^{160}Gd(^{7}Li,p4nγ) 2002Ju08

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 195,1 (2024)	19-Sep-2023

Data set based on the XUNDL entry compiled by M. Lee and B. Singh, McMaster University, August 28, 2002.
Includes the (^{7}Li,d3nγ), (^{7}Li,t2nγ) channels.
^{160}Gd(^{7}Li,p4n): "Incomplete-fusion" reaction, at E(^{7}Li)=35-67 MeV. Measured excitation function to determine the optimal energy for production of ^{162}Dy. The main measurements were made at 56 MeV. ^{160}Gd target, 3.9 mg/cm^2 thick. γ radiation studied using the GASP array, consisting of 40 Compton-suppressed Ge detectors and an 80 elements BGO inner ball. Charged particles were detected in the Si ball ISIS, consisting of 40 Si ΔE-E telescopes arranged in the same geometry as the Ge crystals in GASP. Measured Eγ, Iγ, $\gamma\gamma$, $\gamma\gamma(\theta)$(DCO).
For earlier reports of various aspects of this work, see 1998Ha66 and 2001Ju08.

^{162}Dy Levels

E(level)†	Jπ	E(level)†	Jπ	E(level)†	Jπ	E(level)†	Jπ
0.0#	0+	1636.68e 23	7−	2503.14g 18	11−	3873.66e 17	17−
80.66#	2+	1636.84b 18	5+	2534.21@ 14	12+	3877.74@ 17	18+
265.50# 9	4+	1669.79& 13	8+	2600.95b 17	11+	3966.09d 22	18−
548.28# 11	6+	1682.87c 14	7−	2622.13& 14	12+	4036.60g 24	17−
888.2‡&	2+	1751.68b 15	6+	2670.12f 17	12−	4039.03a 19	17+
920.78# 12	8+	1754.58g 23	(7−)	2682.03c 15	13−	4195.02f 24	18−
962.93a 9	3+	1766.48@ 23	6+	2777.36e 15	13−	4242.68c 21	19−
1061.0‡& 3	4+	1806.75d 14	8−	2859.04a 14	13+	4341.88& 21	18+
1148.2‡f	2−	1845.15f 13	8−	2918.98d 17	14−	4433.97@ 18	20+
1182.38a 11	5+	1877.60a 12	9+	2933.90@ 15	14+	4515.66e 20	19−
1210.1‡e	3−	1887.86b 16	7+	2963.30g 19	13−	4568.19d 24	20−
1275.8‡g	1−	1900.47# 14	12+	3052.45b 20	13+	4577.10# 21	20+
1296.83f 13	4−	1939.05c 16	9−	3122.72f 20	14−	4649.9g 3	19−
1324.14& 13	6+	1958.91e 15	9−	3137.93# 16	16+	4872.59c 23	21−
1357.9‡g	3−	1985.19@ 19	8+	3144.98& 15	14+	5061.17@ 21	22+
1374.33# 13	10+	2086.81& 13	10+	3145.22c 16	15−	5220.5d 3	22−
1390.90e 22	5−	2099.86g 20	9−	3292.58e 16	15−	5351.4# 3	22+
1398.0‡@	0+	2110.10d 14	10−	3373.30@ 16	16+	5553.29c 25	23−
1453.5‡@	2+	2211.26b 16	9+	3415.39d 20	16−	5746.57@ 23	24+
1485.55c 13	5−	2233.72f 14	10−	3433.43a 16	15+	5920.3d 4	24−
1490.10a 12	7+	2261.61?@ 15	10+	3474.20g 21	15−	6152.6# 4	24+
1518.4‡g	5−	2279.97c 14	11−	3563.85b 22	15+	6488.1@ 3	26+
1529.72f 12	6−	2330.32e 14	11−	3626.72f 22	16−	7275.4@ 4	28+
1535.7‡b	4+	2336.79a 13	11+	3666.08c 18	17−		
1574.3‡@	4+	2481.77d 14	12−	3733.58& 18	16+		
1575.31d 15	6−	2491.03# 14	14+	3830.30# 18	18+		

† From a least-squares fit (by the compilers) to the listed Eγ's. With the listed Δ(Eγ) values, 11 Eγ's out of a total of 139 γ's deviate by more than 3σ.
‡ Nominal value from the Adopted Values. Level not reported by 2002Ju08 but given here to make explicit the lower part of the band.
# Band(A): g.s. band.

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^{160}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

^{162}Dy Levels (continued)

@ Band(B): S band, $K^\pi=0^+$.
& Band(C): γ-vibrational band, signature=0 branch.
a Band(c): γ-vibrational band, signature=1 branch. Note that the parities of 3^- to 15^- band members shown in columns 5 and 6 of the level scheme table of 2002Ju08 (their Table II) should be positive instead of negative.
b Band(D): $K^\pi=4^+$ band.
c Band(E): $K^\pi=5-$band, signature=1 branch.
d Band(e): $K^\pi=5-$band, signature=0 branch.
e Band(F): $K^\pi=2^-$, octupole-vibrational band, signature=1 branch.
f Band(f): $K^\pi=2^-$, octupole-vibrational band, signature=0 branch.
g Band(G): $K^\pi=0^-$ band.

$\gamma(^{162}$Dy)

2002Ju08 state that their DCO ratios are ≈1.0 for stretched quadrupole transitions and ≈0.5 for pure dipoles. The placements of those transitions for which DCO ratios are given are consistent with this statement. Since, however, these authors do not explicitly list their deduced multipolarities for these γ's, the evaluator has not attempted to list them here either.

