

$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, Jun Chen and Ameenah R. Farhan		NDS 194,3 (2024)	8-Jan-2024

2011Wa12: ^{40}Ca beam with $E=165\text{ MeV}$ produced at the Argonne National Laboratory using the ATLAS accelerator. Target= $350\text{ }\mu\text{g}/\text{cm}^2$ ^{40}Ca flashed with $150\text{ }\mu\text{g}/\text{cm}^2$ thick layer of gold to prevent oxidation. Gamma rays detected by the Gammasphere array consisting of 99 Compton suppressed Ge detectors and evaporated charged particles identified by the Microball array. Measured E_γ , I_γ , $\gamma\gamma$ -coin. Deduced levels, J , π (with the aid of RADWARE graphical analysis package). Level scheme given in figure 1 of 2011Wa12 is from combined work of these authors and that in 1995Ha13.

 ^{76}Rb Levels

Due to the crossing of even spin negative parity states between bands 3 and 4 around $J=14$ along with the crossing of the odd sequences between bands 3 and 5 around $J=11$ band-mixing calculations were performed which suggest a transition to three smooth unperturbed bands (3', 4', and 5') for the high-spin states. These bands are well described by the Cranked Nilsson-Strutinsky (CNS) calculations performed by the authors which also suggest the coexistence of close-to-prolate and close-to-oblate nuclear shapes.

E(level) [†]	$J\pi^{\ddagger}$	$T_{1/2}$	Comments
0.0 ^b	1 ⁻		
101.3 ^a 4	2 ⁽⁻⁾		
246.3 ^b 4	3 ⁽⁻⁾		
317.2 [#] 6	4 ⁽⁺⁾	3.050 μs 7	$T_{1/2}$: from Adopted Levels.
421.5 ^d 6	4 ⁽⁻⁾		
454.7 ^a 5	4 ⁽⁻⁾		
497.4 [@] 7	5 ⁽⁺⁾		
629.4 ^{&} 7	(4)		
663.1 ^e 6	5 ⁽⁻⁾		
689.8 ^b 5	5 ⁽⁻⁾		
693.0 ^f 10			
707.4 [#] 7	6 ⁽⁺⁾		
954.0 ^d 6	6 ⁽⁻⁾		
978.0 [@] 7	7 ⁽⁺⁾		
989.5 ^f 9			
1010.2 ^a 6	6 ⁽⁻⁾		
1013.5 ^{&} 7	(6)		
1250.0 ^f 7	(6)		
1256.6 [#] 7	8 ⁽⁺⁾		
1287.4 ^e 6	7 ⁽⁻⁾		
1333.0 ^b 6	7 ⁽⁻⁾		
1525.2 10			
1577.1 ^g 7	(7)		
1620.7 [@] 8	9 ⁽⁺⁾		
1658.9 ^{&} 9	(8)		
1679.6 ^d 6	8 ⁽⁻⁾		
1761.5 ^a 6	8 ⁽⁻⁾		
1940.0 ^f 7	(8)		
2019.7 [#] 8	10 ⁽⁺⁾		
2095.1 ^e 7	9 ⁽⁻⁾		
2170.5 ^b 6	9 ⁽⁻⁾		

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$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ **2011Wa12** (continued) ^{76}Rb Levels (continued)

E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]
2350.1 ^g 8	(9)	4884.8 ^d 13	(14 ⁻)	8308.7 ^b 16	(19 ⁻)	13223.6 [#] 25	(24 ⁺)
2440.9 [@] 8	11 ⁽⁺⁾	4963.0 ^{&} 20	(14)	8982.6 [#] 21	(20 ⁺)	13366.8 [@] 25	(25 ⁺)
2547.9 ^{&} 14	(10)	4978.4 ^a 16	(14 ⁻)	8996.5 ^c 22	(19 ⁻)	13523 ^a 3	(24 ⁻)
2588.8 ^d 7	10 ⁽⁻⁾	5401.0 ^e 13	(15 ⁻)	9141.8 ^d 22	(20 ⁻)	13664.8 ^b 22	(25 ⁻)
2698.3 ^a 7	10 ⁽⁻⁾	5502.5 ^b 14	(15 ⁻)	9217.7 [@] 21	(21 ⁺)	14126.8 ^e 22	(25 ⁻)
2805.6 ^f 8	(10)	5602.5 [#] 15	16 ⁽⁺⁾	9488.4 ^a 24	(20 ⁻)	14768 ^d 3	(26 ⁻)
3007.7 [#] 9	12 ⁽⁺⁾	5793.4 ^c 17	(15 ⁻)	9785.8 17	(21 ⁻)	15512 [#] 3	(26 ⁺)
3068.4 ^e 7	11 ⁽⁻⁾	5972.7 [@] 15	17 ⁽⁺⁾	9870 ^{&} 3	(20)	15824 [@] 3	(27 ⁺)
3187.4 ^b 9	11 ⁽⁻⁾	6198.8 ^d 16	(16 ⁻)	9939.8 ^b 17	(21 ⁻)	15898.8 ^b 24	(27 ⁻)
3278.2 ^g 11	(11)	6312.4 ^a 19	(16 ⁻)	9998.8 ^e 17	(21 ⁻)	16496.9 ^e 24	(27 ⁻)
3442.5 [@] 9	13 ⁽⁺⁾	6448.0 ^{&} 22	(16)	10753.5 ^c 24	(21 ⁻)	17156 ^d 3	(28 ⁻)
3655.9 ^{&} 17	(12)	6743.9 ^e 15	(17 ⁻)	10802.8 ^d 24	(22 ⁻)	17806 [#] 3	(28 ⁺)
3665.8 ^d 8	12 ⁽⁻⁾	6834.6 ^b 15	(17 ⁻)	10999.6 [#] 23	(22 ⁺)	18461 ^b 3	(29 ⁻)
3792.4 ^a 12	12 ⁽⁻⁾	7188.5 [#] 18	18 ⁽⁺⁾	11168.7 [@] 23	(23 ⁺)	18574 [@] 3	(29 ⁺)
3841.5 ^f 10	(12)	7336.4 ^c 20	(17 ⁻)	11400 ^a 3	(22 ⁻)	19197 ^e 3	(29 ⁻)
4180.0 ^e 10	13 ⁽⁻⁾	7496.7 [@] 18	19 ⁽⁺⁾	11583.8 20	(23 ⁻)	19935 ^d 3	(30 ⁻)
4207.5 [#] 11	14 ⁽⁺⁾	7612.8 ^d 19	(18 ⁻)	11731.8 ^b 20	(23 ⁻)	20259 [#] 3	(30 ⁺)
4304.4 ^b 11	(13 ⁻)	7815.4 ^a 21	(18 ⁻)	11763 ^{&} 3	(22)	21439 ^b 3	(31 ⁻)
4421.4 ^c 14	(13 ⁻)	8087.0 ^{&} 24	(18)	11947.8 ^e 20	(23 ⁻)	21664 [@] 3	(31 ⁺)
4622.7 [@] 11	15 ⁽⁺⁾	8253.8 ^e 16	(19 ⁻)	12677 ^d 3	(24 ⁻)		

