Coulomb excitation: HI

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

Coulomb excitation through heavy ions.

1102-MeV ^{208}Pb beam on ^{232}Th target. Measured gammas, Ge(Li) in coin with ^{208}Pb and ^{232}Th recoils, position-sensitive detectors. g.s. band measured up to 28^+, $K^\pi=0^-$ band observed up to 25^- (1980Ow01,1982Ow01).

1299-MeV ^{232}Th beam on ^{208}Pb target; g.s. band to 30^+ and octupole band to 27^- were measured (1982Si03).

370- and 450-MeV Kr beam on ^{232}Th. Gammas, Ge(Li), scattered Kr Si(β_0); $\gamma\gamma$(coin). g.s. band measured up to 20^+, $K^\pi=0^-$ band measured up to 21^- (1977Br40,1974Co07).

152-MeV ^{40}Ar Doppler-shift recoil-distance, Ge(Li) Si(Li). g.s. band 4^+ to 10^+ measured (1975Jo07).

^{232}Th(^{84}Kr,^{84}Kr′γ) E=385 MeV, ^{232}Th(^{136}Xe,^{136}Xe′γ) E=595,623 MeV. Doppler-lineshape and recoil-distance $T_{1/2}$ measured for g.s. band 6^+ through 18^+. Coul. ex. yields consistent with $T_{1/2}$ (1976Gu12).

μ: for g-factors up to 22^+ g.s. band, see 1982Ha03. Proton alignment above 16^+ deduced.

^{232}Th(^{32}S,^{32}S′γ) E=135 MeV; β, γ and octupole bands were measured (1983Ge01).

^{232}Th(^{90}Zr,^{90}Zr′γ) E=396, 415 MeV; crystal ball spectrometer $\gamma\gamma$ coin, $\gamma(\theta)$; β, γ and two phonon γ bands were measured (1987KoZU,1989KoZZ).

^{232}Th(^{125}Te,^{125}Te′γ), E=3125 keV. Projectile Coulomb excited. Deduced γ-ray internal conversion between bound atomic states (2000Ca32).

^{232}Th(^{125}Te,^{125}Te′γ), E=3375 keV. Projectile Coulomb excited. Deduced level $T_{1/2\ 1/2}$, γ-ray internal conversion versus ionic change, γ-ray internal conversion dependence on charge state (1997At01,1995At01).

Others: 1992Ec01, 1996OsZZ, 2001JaZZ, 2002AbZV, 2003AbZZ.

^{232}Th Levels

E(level)[†]	J$^\pi$[b]	$T_{1/2}$[‡]	Comments
0[#]	0^+		
49.37[#] *1*	2^+		
162.12[#] *2*	4^+	164 ps *13*	$T_{1/2}$: Recoil-distance Doppler (1975Jo07).
333.2[#] *4*	6^+	62 ps *4*	$T_{1/2}$: Weighted average of 66 ps *5* (1975Jo07) and 58 ps *4* (1976Gu12).
556.9[#] *6*	8^+	24 ps *1*	$T_{1/2}$: Weighted average of 25.1 ps *23* (1975Jo07), 23.8 ps *13* (1976Gu12), and 20 ps *3* (1982Ow01). Excitation probability measured near Coulomb barrier for ^{232}Th(^{206}Pb,^{206}Pb′γ) (1986De36).
714.39 *15*	1^-		
730[&] *1*	0^+		
773.8[&] *7*	2^+		
774.1 *2*	3^-		
784.9[@] *6*	2^+		
826.7[#] *7*	10^+	10.3 ps *6*	$T_{1/2}$: Weighted average of 11.2 ps *17* (1975Jo07), 10.4 ps *6* (1976Gu12), and 9.5 ps *11* (1982Ow01).
829.1[@] *10*	3^+		
872.6[&] *8*	4^+		
883.5 *6*	5^-		
890.5[@] *6*	4^+		
959.3[@] *9*	5^+		
1023.1[&] *6*	6^+		
1042.6 *6*	7^-		
1049.9[@] *7*	6^+		
1052.6	(2)		
1077.6 *7*	1^-		
1107.2 *10*	3^-		

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Coulomb excitation: HI (continued)

^{232}Th Levels (continued)

