Coulomb excitation: Li 1993Mc07,2000Gu22

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	E. Browne	NDS 107,2579 (2006)	1-Nov-2004

Coulomb excitation with light ions.
^{232}Th(α,α'), Eα=18 MeV. Measured Eγ, Iγ at θ=0°, 55°, and 90°. Detector: Ge(Li), FWHM=1.8 keV at 1332 keV. Deduced γ-ray multipolarities, mixing ratios, B(E2) (1993Mc07).
^{232}Th(^{16}O,^{16}O′), E=80 MeV. Measured Eγ, Iγ. Detector: yrast ball, an array with four Clover detectors and seventeen hyperpure Ge detectors. Deduced B(E2) (2000Gu22).
Others: 1970Je04, 1972McYP, 1972McYT, 1973Ei02, 1974Mc15, 1975DaZJ.

^{232}Th Levels

B(E2) and B(E3) experimental values are from 1993Mc07, unless otherwise specified.

E(level)‡	Jπ†	Comments
0.0#	0+	
49.370# 9	2+	B(E2)↑=9.21 9 (1973Be44,1974Ba43)
162.123# 22	4+	B(E4)↑=1.8 4 (1974Ba43) BE4=1.5 4 (1973Be44).
333.29# 7	6+	
556.90# 10	8+	
714.43a 10	1−	
730.65@ 20	0+	
774.42a 9	3−	B(E3)↑=0.54 5
774.44@ 13	2+	B(E2)↑=0.086 14
785.27& 10	2+	B(E2)↑=0.147 7
826.79# 13	10+	
829.6& 3	3+	
872.99@ 21	4+	
883.74a 9	5−	
890.48& 10	4+	
1023.34@ 8	6+	
1042.87a 11	7−	
1050.97& 12	6+	
1053.93c 14	(2+)	B(E2)↑=0.00166 17
1072.4 3	(2+)	B(E2)↑=0.0010 17
1077.94 22	1−	
1078.63d 14	0+	
1094.40 22	2+	B(E2)↑=0.00117 12
1105.68b 8	3−	B(E3)↑=0.250 18
1121.68d 9	2+	B(E2)↑=0.0041 6
1182.61 18	3−	B(E3)↑=0.039 3
1208.79b 8	5−	
1223?d	(4+)	Jπ: Not adopted.
1249.58a 13	9−	
1293.0 3	5−	
1322.3 3	2+	B(E2)↑=0.00220 22
1327.37 18	2+	B(E2)↑=0.00113 13
1352.23e 14	0+	Jπ: Not adopted.

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Coulomb excitation: Li 1993Mc07,2000Gu22 (continued)

^{232}Th Levels (continued)

E(level)‡	Jπ†	$T_{1/2}$	Comments
1387.08 *11*	2^+		B(E2)↑=0.0105 *8*
1413.77[f] *22*	4^+	2.2 ps *5*	$T_{1/2}$: From Adopted Levels.
1466.42[e] *11*	4^+		
1477.01 *18*	2^+		B(E2)↑=0.0059 *8*
1553.85[g] *13*	2^+		B(E2)↑=0.0279 *20* 1993Mc07 assigned this state as possible candidate for a two-phonon state. This assignment has not been confirmed in 2000Gu22.

† J^π and configuration assignments are based on rotational structure, γ-ray angular distributions (γ(θ)), Coulomb excitation cross sections (B(E2) values), and on comparisons of experimental γ-ray reduced transition probability ratios with theoretical values (1993Mc07,2000Gu22).
‡ Deduced by evaluator from a least-squares fit to γ-ray energies.
# Band(A): $K^\pi=0^+$ Ground State Rotational Band.
@ Band(B): $K^\pi=0^+$ Beta Vibrational Band.
& Band(C): $K^\pi=2^+$ Gamma Vibrational Band.
a Band(D): $K^\pi=0^-$ Vibrational Band.
b Band(E): $K^\pi=2^-$ Octupole Vibrational Band.
c Band(F): $K^\pi=(2^+)$ Vibrational Band.
d Band(G): $K^\pi=0^+$ Vibrational Band.
e Band(H): $K^\pi=0^+$ Vibrational Band.
f Band(I): $K^\pi=4^+$ Two-phonon γγ Vibrational Band.
g Band(J): $K^\pi=(0,1)^+$ Vibrational Band.