[†] From a least-squares fit to E γ data, assuming 0.5 keV uncertainty when E γ stated to tenth of a keV, 1.0 keV otherwise for each γ ray.

[‡] As proposed in 2011Wa12 based on band assignments. When considered in Adopted Levels, those assignments of excited states will be placed in parentheses if there are no supporting experimental.

Band(A): Band based on 4⁽⁺⁾, $\alpha=0$.

@ Band(a): Band based on 5⁽⁺⁾, $\alpha=1$.

& Band(B): Band based on (4).

^a Band(C): Band based on 2⁽⁻⁾, $\alpha=0$.

^b Band(c): Band based on 1⁻, $\alpha=1$.

^c Band(D): Band based on (13⁻).

^d Band(E): Band based on 4⁽⁻⁾, $\alpha=0$.

^e Band(e): Band based on 5⁽⁻⁾, $\alpha=1$.

^f Band(F): Band based on 693 level, $\alpha=0$.

^g Band(f): Band based on (7), $\alpha=1$.

 $\gamma(^{76}\text{Rb})$

E γ	E _i (level)	J _i ^π	E _f	J _f ^π	E γ	E _i (level)	J _i ^π	E _f	J _f ^π
70.6	317.2	4 ⁽⁺⁾	246.3	3 ⁽⁻⁾	176	421.5	4 ⁽⁻⁾	246.3	3 ⁽⁻⁾
101.2	101.3	2 ⁽⁻⁾	0.0	1 ⁻	180.2	497.4	5 ⁽⁺⁾	317.2	4 ⁽⁺⁾
104.0	421.5	4 ⁽⁻⁾	317.2	4 ⁽⁺⁾	208.4	454.7	4 ⁽⁻⁾	246.3	3 ⁽⁻⁾
132	629.4	(4)	497.4	5 ⁽⁺⁾	208.4	663.1	5 ⁽⁻⁾	454.7	4 ⁽⁻⁾
134	1658.9	(8)	1525.2		210.0	707.4	6 ⁽⁺⁾	497.4	5 ⁽⁺⁾
145.1	246.3	3 ⁽⁻⁾	101.3	2 ⁽⁻⁾	235.1	689.8	5 ⁽⁻⁾	454.7	4 ⁽⁻⁾

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$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ **2011Wa12** (continued) $\gamma(^{76}\text{Rb})$ (continued)

