2	<0.5	4077.5	16−	3509.8	14−	
574.1 1	1.2 1	4617.7	19+	4043.6	17+	
575.7 1	1.3 1	4256.3	18−	3680.6	16−	DCO=1.02 6.
576.5 1	13.2 7	3089.0	16+	2513.0	14+	DCO=1.01 2.
580.5 1	7.6 4	3669.1	18+	3089.0	16+	DCO=1.01 3.
582.3 1	0.9 1	4349.4	18+	3767.1	16+	
586.4 2	<0.5	4316.2	17−	3729.8	15−	

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^{158}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

γ(^{160}Dy) (continued)

E_γ †	I_γ ‡	E_i(level)	J^π_i	E_f	J^π_f	Comments
596.7 *1*	0.7 *1*	4874.6	20+	4277.9	20+	
603.5 *1*	2.9 *1*	4347.3	19−	3743.8	17−	DCO=0.80 *5*.
608.6 *1*	4.7 *2*	4277.9	20+	3669.1	18+	DCO=0.82 *1*.
615.6 *1*	0.9 *1*	4871.9	20−	4256.3	18−	DCO=1.29 *9*.
619.8 *2*	<0.5	4936.0	19−	4316.2	17−	
623.0 *1*	0.6 *1*	5240.5	21+	4617.7	19+	
624.0 *2*	<0.5	4974.5	20+	4349.4	18+	
634.0 *2*	<0.5	4160.3	18+	3526.1	16+	
645.6 *2*	<0.5	2593.1	12+	1949.6	12+	E_γ: Note: level-energy difference=643.5. A poor energy fit.
653.5 *1*	0.8 *1*	5000.8	21−	4347.3	19−	
655.2 *1*	0.5 *1*	3743.8	17−	3089.0	16+	
655.6 *2*	<0.5	5527.5	22−	4871.9	20−	
657.2 *1*	1.5 *1*	4935.1	22+	4277.9	20+	
675.4 *2*	<0.5	5915.9	23+	5240.5	21+	
678.3 *1*	1.6 *1*	3191.9	15−	2513.0	14+	DCO=0.67 *4*.
679.0 *2*	<0.5	3767.1	16+	3089.0	16+	
680.6 *2*	<0.5	4349.4	18+	3669.1	18+	
691.6 *2*	<0.5	6219.1	24−	5527.5	22−	
696.8 *2*	<0.5	4974.5	20+	4277.9	20+	
703.7 *2*	<0.5	5704.5	23−	5000.8	21−	
706.6 *2*	<0.5	3219.6	14+	2513.0	14+	
711.7 *1*	0.6 *1*	5646.8	24+	4935.1	22+	
713.8 *2*	<0.5	4874.6	20+	4160.3	18+	
715.6 *2*	<0.5	2665.6	12−	1949.6	12+	
726.2 *2*	<0.5	6642.1	25+	5915.9	23+	
727 *1*		5601.6	22+	4874.6	20+	E_γ: taken from the level-scheme drawing of 2002Ju08.
746.5 *2*	<0.5	6965.6	26−	6219.1	24−	
747.3 *1*	4.5 *2*	2696.7	13−	1949.6	12+	DCO=0.51 *2*.
752.8 *2*	<0.5	6457.3	25−	5704.5	23−	
757.5 *1*	0.6 *1*	2707.2	12+	1949.6	12+	DCO=1.09 *11*.
765.2 *2*	<0.5	6412.0	26+	5646.8	24+	
793.8 *1*	1.0 *1*	2220.9	10+	1427.3	10+	DCO=0.68 *5*.
813.9 *1*	0.6 *1*	2241.3	10−	1427.3	10+	
817.8 *2*	<0.5	7229.8	28+	6412.0	26+	
834.0 *1*	2.8 *1*	1799.8	8+	966.1	8+	
836.3 *1*	5.9 *3*	2263.6	11−	1427.3	10+	DCO=0.57 *4*.
857.3 *1*	1.5 *1*	1437.9	6+	580.6	6+	DCO=0.75 *4*.
915.6 *1*	1.9 *1*	1881.6	8−	966.1	8+	DCO=0.99 *6*.
934.1 *1*	2.7 *1*	1900.2	9−	966.1	8+	DCO=0.55 *2*.
949.6 *2*	<0.5	4617.7	19+	3669.1	18+	
953.8 *2*	<0.5	4043.6	17+	3089.0	16+	
961.9 *2*	<0.5	5240.5	21+	4277.9	20+	
994.6 *2*	<0.5	3507.6	15+	2513.0	14+	
1004.6 *2*	2.0 *1*	1288.2	5+	283.58	4+	DCO=0.51 *3*.
1013.3 *2*	2.4 *1*	1593.9	6−	580.6	6+	DCO=1.05 *6*.
1014.5 *2*	1.0 *1*	3526.1	16+	2513.0	14+	DCO=0.87 *3*. E_γ: Note: level-energy difference=1013.1. A poor energy fit.
1032.7 *2*	1.3 *1*	1613.2	7−	580.6	6+	DCO=0.46 *3*.
1036.0 *2*	3.1 *2*	1616.5	7+	580.6	6+	DCO=0.68 *10*.
1038.8 *2*	1.1 *1*	2988.1	13+	1949.6	12+	DCO=0.47 *3*.
1054.6 *2*	2.9 *2*	2020.6	9+	966.1	8+	DCO=0.56 *2*.
1056.5 *2*	1.3 *1*	3007.0	14+	1949.6	12+	
1058.1 *2*	1.9 *1*	2484.8	11+	1427.3	10+	DCO=0.58 *3*.
1071.7 *2*	<0.5	4160.3	18+	3089.0	16+	
1102.4 *2*	<0.5	1386.0	4−	283.58	4+	
1124.3 *2*		1408.1	5−	283.58	4+	