γ(^{232}Th)

E_γ†	I_γ†	E_i(level)	J_i^π	E_f	J_f^π	Mult.#	Comments
49.369 *9*		49.370	2^+	0.0	0^+		E_γ: From Adopted Gammas.
112.75 *2*		162.123	4^+	49.370	2^+		E_γ: From Adopted Gammas.
159.2 *1*	6.9 *10*	1042.87	7^-	883.74	5^-		
171.2[&] *1*	1.00×10^3 *15*	333.29	6^+	162.123	4^+		Excitation yield per nC=14.3.
206.8 *1*	2.4 *4*	1249.58	9^-	1042.87	7^-		
223.6[&] *1*	128 *19*	556.90	8^+	333.29	6^+		
268.4	<0.7	1053.93	(2^+)	785.27	2^+		
269.8 *1*	9.6 *15*	826.79	10^+	556.90	8^+		
279.5 *3*	1.7 *6*	1053.93	(2^+)	774.44	2^+		
323.2 *2*	2.1 *3*	1053.93	(2^+)	730.65	0^+		
325.0 *1*	4.5 *7*	1208.79	5^-	883.74	5^-		
331.3 *1*	13.3 *20*	1105.68	3^-	774.42	3^-		Excitation yield per nC=15.9.
347.2 *1*	6.0 *9*	1121.68	2^+	774.42	3^-	E1	Excitation yield per nC=2.87.
364.2 *1*	9.8 *15*	1078.63	0^+	714.43	1^-		
391.3 *3*	1.7 *3*	1105.68	3^-	714.43	1^-		
407.3 *1*	7.4 *11*	1121.68	2^+	714.43	1^-		
408.2[‡] *3*		1182.61	3^-	774.44	2^+	E1	Excitation yield per nC=2.7.
422.7 *1*	3.4 *5*	1249.58	9^-	826.79	10^+		
434.3 *2*	1.6 *5*	1208.79	5^-	774.42	3^-		
466.7 *2*	0.6 *1*	1023.34	6^+	556.90	8^+		
486.0[&] *1*	4.5 *7*	1042.87	7^-	556.90	8^+		
539.7[‡] *3*		872.99	4^+	333.29	6^+		Excitation yield per nC=2.48.
550.4[&] *1*	243 *36*	883.74	5^-	333.29	6^+		Excitation yield per nC=13.3.
582.6 *1*	4.1 *6*	1466.42	4^+	883.74	5^-		

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Coulomb excitation: Li 1993Mc07,2000Gu22 (continued)

$\gamma(^{232}Th)$ (continued)