E_γ †	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Comments
80.66		80.66	2^+	0.0	0^+	E_γ: nominal value from the Adopted Values. 2002Ju08 report Eγ=80.
89.7 *1*	0.9 *1*	1575.31	6^-	1485.55	5^-	
123.8 *1*	1.9 *1*	1806.75	8^-	1682.87	7^-	
151.0 *1*	0.5 *1*	2481.77	12^-	2330.32	11^-	
151.6 *1*	1.2 *1*	2110.10	10^-	1958.91	9^-	
171.0 *1*	0.8 *1*	2110.10	10^-	1939.05	9^-	
184.9 *1*	100.0	265.50	4^+	80.66	2^+	
202.0 *1*	0.9 *1*	2481.77	12^-	2279.97	11^-	
217.3 *2*	<0.5	1182.38	5^+	962.93	3^+	E_γ: poor fit. Level-energy difference=219.4.
231.4 *1*	1.0 *1*	1806.75	8^-	1575.31	6^-	
232.9 *2*	<0.5	1529.72	6^-	1296.83	4^-	
237.0 *2*	<0.5	2918.98	14^-	2682.03	13^-	
252.9 *2*	<0.5	1887.86	7^+	1636.84	5^+	E_γ: poor fit. Level-energy difference=251.0.
263.3 *2*	<0.5	2600.95	11^+	2336.79	11^+	E_γ: level-energy difference=264.1.
272.6‡ *2*	<0.5	2534.21	12^+	2261.61?	10^+	
276.6‡ *2*	<0.5	2261.61?	10^+	1985.19	8^+	
277 *1*		1806.75	8^-	1529.72	6^-	E_γ: value given on the level-scheme drawing of 2002Ju08, but not listed in their level-scheme table (their Table II).
282.7 *1*	91.3 *26*	548.28	6^+	265.50	4^+	
303.2 *1*	3.8 *1*	2110.10	10^-	1806.75	8^-	DCO=1.14 *6*.
307.5 *1*	0.9 *1*	1490.10	7^+	1182.38	5^+	
311.6 *2*	<0.5	2933.90	14^+	2622.13	12^+	
315.4 *1*	1.6 *1*	1845.15	8^-	1529.72	6^-	DCO=0.97 *7*.
322.2‡		1958.91	9^-	1636.68	7^-	E_γ: computed from the level-energy difference according to the placement given by 2002Ju08 in their level-scheme table (their Table II). The Eγ value shown in this level-scheme table is 291.8. The only reported level near this implied final-state energy (1667.1 keV) is the 8^+ member of the γ-vibrational band (at 1669.8 keV). From J^π considerations only, this could be a possible placement, but these authors do not place it here.
323.7 *1*	0.6 *1*	2211.26	9^+	1887.86	7^+	
333.3 *2*	<0.5	2211.26	9^+	1877.60	9^+	
333.9 *1*	0.6 *1*	1296.83	4^-	962.93	3^+	
345.6 *1*	1.5 *1*	1669.79	8^+	1324.14	6^+	DCO=0.98 *10*.

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^{160}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

$\gamma(^{162}Dy)$ (continued)

E_γ †	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Comments
347.3 *1*	2.2 *1*	1529.72	6^-	1182.38	5^+	DCO=0.62 *5*.
355.0 *1*	2.8 *1*	1845.15	8^-	1490.10	7^+	DCO=0.59 *3* for 355.0+356.2.
356.2 *1*	2.3 *1*	2233.72	10^-	1877.60	9^+	DCO=0.59 *3* for 355.0+356.2.
360.8 *2*	<0.5	2622.13	12^+	2261.61?	10^+	
370.9 *1*	0.9 *1*	2330.32	11^-	1958.91	9^-	
371.9 *1*	4.4 *2*	2481.77	12^-	2110.10	10^-	DCO=1.02 *32*.
372.5 *1*	77.4 *23*	920.78	8^+	548.28	6^+	
387.3 *1*	3.3 *1*	1877.60	9^+	1490.10	7^+	DCO=1.05 *6*.
388.5 *1*	3.7 *1*	2233.72	10^-	1845.15	8^-	DCO=1.06 *6*.
389.9 *1*	0.6 *1*	2600.95	11^+	2211.26	9^+	
399.8 *1*	3.8 *1*	2933.90	14^+	2534.21	12^+	DCO=1.02 *6*.
402.0 *1*	1.5 *1*	2682.03	13^-	2279.97	11^-	DCO=0.90 *7*.
403.3 *2*	<0.5	2503.14	11^-	2099.86	9^-	
417.0 *1*	3.7 *1*	2086.81	10^+	1669.79	8^+	DCO=0.99 *7*.
436.4 *1*	3.3 *1*	2670.12	12^-	2233.72	10^-	DCO=0.87 *5*.
437.2 *1*	5.2 *2*	2918.98	14^-	2481.77	12^-	DCO=1.02 *3*.
439.4 *1*	3.9 *1*	3373.30	16^+	2933.90	14^+	DCO=1.00 *6*.
442.7 *1*	0.8 *1*	2933.90	14^+	2491.03	14^+	
446.1 *2*	<0.5	2777.36	13^-	2330.32	11^-	E_γ: level-energy difference=447.0.
447.3 *1*	3.4 *1*	2534.21	12^+	2086.81	10^+	DCO=1.09 *7*.
451.5 *1*	1.5 *1*	3052.45	13^+	2600.95	11^+	
452.6 *1*	1.7 *1*	3122.72	14^-	2670.12	12^-	DCO=1.16 *6*.
453.6 *1*	57.6 *17*	1374.33	10^+	920.78	8^+	
459.1 *1*	4.6 *2*	2336.79	11^+	1877.60	9^+	DCO=1.07 *4*.
460.2 *1*	1.1 *1*	2963.30	13^-	2503.14	11^-	
463.2 *1*	3.5 *1*	3145.22	15^-	2682.03	13^-	DCO=0.92 *5*.
496.4 *1*	3.6 *1*	3415.39	16^-	2918.98	14^-	DCO=1.04 *5*.
504.0 *1*	1.2 *1*	3626.72	16^-	3122.72	14^-	
504.4 *1*	2.4 *1*	3877.74	18^+	3373.30	16^+	DCO=0.95 *7*. Initial level listed as 388 in the level-scheme table of 2002Ju08 (their Table II) seems to be a misprint.
510.9 *1*	1.7 *1*	3474.20	15^-	2963.30	13^-	
511.4 *1*	0.6 *1*	3563.85	15^+	3052.45	13^+	
515.1 *1*	0.6 *1*	3292.58	15^-	2777.36	13^-	
521.1 *1*	3.3 *1*	3666.08	17^-	3144.98	14^+	DCO=1.00 *6*.
522.2 *1*	3.8 *1*	2859.04	13^+	2336.79	11^+	DCO=0.92 *5*.
523.2 *1*	1.4 *1*	3144.98	14^+	2622.13	12^+	
526.2 *1*	36.4 *11*	1900.47	12^+	1374.33	10^+	DCO=0.98 *1*.
535.5 *1*	1.6 *1*	2622.13	12^+	2086.81	10^+	DCO=0.94 *9*.
550.7 *1*	2.5 *1*	3966.09	18^-	3415.39	16^-	DCO=1.08 *7*.
556.2 *1*	1.7 *1*	4433.97	20^+	3877.74	18^+	DCO=0.82 *12*.
562.4 *1*	0.9 *1*	4036.60	17^-	3474.20	15^-	
568.3 *1*	1.1 *1*	4195.02	18^-	3626.72	16^-	
569.3 *1*	0.5 *1*	1751.68	6^+	1182.38	5^+	
573.3 *2*	<0.5	1636.84	5^+			
574.3 *1*	2.8 *1*	3433.43	15^+	2859.04	13^+	DCO=0.86 *6*.
576.6 *1*	2.2 *1*	4242.68	19^-	3666.08	17^-	DCO=1.14 *9*.
581.0 *1*	1.0 *1*	3873.66	17^-	3292.58	15^-	
588.6 *1*	1.9 *1*	3733.58	16^+	3144.98	14^+	
590.6 *1*	18.3 *6*	2491.03	14^+	1900.47	12^+	DCO=1.01 *2*.
602.1 *1*	2.1 *1*	4568.19	20^-	3966.09	18^-	
603.7 *1*	1.5 *1*	4433.97	20^+	3830.30	18^+	
605.6 *1*	3.2 *1*	4039.03	17^+	3433.43	15^+	
608.3 *1*	1.1 *1*	4341.88	18^+	3733.58	16^+	
610.5 *1*	1.7 *1*	3144.98	14^+	2534.21	12^+	