E_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	E_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π
241.7	663.1	5 ⁽⁻⁾	421.5	4 ⁽⁻⁾	555.7	1010.2	6 ⁽⁻⁾	454.7	4 ⁽⁻⁾
246.4	246.3	3 ⁽⁻⁾	0.0	1 ⁻	566.8	3007.7	12 ⁽⁺⁾	2440.9	11 ⁽⁺⁾
260	1250.0	(6)	989.5		568	989.5		421.5	4 ⁽⁻⁾
264	954.0	6 ⁽⁻⁾	689.8	5 ⁽⁻⁾	587	1250.0	(6)	663.1	5 ⁽⁻⁾
269	689.8	5 ⁽⁻⁾	421.5	4 ⁽⁻⁾	598 [†]	1287.4	7 ⁽⁻⁾	689.8	5 ⁽⁻⁾
270.7	978.0	7 ⁽⁺⁾	707.4	6 ⁽⁺⁾	598 [†]	3665.8	12 ⁽⁻⁾	3068.4	11 ⁽⁻⁾
271	693.0		421.5	4 ⁽⁻⁾	623	1577.1	(7)	954.0	6 ⁽⁻⁾
277	1287.4	7 ⁽⁻⁾	1010.2	6 ⁽⁻⁾	624.2	1287.4	7 ⁽⁻⁾	663.1	5 ⁽⁻⁾
278.8	1256.6	8 ⁽⁺⁾	978.0	7 ⁽⁺⁾	642.8	1620.7	9 ⁽⁺⁾	978.0	7 ⁽⁺⁾
290.9	954.0	6 ⁽⁻⁾	663.1	5 ⁽⁻⁾	643.1	1333.0	7 ⁽⁻⁾	689.8	5 ⁽⁻⁾
296 [†]	989.5		693.0		645	1658.9	(8)	1013.5	(6)
296 [†]	1250.0	(6)	954.0	6 ⁽⁻⁾	653	1940.0	(8)	1287.4	7 ⁽⁻⁾
306.1	1013.5	(6)	707.4	6 ⁽⁺⁾	671	2350.1	(9)	1679.6	8 ⁽⁻⁾
312	629.4	(4)	317.2	4 ⁽⁺⁾	681	1658.9	(8)	978.0	7 ⁽⁺⁾
320	421.5	4 ⁽⁻⁾	101.3	2 ⁽⁻⁾	690.0	1940.0	(8)	1250.0	(6)
320.5	1010.2	6 ⁽⁻⁾	689.8	5 ⁽⁻⁾	710	2805.6	(10)	2095.1	9 ⁽⁻⁾
322.9	1333.0	7 ⁽⁻⁾	1010.2	6 ⁽⁻⁾	725.6	1679.6	8 ⁽⁻⁾	954.0	6 ⁽⁻⁾
324	1013.5	(6)	689.8	5 ⁽⁻⁾	751.6	1761.5	8 ⁽⁻⁾	1010.2	6 ⁽⁻⁾
327.1	1577.1	(7)	1250.0	(6)	763.0	2019.7	10 ⁽⁺⁾	1256.6	8 ⁽⁺⁾
333.4	1287.4	7 ⁽⁻⁾	954.0	6 ⁽⁻⁾	765	4207.5	14 ⁽⁺⁾	3442.5	13 ⁽⁺⁾
346	1679.6	8 ⁽⁻⁾	1333.0	7 ⁽⁻⁾	773	2350.1	(9)	1577.1	(7)
353.4	454.7	4 ⁽⁻⁾	101.3	2 ⁽⁻⁾	807.5	2095.1	9 ⁽⁻⁾	1287.4	7 ⁽⁻⁾
362.8	1940.0	(8)	1577.1	(7)	820.1	2440.9	11 ⁽⁺⁾	1620.7	9 ⁽⁺⁾
364.1	1620.7	9 ⁽⁺⁾	1256.6	8 ⁽⁺⁾	837.3	2170.5	9 ⁽⁻⁾	1333.0	7 ⁽⁻⁾
379	1333.0	7 ⁽⁻⁾	954.0	6 ⁽⁻⁾	865.8	2805.6	(10)	1940.0	(8)
383	629.4	(4)	246.3	3 ⁽⁻⁾	889	2547.9	(10)	1658.9	(8)
384	1013.5	(6)	629.4	(4)	909.3	2588.8	10 ⁽⁻⁾	1679.6	8 ⁽⁻⁾
390.1	707.4	6 ⁽⁺⁾	317.2	4 ⁽⁺⁾	928	3278.2	(11)	2350.1	(9)
392.3	1679.6	8 ⁽⁻⁾	1287.4	7 ⁽⁻⁾	937.2	2698.3	10 ⁽⁻⁾	1761.5	8 ⁽⁻⁾
399.1	2019.7	10 ⁽⁺⁾	1620.7	9 ⁽⁺⁾	973.2	3068.4	11 ⁽⁻⁾	2095.1	9 ⁽⁻⁾
409	2350.1	(9)	1940.0	(8)	988.0	3007.7	12 ⁽⁺⁾	2019.7	10 ⁽⁺⁾
409.1	2170.5	9 ⁽⁻⁾	1761.5	8 ⁽⁻⁾	1001.5	3442.5	13 ⁽⁺⁾	2440.9	11 ⁽⁺⁾
415.2	4622.7	15 ⁽⁺⁾	4207.5	14 ⁽⁺⁾	1017	3187.4	11 ⁽⁻⁾	2170.5	9 ⁽⁻⁾
415.3	2095.1	9 ⁽⁻⁾	1679.6	8 ⁽⁻⁾	1026	4304.4	(13 ⁻)	3278.2	(11)
419	2588.8	10 ⁽⁻⁾	2170.5	9 ⁽⁻⁾	1036	3841.5	(12)	2805.6	(10)
421.3	2440.9	11 ⁽⁺⁾	2019.7	10 ⁽⁺⁾	1077.0	3665.8	12 ⁽⁻⁾	2588.8	10 ⁽⁻⁾
428.6	1761.5	8 ⁽⁻⁾	1333.0	7 ⁽⁻⁾	1094	3792.4	12 ⁽⁻⁾	2698.3	10 ⁽⁻⁾
434.8	3442.5	13 ⁽⁺⁾	3007.7	12 ⁽⁺⁾	1108	3655.9	(12)	2547.9	(10)
443.5	689.8	5 ⁽⁻⁾	246.3	3 ⁽⁻⁾	1111	4180.0	13 ⁽⁻⁾	3068.4	11 ⁽⁻⁾
455	2805.6	(10)	2350.1	(9)	1117	4304.4	(13 ⁻)	3187.4	11 ⁽⁻⁾
479.7	3068.4	11 ⁽⁻⁾	2588.8	10 ⁽⁻⁾	1143	3841.5	(12)	2698.3	10 ⁽⁻⁾
480.7	978.0	7 ⁽⁺⁾	497.4	5 ⁽⁺⁾	1180	4622.7	15 ⁽⁺⁾	3442.5	13 ⁽⁺⁾
489	3187.4	11 ⁽⁻⁾	2698.3	10 ⁽⁻⁾	1186	4978.4	(14 ⁻)	3792.4	12 ⁽⁻⁾
490	2170.5	9 ⁽⁻⁾	1679.6	8 ⁽⁻⁾	1198	5502.5	(15 ⁻)	4304.4	(13 ⁻)
493.5	2588.8	10 ⁽⁻⁾	2095.1	9 ⁽⁻⁾	1200	4207.5	14 ⁽⁺⁾	3007.7	12 ⁽⁺⁾
512	1525.2		1013.5	(6)	1219	4884.8	(14 ⁻)	3665.8	12 ⁽⁻⁾
515	4180.0	13 ⁽⁻⁾	3665.8	12 ⁽⁻⁾	1221	5401.0	(15 ⁻)	4180.0	13 ⁽⁻⁾
527.5	2698.3	10 ⁽⁻⁾	2170.5	9 ⁽⁻⁾	1234	4421.4	(13 ⁻)	3187.4	11 ⁽⁻⁾
532	954.0	6 ⁽⁻⁾	421.5	4 ⁽⁻⁾	1307	4963.0	(14)	3655.9	(12)
549.0	1256.6	8 ⁽⁺⁾	707.4	6 ⁽⁺⁾	1314	6198.8	(16 ⁻)	4884.8	(14 ⁻)