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^{158}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

γ(^{160}Dy) (continued)

E_γ†	I_γ‡	E_i(level)	J^π_i	E_f	J^π_f	Comments
1154.5 *2*	<0.5	1437.9	6+	283.58	4+	
1164.1 *2*	0.5 *1*	2593.1	12+	1427.3	10+	E_γ: Note: level-energy difference=1165.8. A poor energy fit.
1205.9 *2*	<0.5	4874.6	20+	3669.1	18+	
1219.6 *2*	0.9 *1*	1799.8	8+	580.6	6+	
1251.1 *2*	<0.5	2220.9	10+			E_γ: Note: level-energy difference=1254.7. A poor energy fit.
1253.7 *2*	<0.5	3767.1	16+	2513.0	14+	
1259.2 *2*	<0.5	4349.4	18+	3089.0	16+	E_γ: Note: level-energy difference=1260.5. A poor energy fit.
1268.3 *2*	<0.5	2695.5	11−	1427.3	10+	
1270.6 *2*	<0.5	3219.6	14+	1949.6	12+	
1280.2 *2*	0.6 *1*	2707.2	12+	1427.3	10+	
1297.1 *2*	0.7 *1*	2263.1	9−	966.1	8+	DCO=0.55 *5*.
1306.2 *2*	<0.5	4974.5	20+	3669.1	18+	
1316.7 *2*	<0.5	1897.5	7−	580.6	6+	

† 2002Ju08 state that Δ(Eγ)=0.1 keV for Eγ<1 MeV and 0.2 keV for Eγ above this. The evalutor has assigned Δ(Eγ)=0.2 keV for all the weak (Iγ<0.5) γ′s, 1 keV for those Eγ values quoted only to the nearest keV, and 0.1 keV in all other cases.

‡ The authors quote no Iγ values for “weak” γ′s (defined as those having Iγ<0.5). In these instances, the evaluator has listed these as Iγ<0.5.