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^{160}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

$\gamma(^{162}Dy)$ (continued)

E_γ †	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Comments
613.3 *1*	0.7 *1*	4649.9	19^-	4036.60	17^-	
627.2 *1*	1.6 *1*	5061.17	22^+	4433.97	20^+	
629.9 *1*	1.3 *1*	4872.59	21^-	4242.68	19^-	
633.6 *1*	2.5 *1*	2534.21	12^+	1900.47	12^+	
642.0 *1*	0.6 *1*	4515.66	19^-	3873.66	17^-	
647.0 *1*	8.9 *3*	3137.93	16^+	2491.03	14^+	DCO=0.95 *3*.
652.3 *1*	0.7 *1*	5220.5	22^-	4568.19	20^-	
654.2 *1*	2.3 *1*	3145.22	15^-	2491.03	14^+	DCO=0.65 *4*.
675.8 *2*	<0.5	1636.84	5^+	962.93	3^+	E_γ: poor fit. Level-energy difference=673.9.
680.7 *1*	0.5 *1*	5553.29	23^-	4872.59	21^-	
685.4 *1*	0.5 *1*	5746.57	24^+	5061.17	22^+	
692.4 *1*	3.4 *1*	3830.30	18^+	3137.93	16^+	DCO=1.02 *5*.
699.8 *2*	<0.5	5920.3	24^-	5220.5	22^-	
704.8 *2*	<0.5	1887.86	7^+	1182.38	5^+	E_γ: level-energy difference=705.5.
712.5 *1*	2.1 *1*	2086.81	10^+	1374.33	10^+	DCO=0.59 *4*.
721.7 *1*	0.5 *1*	2622.13	12^+	1900.47	12^+	
735.8 *1*	0.6 *1*	3873.66	17^-	3137.93	16^+	
739.8 *1*	1.6 *1*	3877.74	18^+	3137.93	16^+	
741.5 *2*	<0.5	6488.1	26^+	5746.57	24^+	
746.8 *1*	1.0 *1*	4577.10	20^+	3830.30	18^+	
749.0 *1*	2.7 *1*	1669.79	8^+	920.78	8^+	DCO=0.65 *5*.
762.0 *1*	0.8 *1*	1682.87	7^-	920.78	8^+	DCO=0.53 *5*.
774.3 *2*	<0.5	5351.4	22^+	4577.10	20^+	
775.8 *1*	2.2 *1*	1324.14	6^+	548.28	6^+	DCO=0.56 *7*.
781.6 *1*	3.6 *1*	2682.03	13^-	1900.47	12^+	DCO=0.51 *4*.
787.3 *2*	<0.5	7275.4	28^+	6488.1	26^+	
801.2 *2*	<0.5	6152.6	24^+	5351.4	22^+	
801.6 *1*	1.3 *1*	3292.58	15^-	2491.03	14^+	
877.0 *1*	2.0 *1*	2777.36	13^-	1900.47	12^+	DCO=0.55 *4*.
882.2 *1*	0.6 *1*	962.93	3^+	80.66	2^+	
882.2 *2*	<0.5	3373.30	16^+	2491.03	14^+	
887.3 *1*	1.0 *1*	2261.61?	10^+	1374.33	10^+	
905.8 *1*	3.7 *1*	2279.97	11^-	1374.33	10^+	DCO=0.56 *3*.
917.0 *1*	3.9 *2*	1182.38	5^+	265.50	4^+	DCO=0.48 *2*.
937.2 *1*	1.2 *1*	1485.55	5^-	548.28	6^+	DCO=0.54 *4*.
941.8 *1*	5.5 *2*	1490.10	7^+	548.28	6^+	DCO=0.56 *2*.
942.5 *1*	0.6 *1*	3433.43	15^+	2491.03	14^+	
955.8 *1*	1.7 *1*	2330.32	11^-	1374.33	10^+	
956.9 *1*	4.4 *2*	1877.60	9^+	920.78	8^+	DCO=0.59 *4*.
958.5 *1*	1.2 *1*	2859.04	13^+	1900.47	12^+	
962.3 *1*	2.1 *1*	2336.79	11^+	1374.33	10^+	DCO=0.62 *4*.
1018.1 *2*	2.3 *1*	1939.05	9^-	920.78	8^+	DCO=0.52 *3*.
1033.8 *2*	0.6 *1*	2933.90	14^+	1900.47	12^+	
1037.8 *2*	2.6 *1*	1958.91	9^-	920.78	8^+	DCO=0.60 *3*.
1058.7 *2*	1.0 *1*	1324.14	6^+	265.50	4^+	
1062.6 *2*	1.1 *1*	2963.30	13^-	1900.47	12^+	
1064.6 *2*	0.8 *1*	1985.19	8^+	920.78	8^+	
1088.4 *2*	0.8 *1*	1636.68	7^-	548.28	6^+	
1121.7 *2*	1.4 *1*	1669.79	8^+	548.28	6^+	
1125.4 *2*	0.6 *1*	1390.90	5^-	265.50	4^+	
1129.0 *2*	1.5 *1*	2503.14	11^-	1374.33	10^+	
1134.6 *2*	2.5 *1*	1682.87	7^-	548.28	6^+	DCO=0.50 *3*.
1160.1 *2*	1.0 *1*	2534.21	12^+	1374.33	10^+	
1166.3 *2*	1.3 *1*	2086.81	10^+	920.78	8^+	DCO=0.97 *9*.
1179.1 *2*	0.7 *1*	2099.86	9^-	920.78	8^+	