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$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ **2011Wa12** (continued) $\gamma(^{76}\text{Rb})$ (continued)

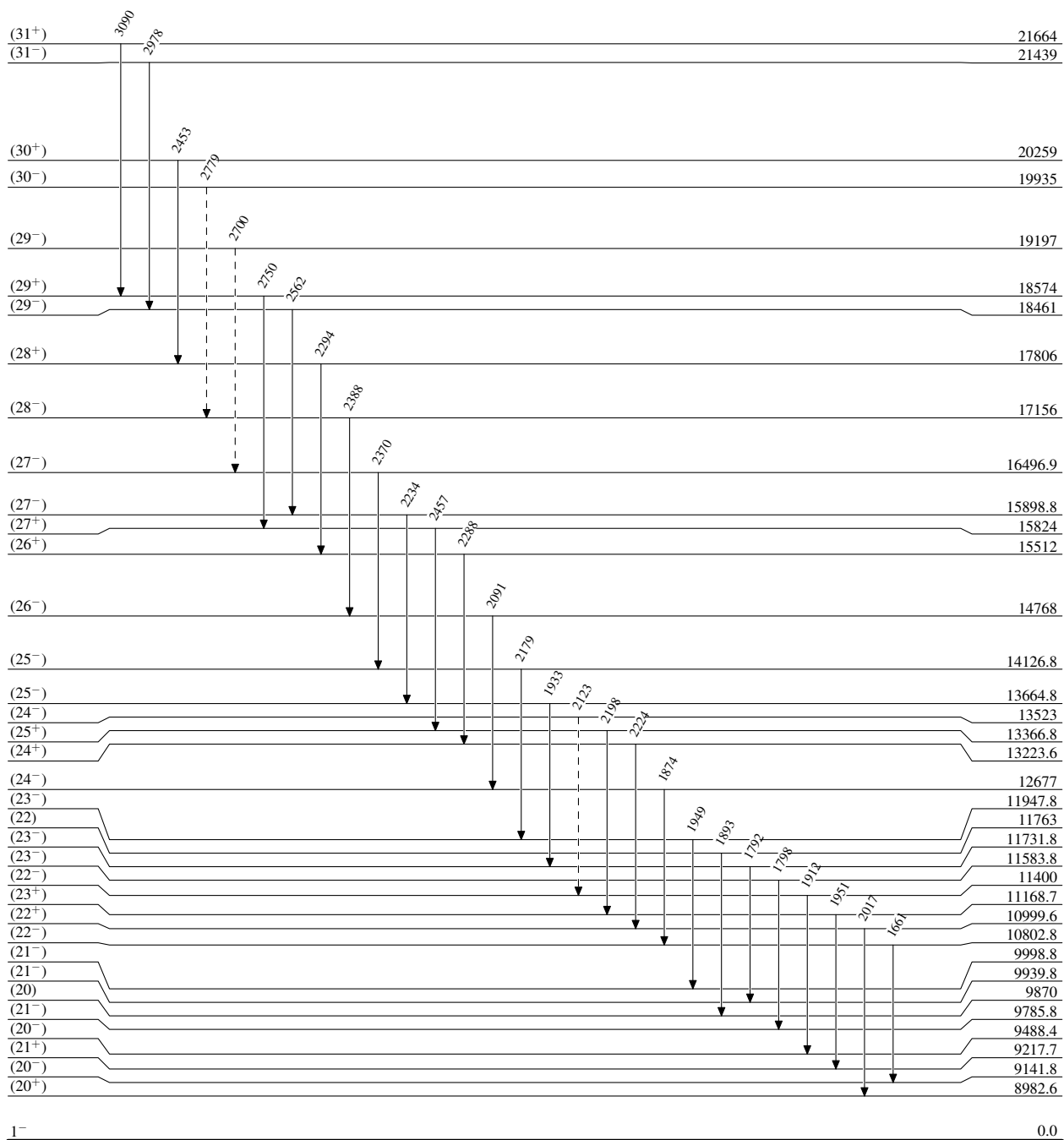
E_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	E_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π
1332	6834.6	(17 ⁻)	5502.5	(15 ⁻)	1792	11731.8	(23 ⁻)	9939.8	(21 ⁻)
1334	6312.4	(16 ⁻)	4978.4	(14 ⁻)	1794	8982.6	(20 ⁺)	7188.5	18 ⁽⁺⁾
1343	6743.9	(17 ⁻)	5401.0	(15 ⁻)	1798	11583.8	(23 ⁻)	9785.8	(21 ⁻)
1350	5972.7	17 ⁽⁺⁾	4622.7	15 ⁽⁺⁾	1874	12677	(24 ⁻)	10802.8	(22 ⁻)
1372	5793.4	(15 ⁻)	4421.4	(13 ⁻)	1893	11763	(22)	9870	(20)
1395	5602.5	16 ⁽⁺⁾	4207.5	14 ⁽⁺⁾	1912	11400	(22 ⁻)	9488.4	(20 ⁻)
1414	7612.8	(18 ⁻)	6198.8	(16 ⁻)	1933	13664.8	(25 ⁻)	11731.8	(23 ⁻)
1428 [‡]	6312.4	(16 ⁻)	4884.8	(14 ⁻)	1949	11947.8	(23 ⁻)	9998.8	(21 ⁻)
1474	8308.7	(19 ⁻)	6834.6	(17 ⁻)	1951	11168.7	(23 ⁺)	9217.7	(21 ⁺)
1477	9785.8	(21 ⁻)	8308.7	(19 ⁻)	2017	10999.6	(22 ⁺)	8982.6	(20 ⁺)
1485	6448.0	(16)	4963.0	(14)	2091	14768	(26 ⁻)	12677	(24 ⁻)
1503	7815.4	(18 ⁻)	6312.4	(16 ⁻)	2123 [‡]	13523	(24 ⁻)	11400	(22 ⁻)
1510	8253.8	(19 ⁻)	6743.9	(17 ⁻)	2179	14126.8	(25 ⁻)	11947.8	(23 ⁻)
1524	7496.7	19 ⁽⁺⁾	5972.7	17 ⁽⁺⁾	2198	13366.8	(25 ⁺)	11168.7	(23 ⁺)
1529	9141.8	(20 ⁻)	7612.8	(18 ⁻)	2224	13223.6	(24 ⁺)	10999.6	(22 ⁺)
1532	9785.8	(21 ⁻)	8253.8	(19 ⁻)	2234	15898.8	(27 ⁻)	13664.8	(25 ⁻)
1543	7336.4	(17 ⁻)	5793.4	(15 ⁻)	2288	15512	(26 ⁺)	13223.6	(24 ⁺)
1586	7188.5	18 ⁽⁺⁾	5602.5	16 ⁽⁺⁾	2294	17806	(28 ⁺)	15512	(26 ⁺)
1631	9939.8	(21 ⁻)	8308.7	(19 ⁻)	2370	16496.9	(27 ⁻)	14126.8	(25 ⁻)
1639	8087.0	(18)	6448.0	(16)	2388	17156	(28 ⁻)	14768	(26 ⁻)
1660	8996.5	(19 ⁻)	7336.4	(17 ⁻)	2453	20259	(30 ⁺)	17806	(28 ⁺)
1661	10802.8	(22 ⁻)	9141.8	(20 ⁻)	2457	15824	(27 ⁺)	13366.8	(25 ⁺)
1673	9488.4	(20 ⁻)	7815.4	(18 ⁻)	2562	18461	(29 ⁻)	15898.8	(27 ⁻)
1686	9939.8	(21 ⁻)	8253.8	(19 ⁻)	2700 [‡]	19197	(29 ⁻)	16496.9	(27 ⁻)
1690	9998.8	(21 ⁻)	8308.7	(19 ⁻)	2750	18574	(29 ⁺)	15824	(27 ⁺)
1721	9217.7	(21 ⁺)	7496.7	19 ⁽⁺⁾	2779 [‡]	19935	(30 ⁻)	17156	(28 ⁻)
1745	9998.8	(21 ⁻)	8253.8	(19 ⁻)	2978	21439	(31 ⁻)	18461	(29 ⁻)
1757 [‡]	10753.5	(21 ⁻)	8996.5	(19 ⁻)	3090	21664	(31 ⁺)	18574	(29 ⁺)
1783	9870	(20)	8087.0	(18)					