The authors′ quoted uncertainty (0.3) seems unrealistically small. The evalutor increased this to 3.

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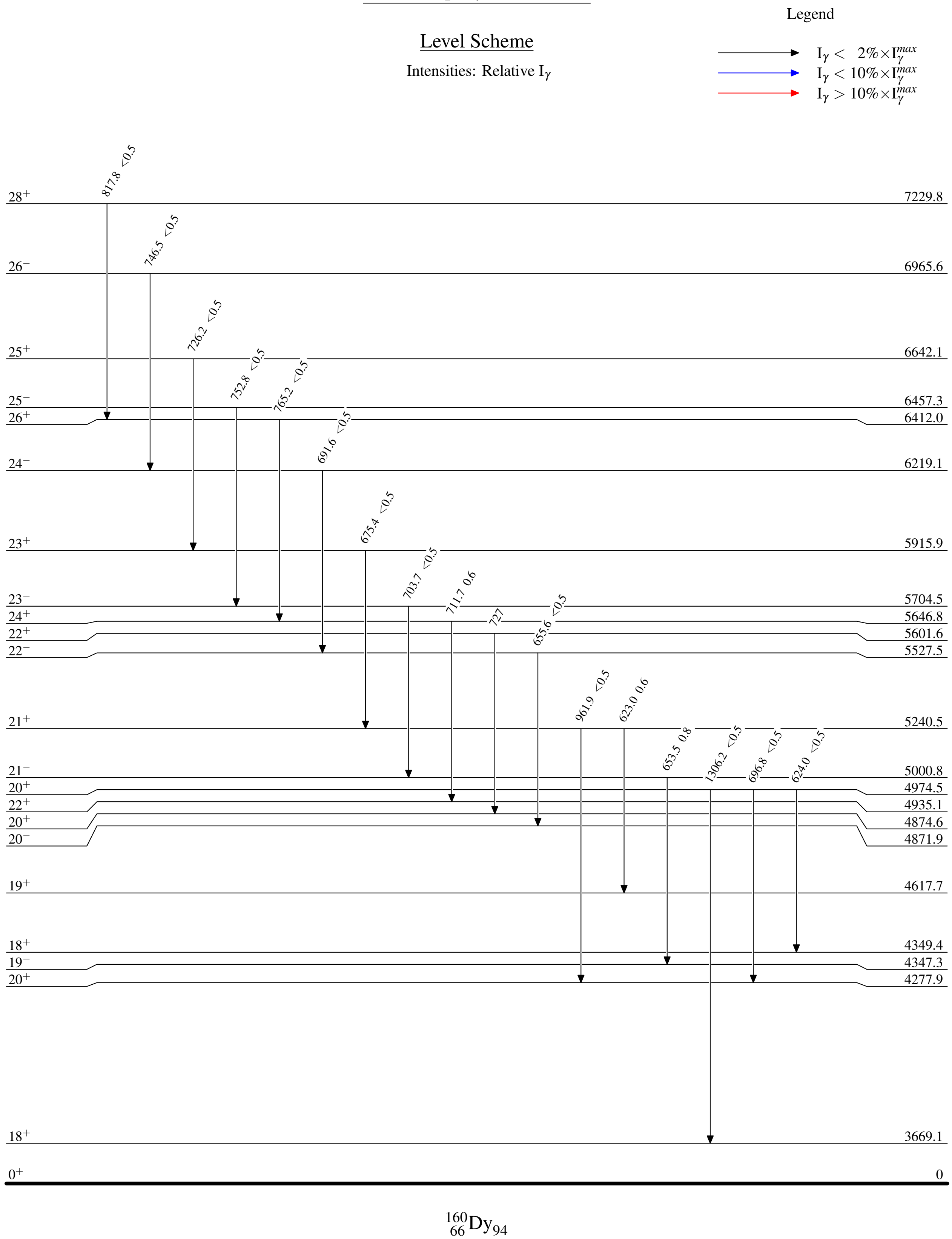