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^{160}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)

$\gamma(^{162}Dy)$ (continued)

E_γ [†]	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Comments
1206.3 *2*	0.6 *1*	1754.58	(7^-)	548.28	6^+	
1218.2 *2*	1.0 *1*	1766.48	6^+	548.28	6^+	
1220.1 *2*	2.1 *1*	1485.55	5^-	265.50	4^+	DCO=0.50 *3*.
1244.2 *2*	0.5 *1*	3144.98	14^+	1900.47	12^+	DCO=0.65 *4*.
1247.9 *2*	<0.5	2622.13	12^+	1374.33	10^+	

[†] From 2002Ju08, $\Delta(E\gamma)$=0.1 keV for $E\gamma$ below 1 MeV and 0.2 keV for $E\gamma$ above this energy. The evaluator assigns $\Delta(E\gamma)$=0.2 keV for $E\gamma'$s when no $I\gamma$ value is given and 1 keV when $E\gamma$ is quoted to only the nearest keV.

[‡] Placement of transition in the level scheme is uncertain.

^{160}Gd(^{7}Li,p4nγ) 2002Ju08

Level Scheme

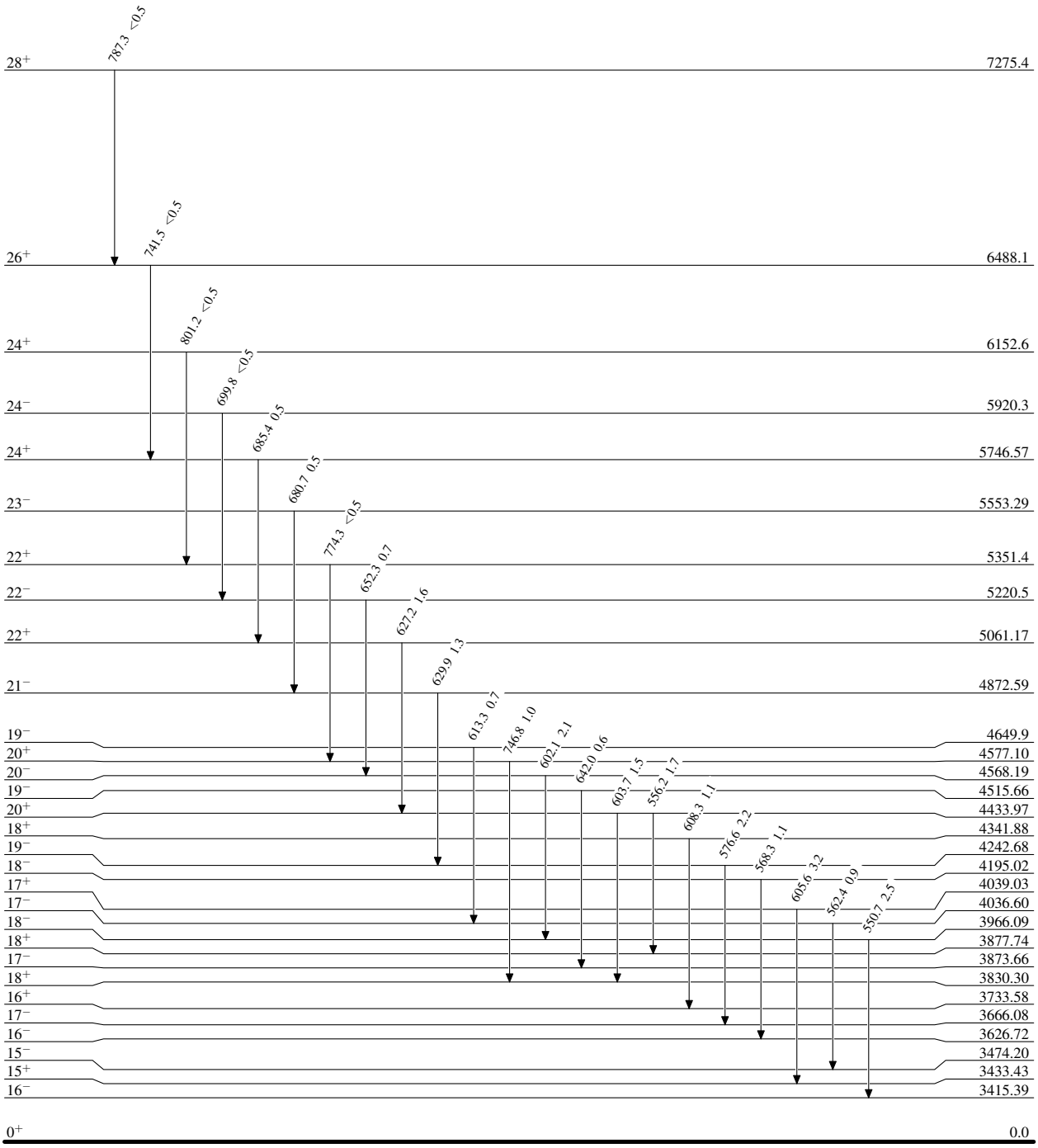
Intensities: Relative I_γ

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$



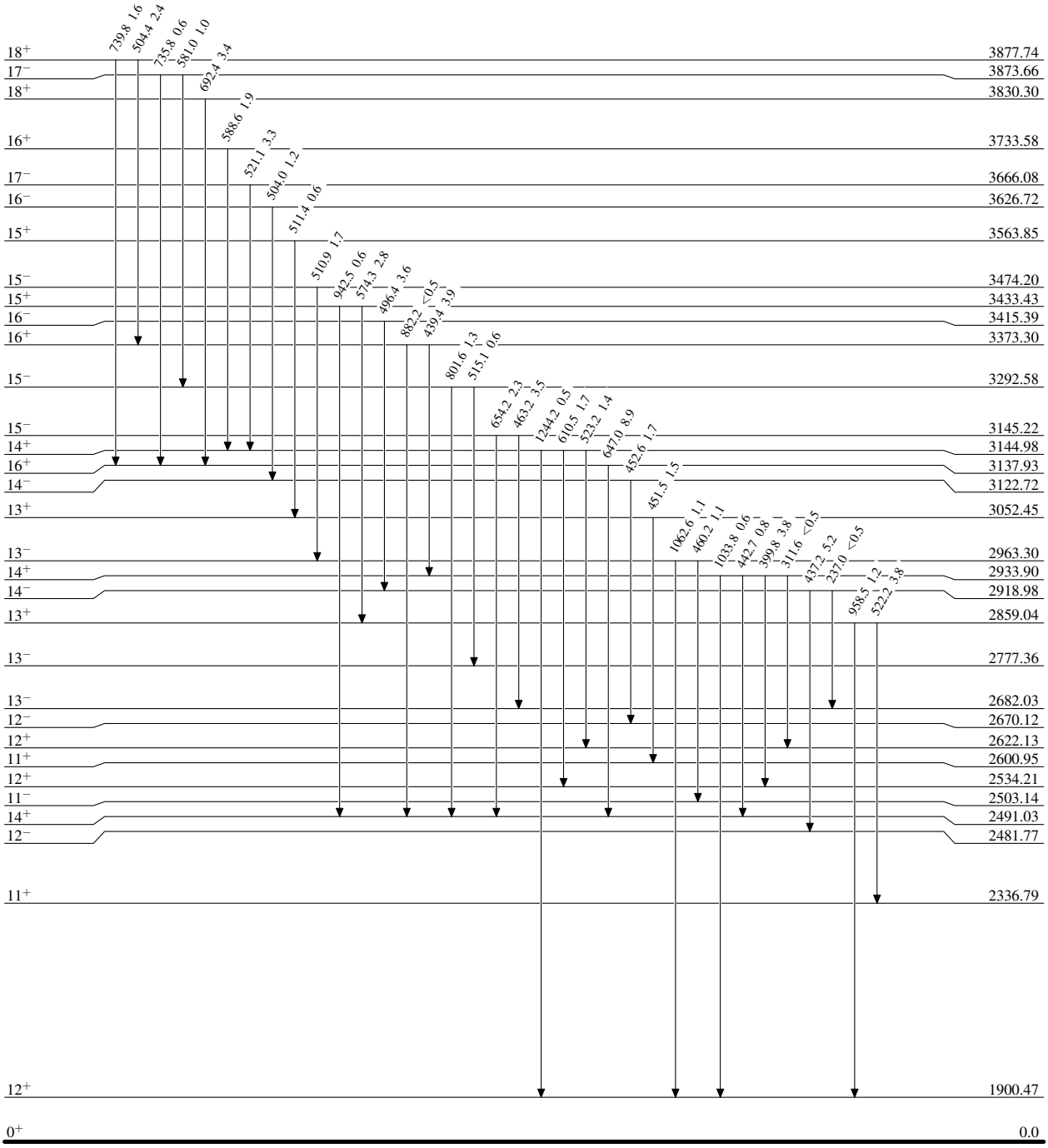
$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08

Level Scheme (continued)