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

$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

Legend

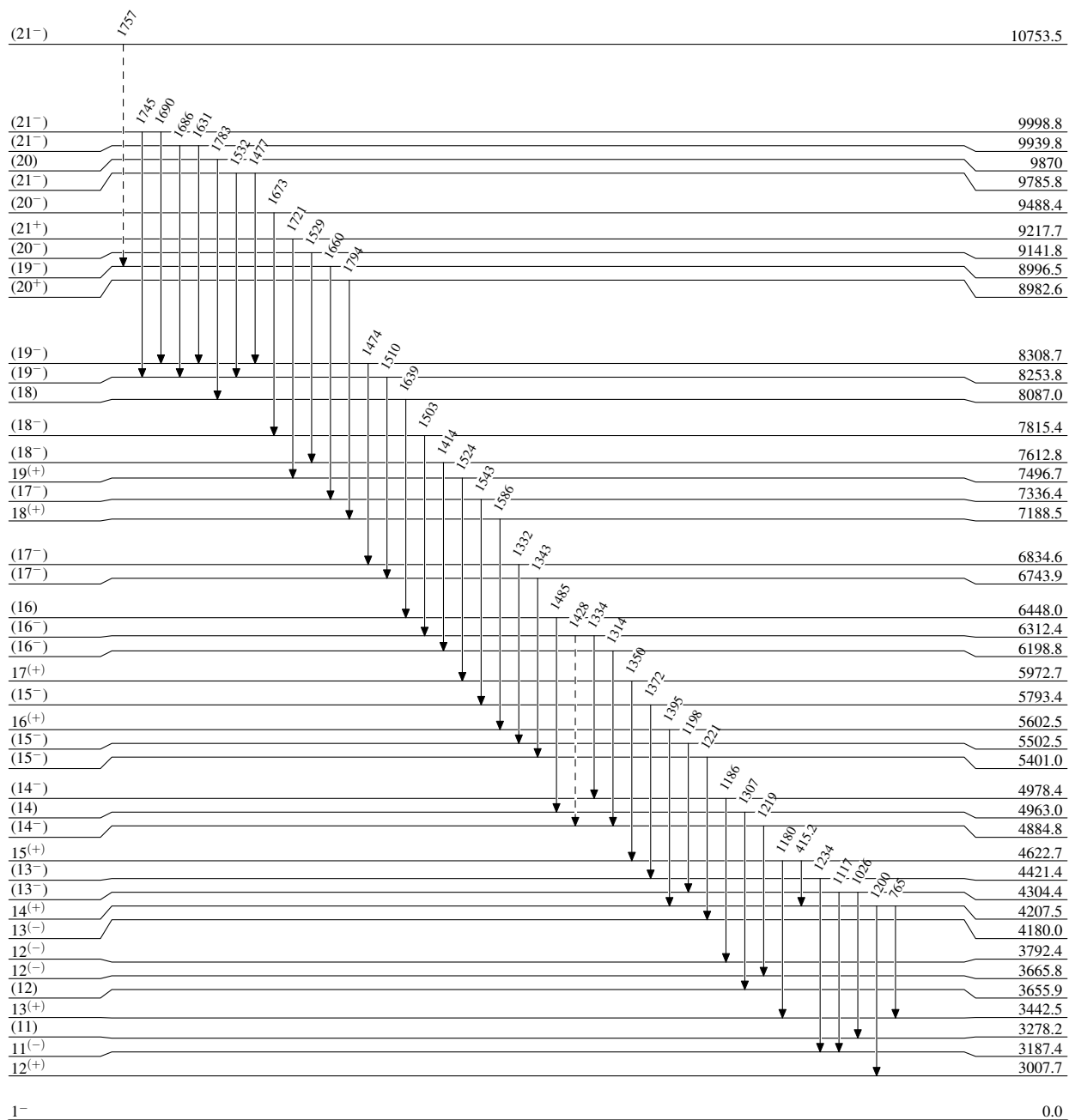
Level Scheme

-----► γ Decay (Uncertain)