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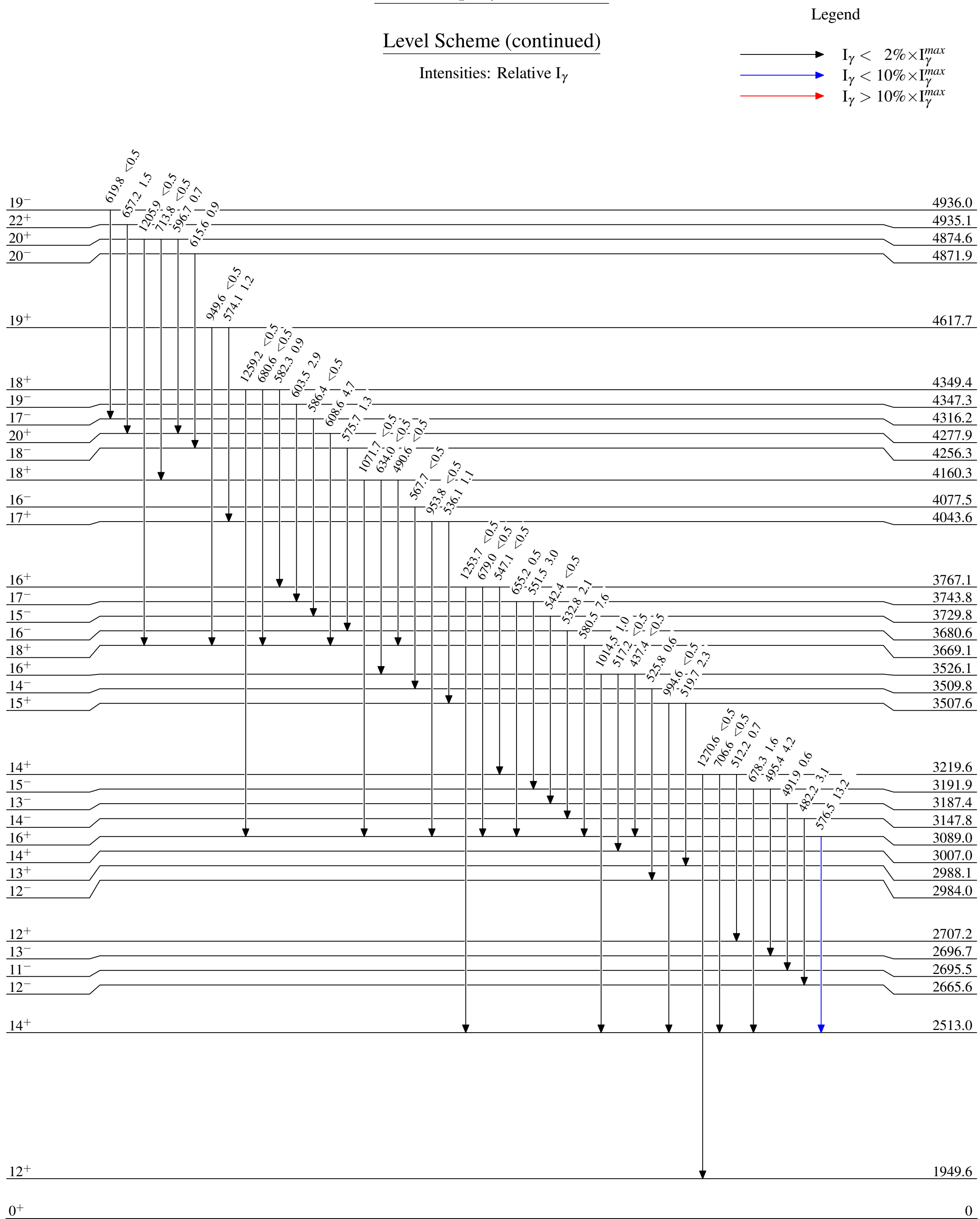
Level Scheme (continued)