Intensities: Relative I_γ

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$



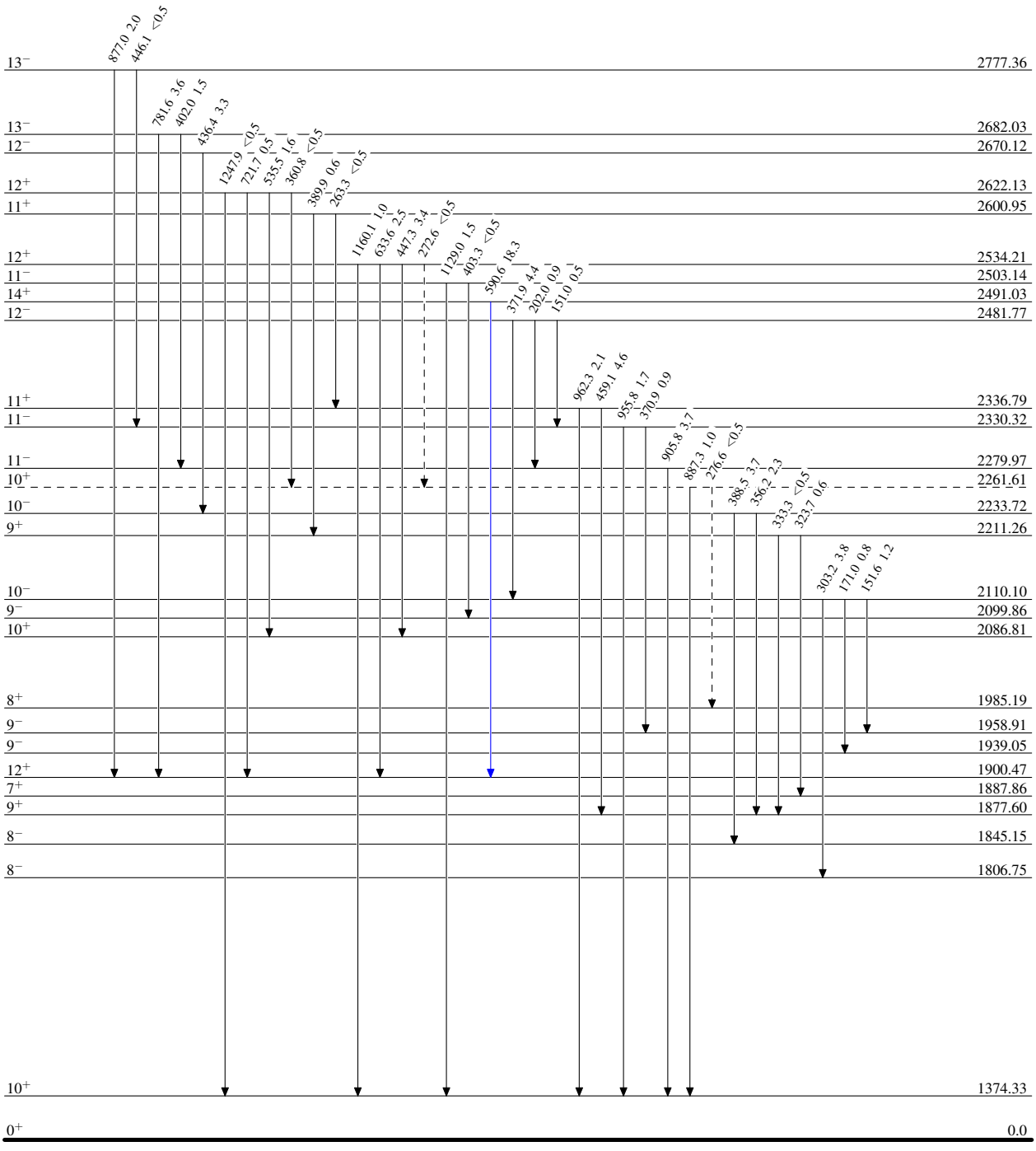
$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08

Level Scheme (continued)

Intensities: Relative I_γ

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)