$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

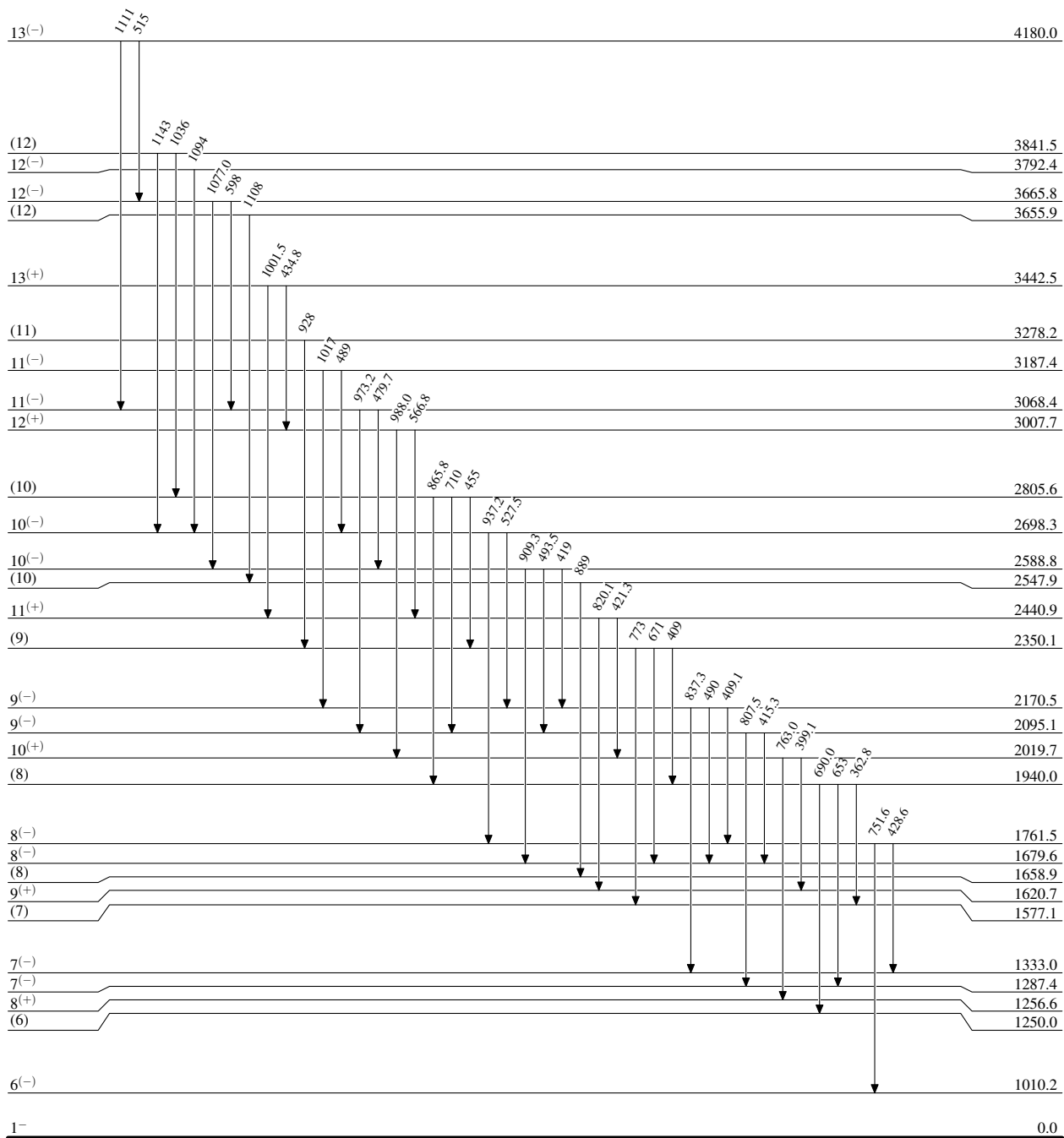
Legend

Level Scheme (continued)

-----► γ Decay (Uncertain)

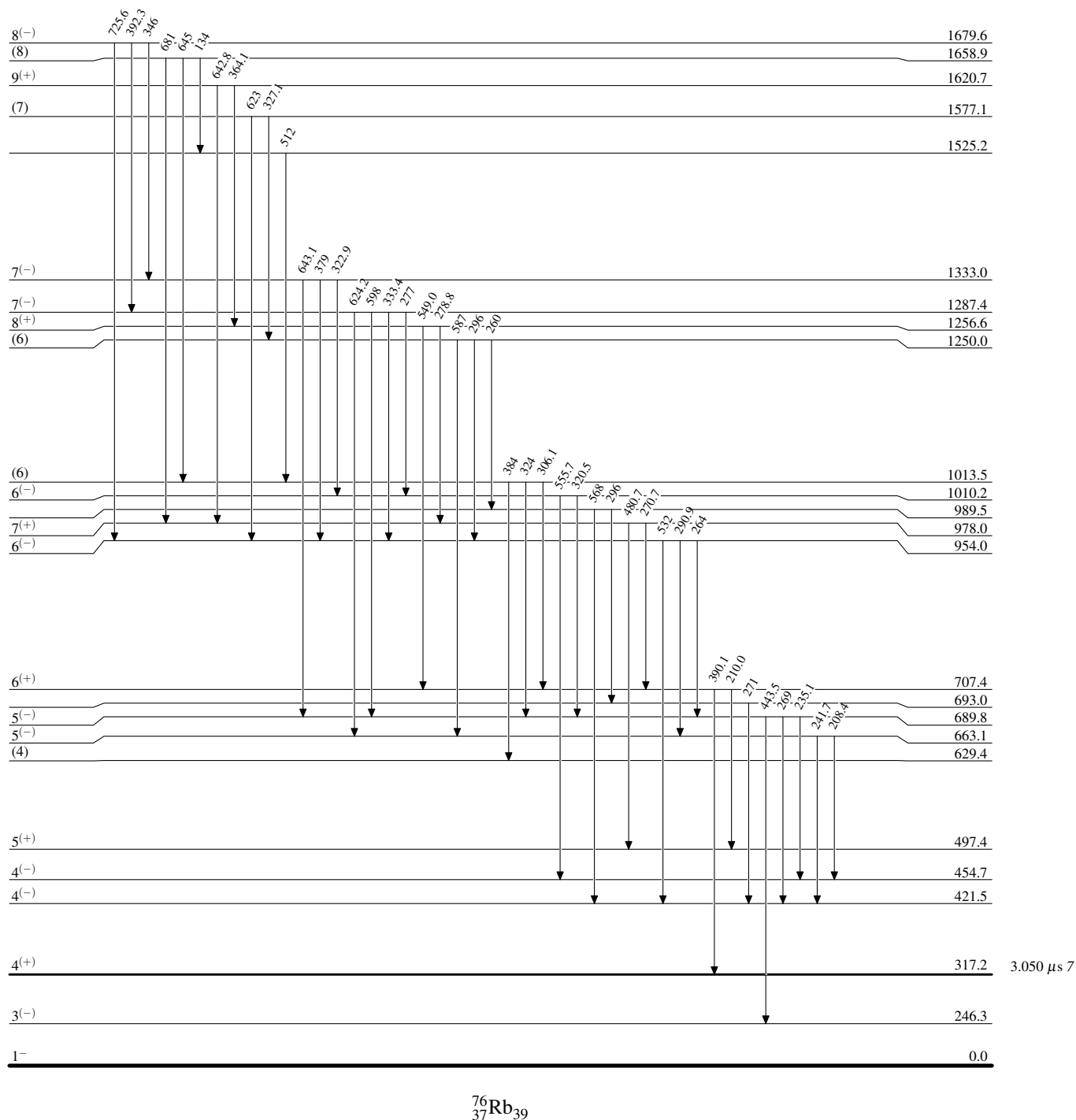
$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

Level Scheme (continued)

 $^{76}_{37}\text{Rb}_{39}$

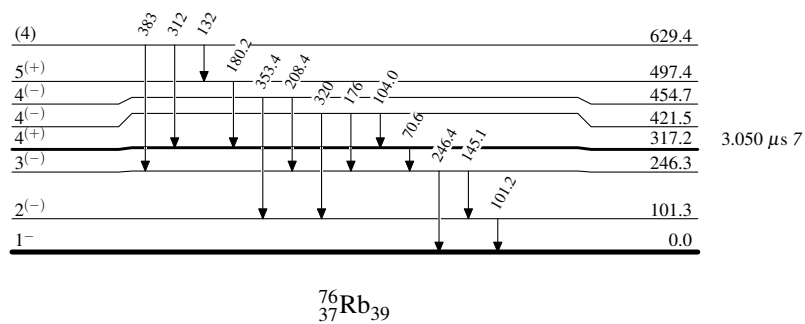
$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

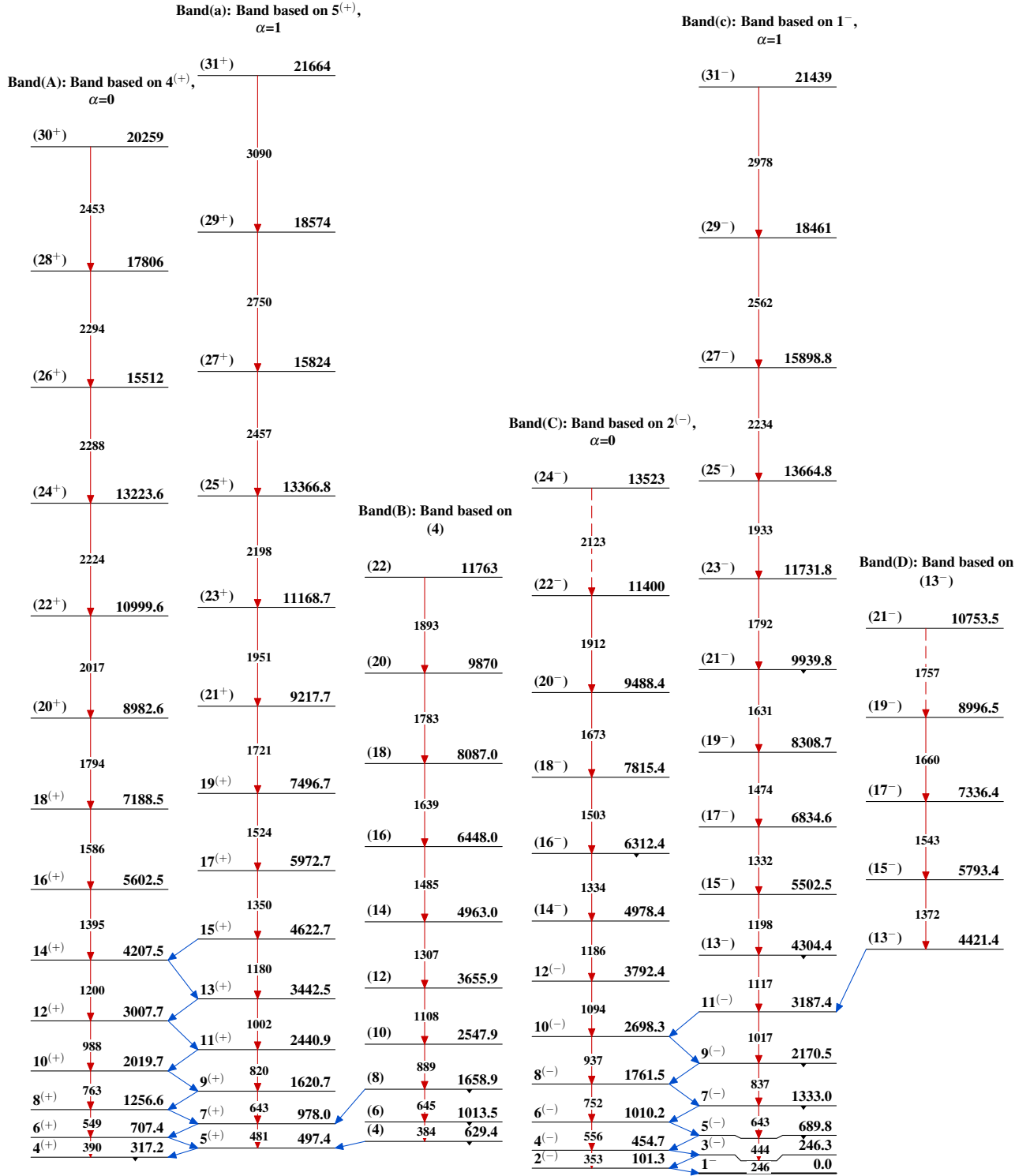
Level Scheme (continued)