Intensities: Relative I_γ

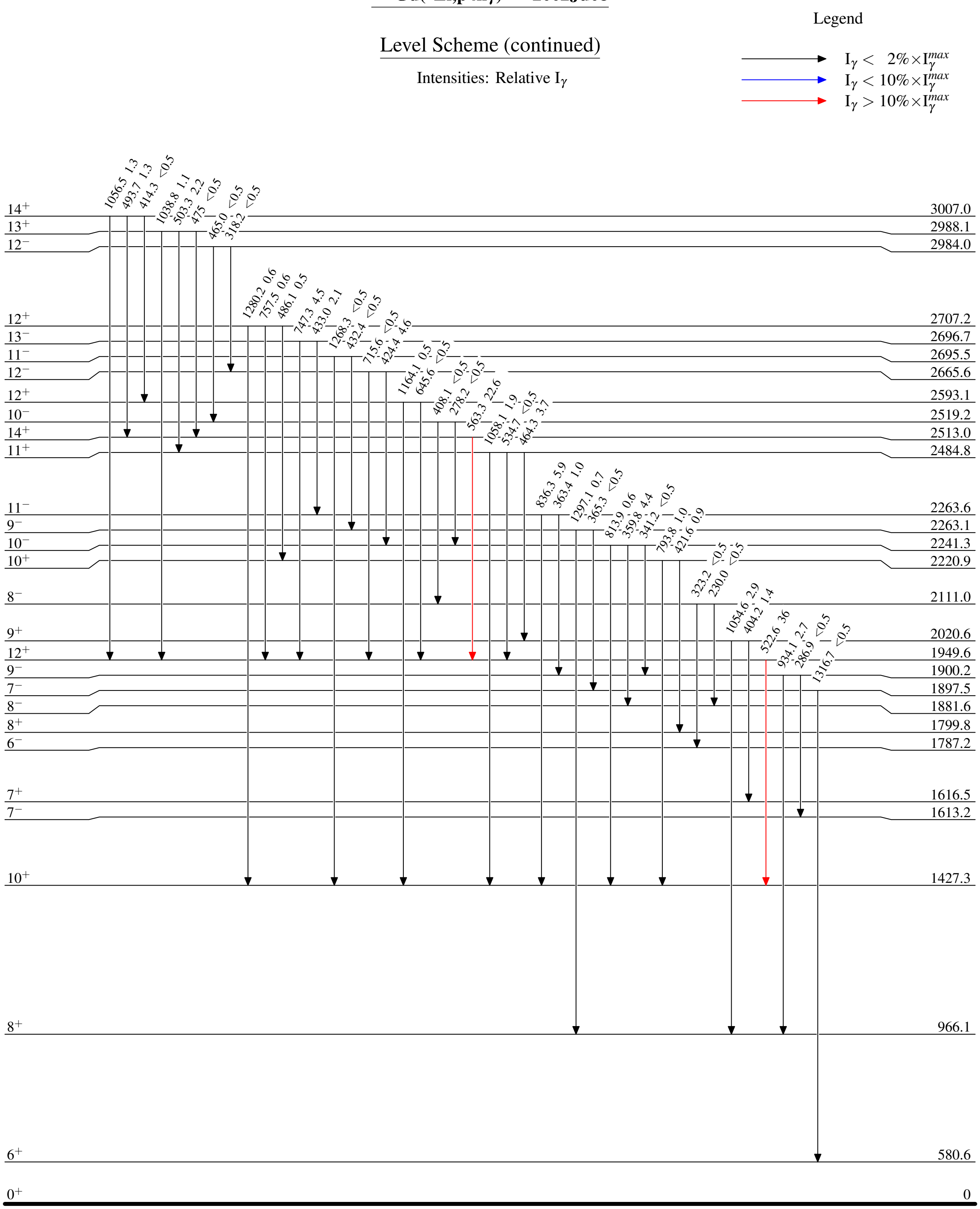


$^{160}_{66}Dy_{94}$

^{158}Gd(^{7}Li,p4nγ) 2002Ju08

Level Scheme (continued)