E_γ †	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult.#	δ#	Comments
584.2 *2*	3.0 *5*	1413.77	4^+	829.6	3^+			
612.3‡& *3*		774.42	3^-	162.123	4^+	E1		Excitation yield per nC=468.
612.3‡& *3*		774.44	2^+	162.123	4^+	E2		Excitation yield per nC=177.
612.7 *3*	14 *3*	1387.08	2^+	774.42	3^-			
623.1 *1*	12.8 *20*	785.27	2^+	162.123	4^+	E2		Excitation yield per nC=10.9.
628.5 *2*	10.2 *15*	1413.77	4^+	785.27	2^+			
637.8 *1*	7.0 *10*	1352.23	0^+	714.43	1^-			
656.7‡a *3*	<1.5	1387.08	2^+	730.65	0^+	E2		Excitation yield per nC=1.48.
665.0‡& *3*		714.43	1^-	49.370	2^+			Excitation yield per nC=63.4.
672.6 *1*	7.7 *11*	1387.08	2^+	714.43	1^-	E1		Excitation yield per nC=3.68.
681.0@‡a *3*		1553.85	2^+	872.99	4^+	E2		Excitation yield per nC=2.0 *LE*.
681.1‡& *3*		730.65	0^+	49.370	2^+			Excitation yield per nC=21.0.
690.0 *1*	9.0 *14*	1023.34	6^+	333.29	6^+			
691.9 *2*	1.6 *3*	1466.42	4^+	774.44	2^+			
702.6‡ *3*		1477.01	2^+	774.44	2^+	M1+E2	2.0 *5*	Excitation yield per nC=4.19.
711	13 *4*	872.99	4^+	162.123	4^+			E_γ: From level energy difference.
714.4‡ *3*		714.43	1^-	0.0	0^+			Excitation yield per nC=11.1.
717.7 *1*	20.7 *31*	1050.97	6^+	333.29	6^+			
725.0‡& *3*		774.42	3^-	49.370	2^+	E1		Excitation yield per nC=72.6.
725.0‡& *3*		774.44	2^+	49.370	2^+	M1+E2	−1.5 *+11−5*	Excitation yield per nC=59.0.
728.4& *1*	207 *31*	890.48	4^+	162.123	4^+			Excitation yield per nC=16.8.
736.1‡& *3*		785.27	2^+	49.370	2^+	M1+E2	10.8 *+5−11*	Excitation yield per nC=1088.
768.5@‡a *3*		1553.85	2^+	785.27	2^+	M1+E2	≈6	Excitation yield per nC=3.0.
774.4‡& *3*		774.44	2^+	0.0	0^+	E2		Excitation yield per nC=291.
779.6 *3*	12 *2*	1553.85	2^+	774.44	2^+	M1+E2	2.5 *5*	Excitation yield per nC=7.0.
785.5‡& *3*		785.27	2^+	0.0	0^+	E2		Excitation yield per nC=625.
823.5@‡a *3*		1553.85	2^+	730.65	0^+	E2		Excitation yield per nC=12.9.
823.6‡& *3*		872.99	4^+	49.370	2^+			Excitation yield per nC=2.0.
839.4 *1*	5.8 *9*	1553.85	2^+	714.43	1^-	E1		Excitation yield per nC=3.4.
840.7‡ *3*		890.48	4^+	49.370	2^+			Excitation yield per nC=3.0.
861.2 *1*	30.0 *50*	1023.34	6^+	162.123	4^+			
875.6 *2*	0.9 *3*	1208.79	5^-	333.29	6^+			
888.4 *5*	5.2 *8*	1050.97	6^+	162.123	4^+			
889.5a *3*	4.3 *6*	1223?	(4^+)	333.29	6^+			
891.9‡ *3*		1053.93	(2^+)	162.123	4^+	(E2)		Excitation yield per nC=0.88.
932.3‡ *3*		1094.40	2^+	162.123	4^+			Excitation yield per nC=3.30.
943.5 *1*	34 *5*	1105.68	3^-	162.123	4^+			Excitation yield per nC=24.3.
959.3 *2*	20 *3*	1121.68	2^+	162.123	4^+	E2		Excitation yield per nC=7.9.
959.7‡ *3*		1293.0	5^-	333.29	6^+			Excitation yield per nC=4.0.
1004.6‡ *3*		1053.93	(2^+)	49.370	2^+	(M1+E2)	2.6 *4*	Excitation yield per nC=7.63.
1020.5‡ *3*		1182.61	3^-	162.123	4^+	E1		Excitation yield per nC=4.14.
1023.0‡ *3*		1072.4	(2^+)	49.370	2^+	(M1+E2)	4.4 *10*	Excitation yield per nC=6.25.
1028.5‡ *3*		1077.94	1^-	49.370	2^+			Excitation yield per nC=4.4.
1029.2		1078.63	0^+	49.370	2^+			
1045.0‡ *3*		1094.40	2^+	49.370	2^+	M1+E2	−3.7 *+34−17*	Excitation yield per nC=3.70.
1046.7 *1*	47 *7*	1208.79	5^-	162.123	4^+			
1054.0‡ *3*		1053.93	(2^+)	0.0	0^+	(E2)		Excitation yield per nC=2.36.
1056.4‡& *3*		1105.68	3^-	49.370	2^+			Excitation yield per nC=127.0.
1072.6‡ *3*		1121.68	2^+	49.370	2^+	M1+E2	1.45 *16*	Excitation yield per nC=10.2.