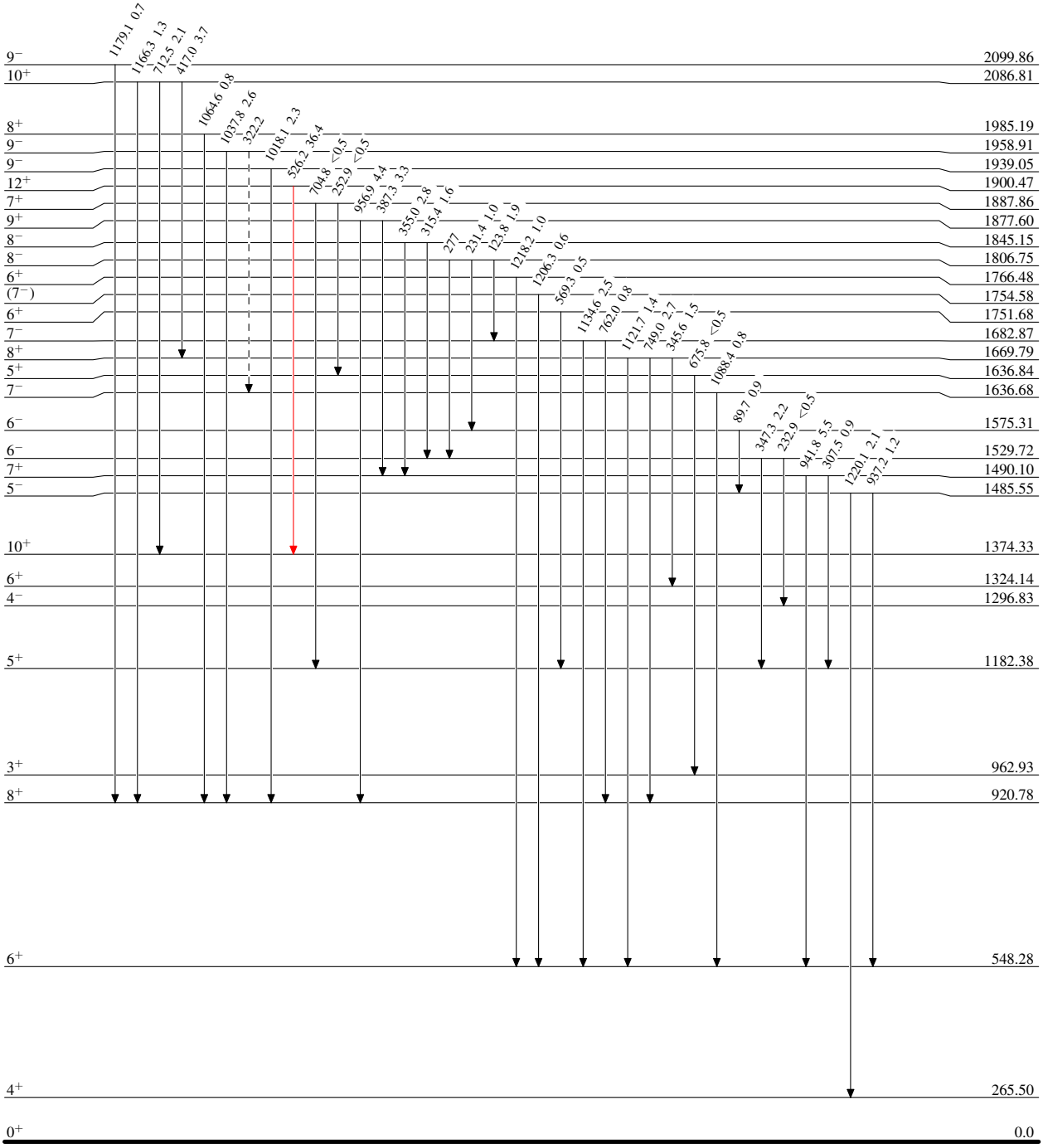
$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08

Level Scheme (continued)

Intensities: Relative I_γ

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- γ Decay (Uncertain)

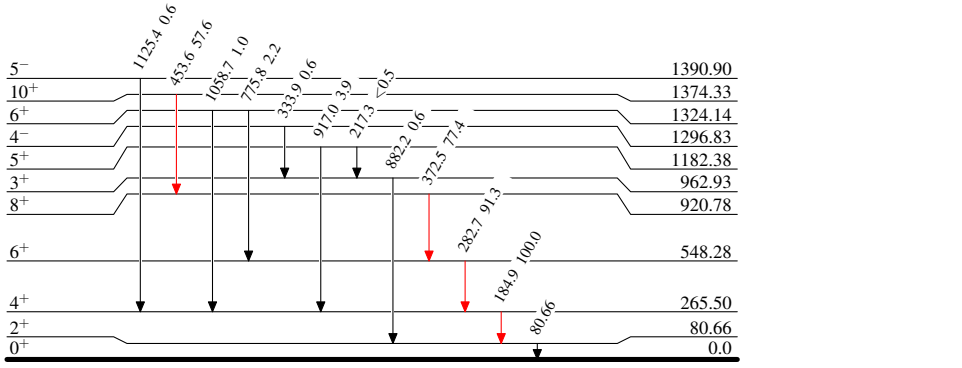


$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08

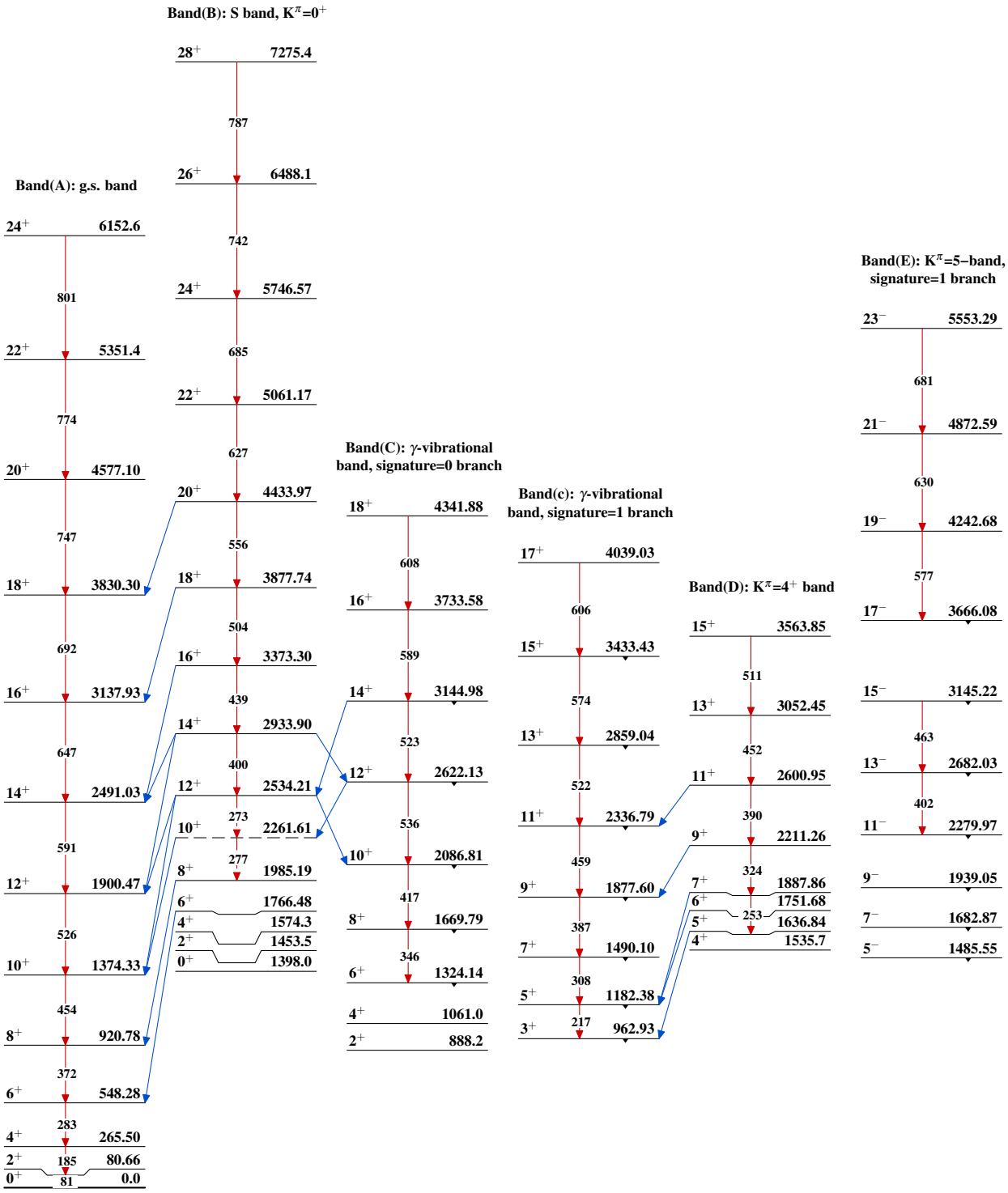
Level Scheme (continued)