Intensities: Relative I_γ

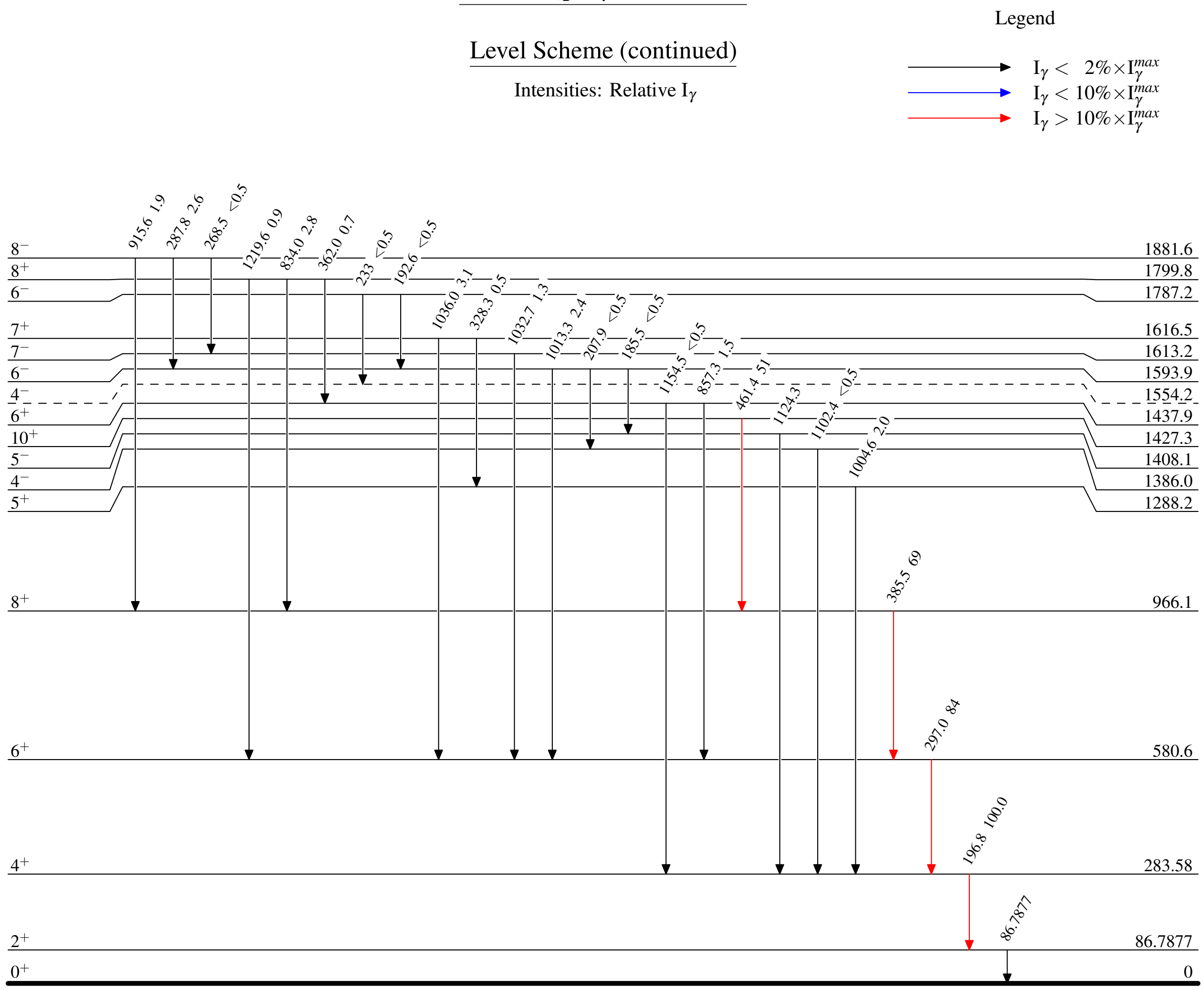


$^{160}_{66}Dy_{94}$