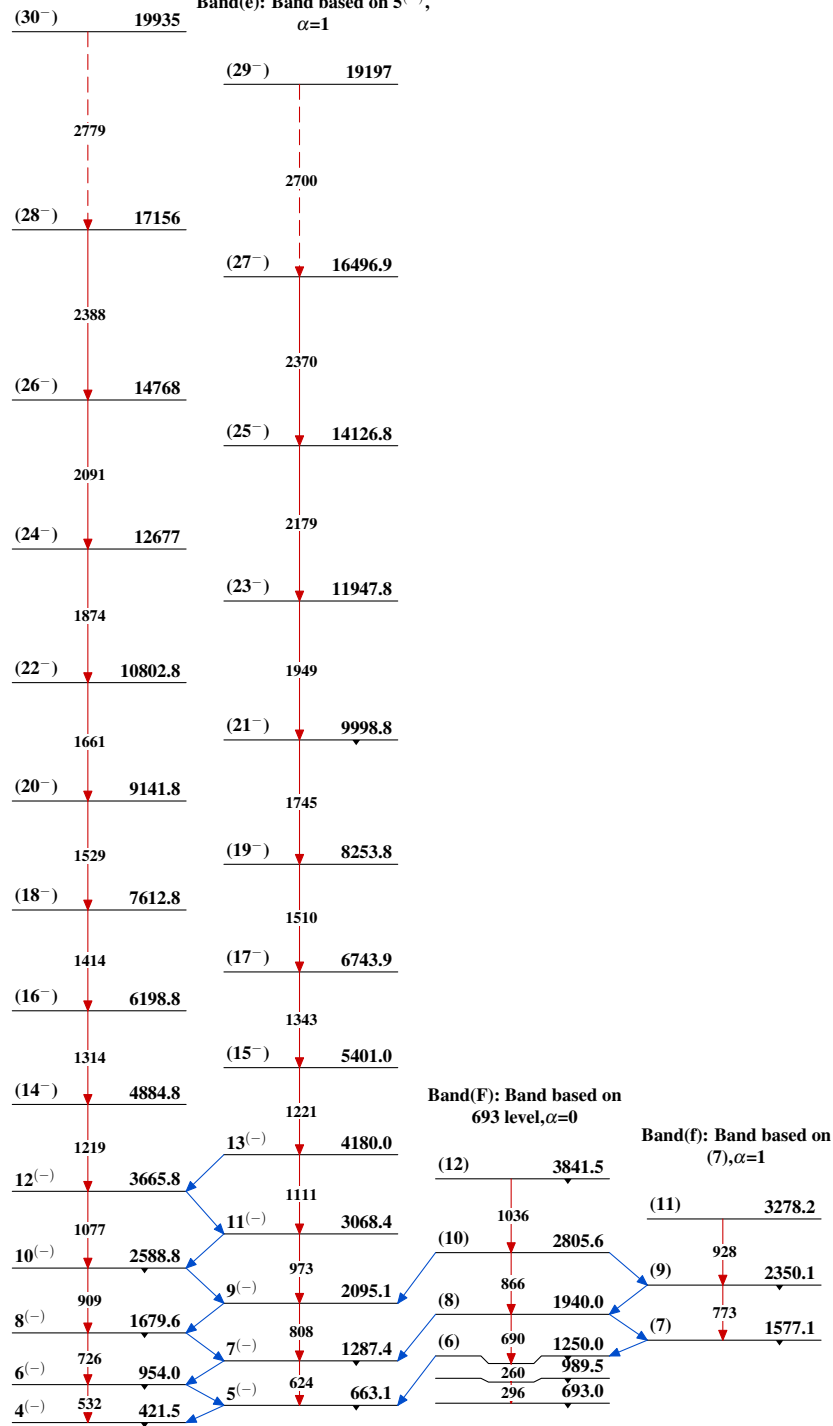


$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

Level Scheme (continued)



$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12

$^{40}\text{Ca}(^{40}\text{Ca},3\text{pn}\gamma):E=165\text{ MeV}$ 2011Wa12 (continued)Band(E): Band based on $4^{(-)}$,
 $\alpha=0$ Band(e): Band based on $5^{(-)}$,
 $\alpha=1$  $^{76}_{37}\text{Rb}_{39}$