Intensities: Relative I_γ



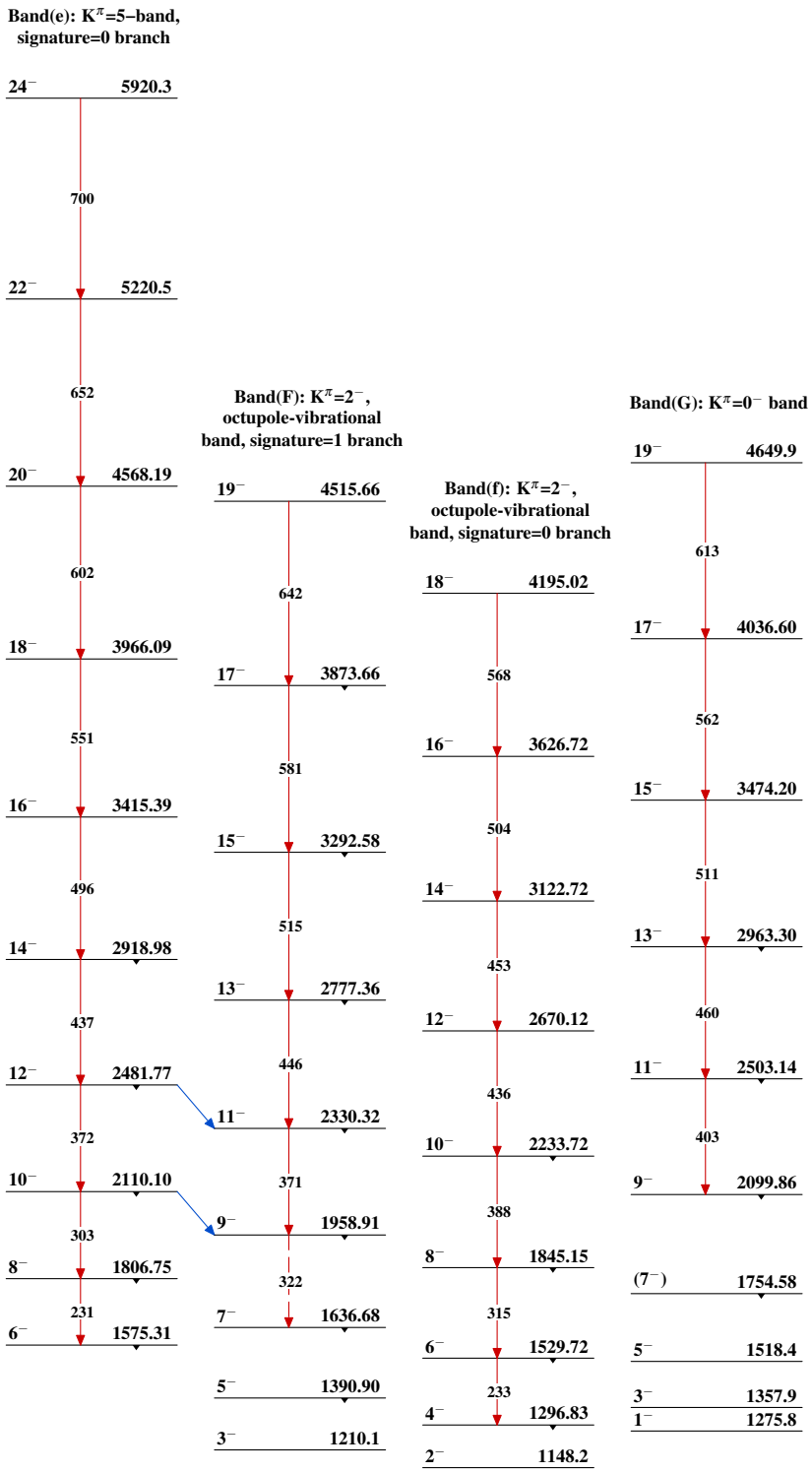
$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08



$^{162}_{66}Dy_{96}$

^{160}Gd(^{7}Li,p4nγ) 2002Ju08 (continued)



$^{162}_{66}Dy_{96}$