$^{158}Gd(^{7}Li,p4n\gamma)$ 2002Ju08

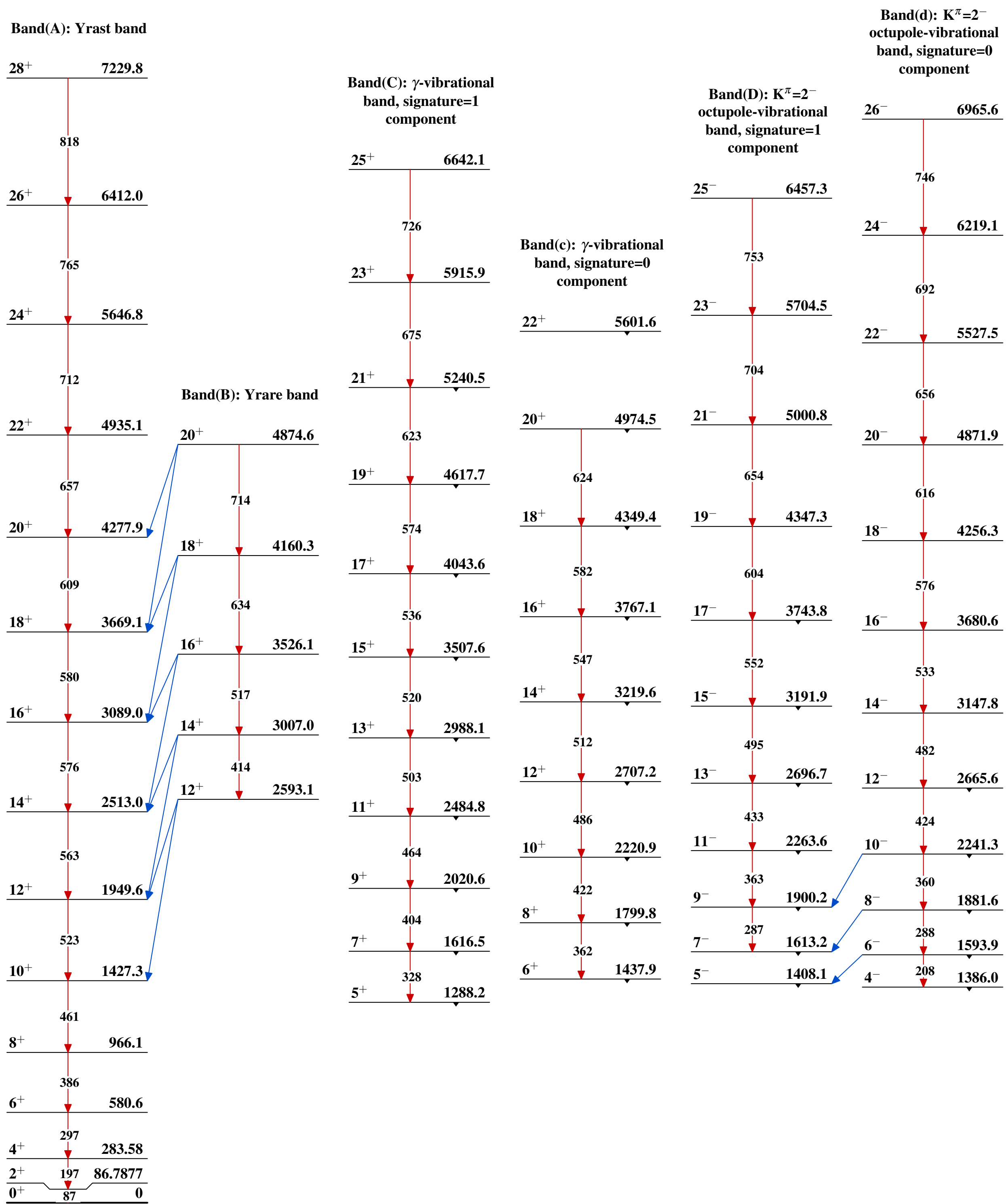
Level Scheme (continued)