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Coulomb excitation: Li 1993Mc07,2000Gu22 (continued)

$\gamma(^{232}Th)$ (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ[#]	Comments
1078.0[‡] *3*		1077.94	1^-	0.0	0^+			Excitation yield per nC=1.7.
1122.0[‡] *3*		1121.68	2^+	0.0	0^+	E2		Excitation yield per nC=1.94.
1133.2[‡] *3*		1182.61	3^-	49.370	2^+	E1		Excitation yield per nC=16.5.
1133.5 *2*	4.7 *9*	1466.42	4^+	333.29	6^+			
1165.1[‡] *3*		1327.37	2^+	162.123	4^+	E2		Excitation yield per nC=1.74.
1225.1 *3*	9 *3*	1387.08	2^+	162.123	4^+	E2		Excitation yield per nC=13.2.
1277.8[‡] *3*		1327.37	2^+	49.370	2^+	(M1+E2)		Excitation yield per nC=1.02.
1304.3[a]	<4	1466.42	4^+	162.123	4^+			
1322.3[‡] *3*		1322.3	2^+	0.0	0^+	E2		Excitation yield per nC=7.74.
1327.7[‡] *3*		1327.37	2^+	0.0	0^+	E2		Excitation yield per nC=1.19.
1337.8[‡] *3*		1387.08	2^+	49.370	2^+	M1+E2	−1.5 *5*	Excitation yield per nC=7.69.
1387.2[‡] *3*		1387.08	2^+	0.0	0^+	E2		Excitation yield per nC=5.37.
1391.9[@‡a] *3*		1553.85	2^+	162.123	4^+	E2		Excitation yield per nC=5.40.
1427.6[‡] *3*		1477.01	2^+	49.370	2^+			Excitation yield per nC=0.6 *LE*.
1477.0[‡] *3*		1477.01	2^+	0.0	0^+	E2		Excitation yield per nC=9.95.
1504.6[@‡a] *3*		1553.85	2^+	49.370	2^+	M1+E2	−2.7 *+26−12*	Excitation yield per nC=4.75.
1554.0[@‡a] *3*		1553.85	2^+	0.0	0^+	E2		Excitation yield per nC=4.18.

[†] From 2000Gu22, unless otherwise specified.
[‡] From 1993Mc07. Uncertainties not given. Evaluator has estimated ΔE=0.3 keV for all γ rays, unless otherwise specified.
[#] From γ(θ) in 1993Mc07.
[@] Not seen by 2000Gu22 (Iγ<0.5).
[&] Observed in coincidence with thorium K x ray.
[a] Placement of transition in the level scheme is uncertain.