Intensities: Relative I_γ



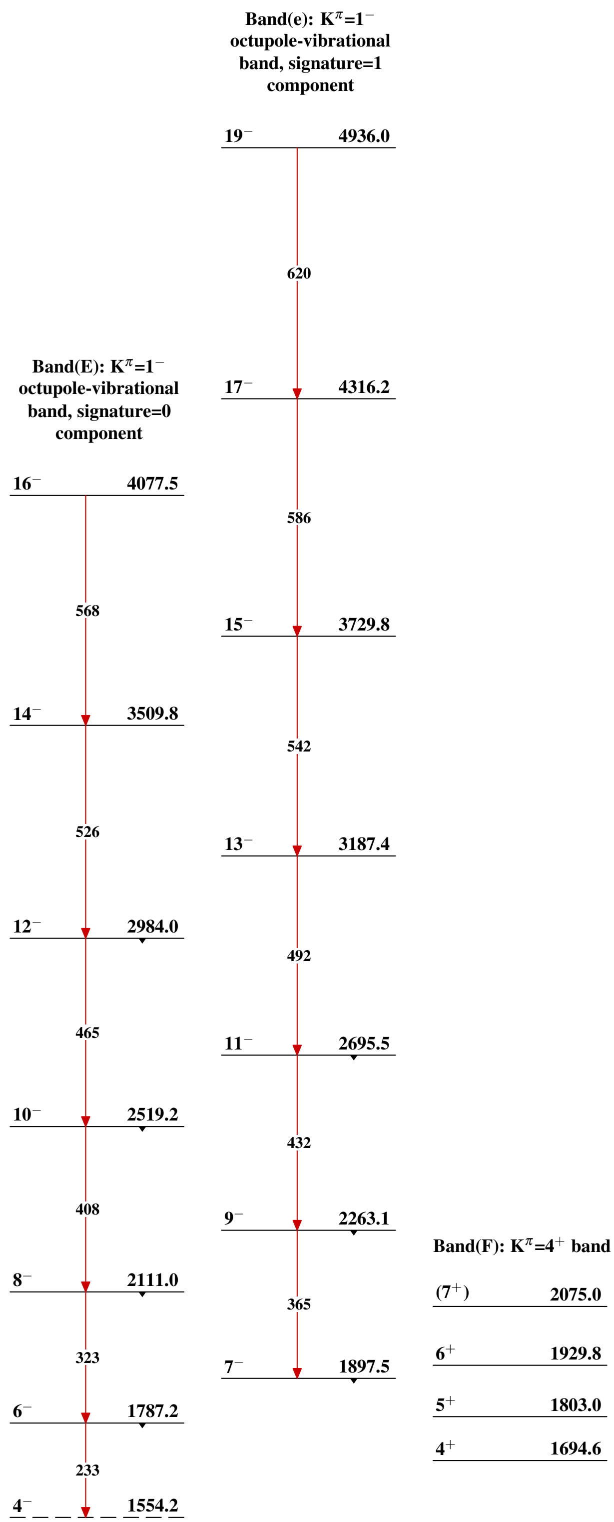
$^{160}_{66}Dy_{94}$

$^{158}Gd(^{7}Li,p4n\gamma)$ 2002Ju08



$^{160}_{66}Dy_{94}$

^{158}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)



$^{160}_{66}Dy_{94}$