Coulomb excitation: Li 1993Mc07,2000Gu22

Level Scheme

Intensities: Relative $I_{(\gamma+ce)}$

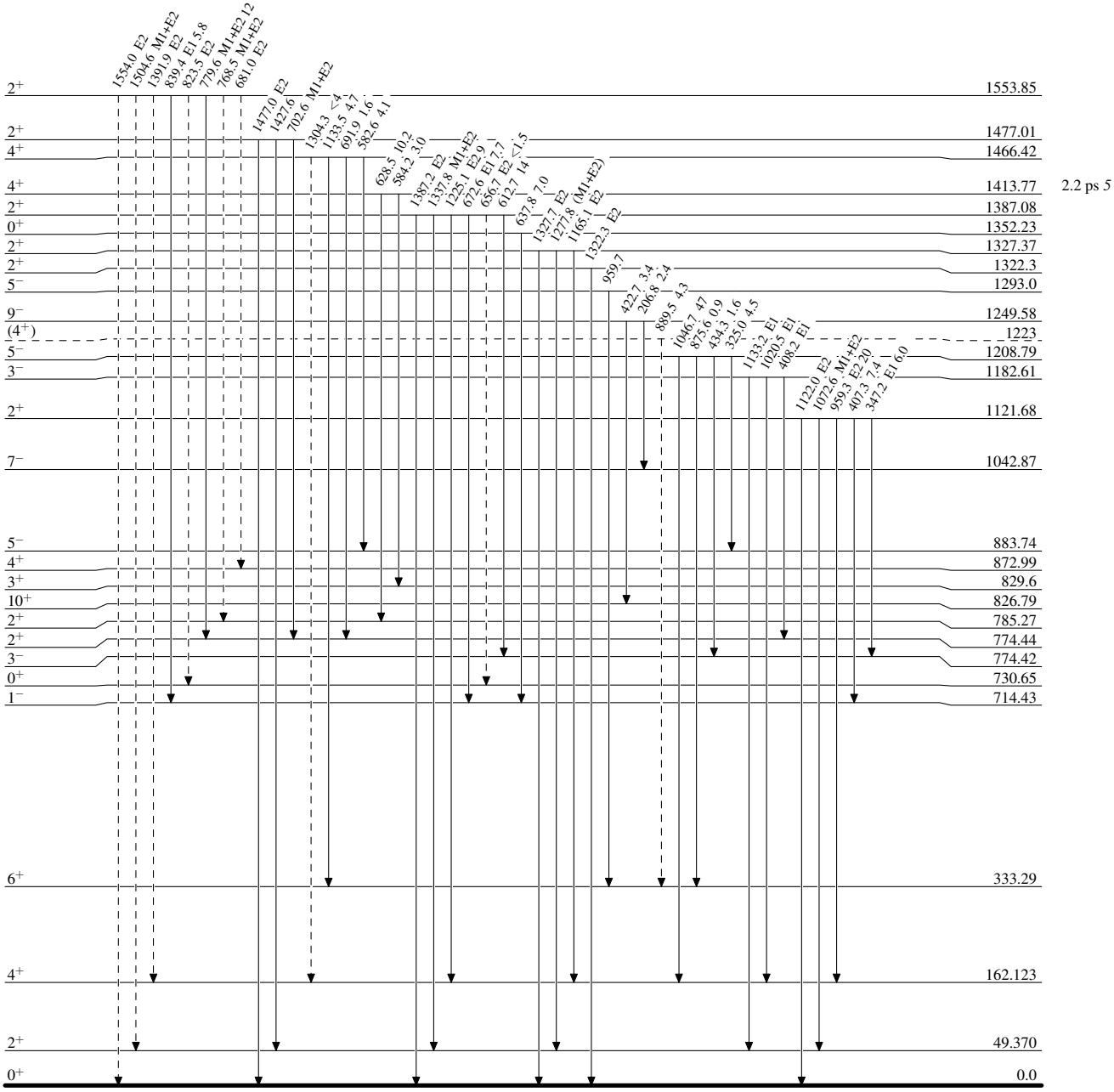
Legend

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

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

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

γ Decay (Uncertain)



$^{232}_{90}Th_{142}$

Coulomb excitation: Li 1993Mc07,2000Gu22

Level Scheme (continued)

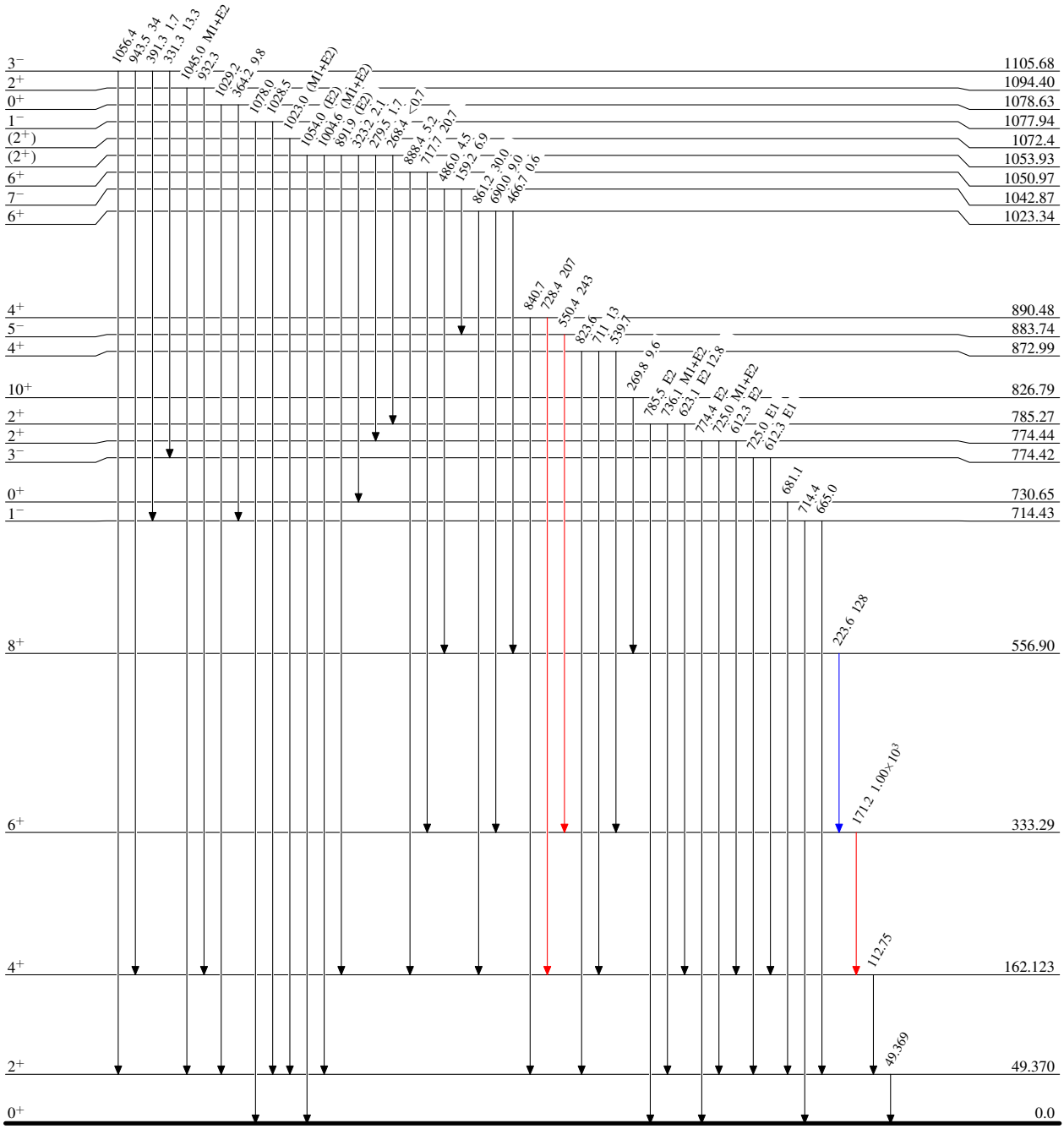
Intensities: Relative $I_{(\gamma+ce)}$

Legend

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

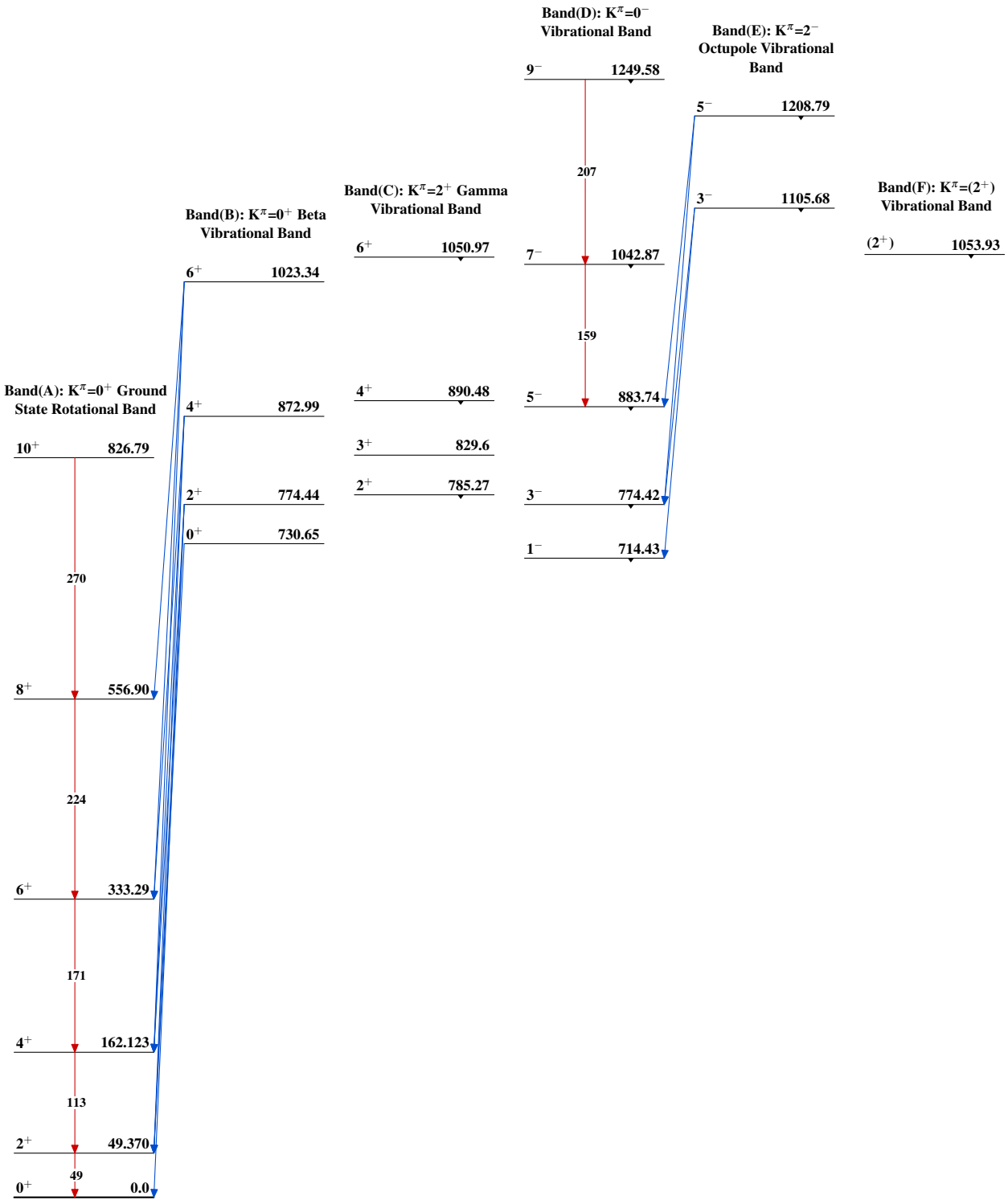
$I_\gamma < 10\% \times I_\gamma^{max}$

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



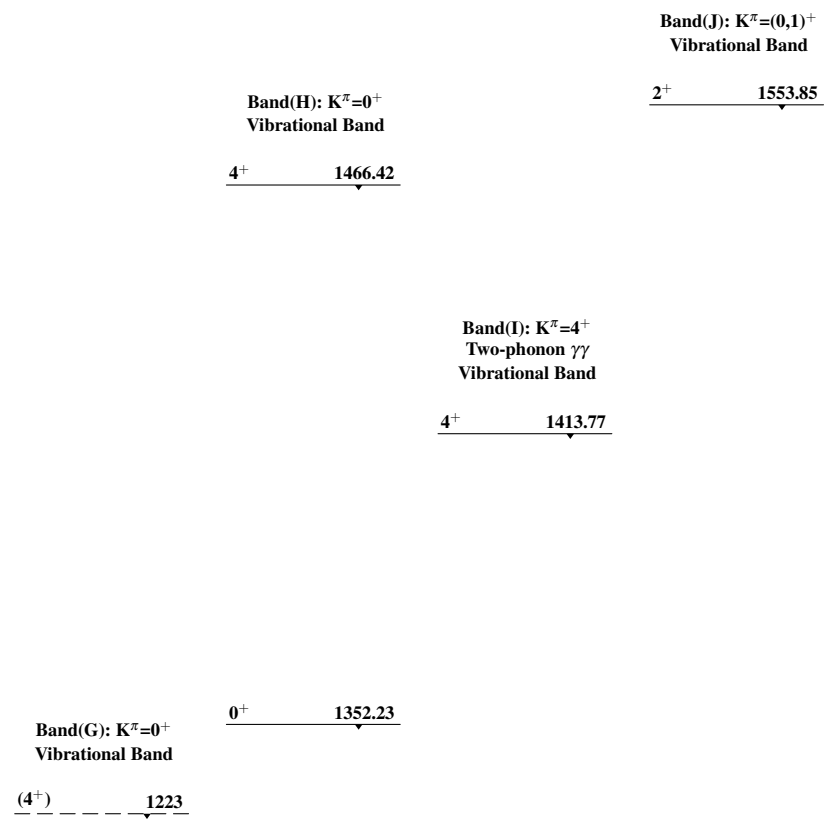
$^{232}_{90}Th_{142}$

Coulomb excitation: Li 1993Mc07,2000Gu22



$^{232}_{90}Th_{142}$

Coulomb excitation: Li 1993Mc07,2000Gu22 (continued)



$^{232}_{90}Th_{142}$