E(level)[†]	J$^{\pi}$[b]	T$_{1/2}$[‡]	Comments
1121.7 *7*	(2$^+$)		
1136.8[#] *8*	12$^+$	5.6 ps *4*	T$_{1/2}$: Weighted average of 5.5 ps *4* (1976Gu12) and 5.8 ps *7* (1982Ow01).
1146.1[@] *16*	7$^+$		
1148.7			
1183.5 *7*	3$^-$		
1208.4 *10*	(5$^-$)		
1222[&] *1*	8$^+$		
1249.1 *7*	9$^-$		
1258.7?[@]	8$^+$		
1293.2 *10*			
1328.6 *10*			
1370[@]	9$^+$		
1414[a] *2*	4$^+$	2.2 ps *5*	T$_{1/2}$: Recoil-distance Doppler (1995Ko15).
1469?[&] *3*	10$^+$		
1482.0[#] *9*	14$^+$	3.1 ps *2*	T$_{1/2}$: Weighted average of 3.1 ps *2* (1976Gu12) and 3.1 ps (3) (1982Ow01).
1484.1 *11*	(5$^-$)		
1490[a]	(5$^+$)		
1498.4 *8*	11$^-$		
1511.9[@]	10$^+$		
1573[a] *1*	(6$^+$)		
1640?[@]	11$^+$		
1755.0[&]	12$^+$		
1780[a]	(7$^+$)		
1783.1[a] *12*	(8$^+$)		
1784.4 *9*	13$^-$		
1801.2[@]	12$^+$		
1858.3[#] *9*	16$^+$	2.3 ps *2*	T$_{1/2}$: Weighted average of 2.2 ps *2* (1976Gu12) and 2.7 ps *6* (1982Ow01).
2080.3[&]	14$^+$		
2101.3 *9*	15$^-$		
2117.3[@]	14$^+$		
2262.2[#] *11*	18$^+$	1.4 ps *2*	T$_{1/2}$: Weighted average of 1.3 ps *2* (1976Gu12) and 1.6 ps *4* (1982Ow01).
2440.7[&]	16$^+$		
2445.0 *11*	17$^-$		
2445.7[@]	16$^+$		
2691.1[#] *12*	20$^+$	1.2 ps *2*	T$_{1/2}$: Deduced by evaluator from B(E2)(18$^+$ to 20$^+$)=3.4 *5* (1982Ow01).
2766.6[@]	18$^+$		
2812.9 *15*	19$^-$		
2831.6[&]	18$^+$		
3130?[@]	20$^+$		
3143.8[#] *13*	22$^+$	0.79 ps *12*	T$_{1/2}$: Deduced by evaluator from B(E2)(20$^+$ to 22$^+$)=3.9 *6* (1982Ow01).
3203.5 *18*	21$^-$		
3249	20$^+$		
3616.1 *21*	23$^-$		
3620[#] *2*	24$^+$	1.1 ps *3*	T$_{1/2}$: Deduced by evaluator from B(E2)(22$^+$ to 24$^+$)=2.1 *7* (1982Ow01).
4049.9 *23*	25$^-$	0.6 ps *2*	T$_{1/2}$: Deduced by evaluator from B(E2)(24$^+$ to 26$^+$)=3.3 *13* (1982Ow01).
4117[#] *2*	26$^+$		
4506 *3*	27$^-$		
4633[#] *2*	28$^+$	0.2 ps *2*	T$_{1/2}$: Deduced by evaluator from B(E2)(26$^+$ to 28$^+$)=7 *6* (1982Ow01).
5163[#] *3*	(30$^+$)		

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Coulomb excitation: HI (continued)

^{232}Th Levels (continued)

† Deduced by evaluator from a least-squares fit to γ-ray energies.
‡ From 1975Jo07, 1976Gu12. The B(E2)′s are consistent with the rigid rotor theory. See also 1982Ow01 for B(E2) from 8^+ up to 28^+.
# g.s. band.
@ γ vibrational band (1979BrZG,1983Ge01,1987KoZU).
& β vibrational band (1979BrZG,1983Ge01,1987KoZU).
a Two phonon $K^\pi=4^+$ γγ vibrational band; γ decay to $K^\pi=2^+$ γ band (1989KoZZ, 1993Ko42).
b As given by the various authors in Coulomb Excitation. See Adopted Levels for evaluator's J^π assignments.

γ(^{232}Th)

E_γ†	I_γ#	E_i(level)	J_i^π	E_f	J_f^π	Mult.&	δ	α[a]	Comments
49.37 *1*		49.37	2^+	0	0^+	E2		334	
112.75 *2*		162.12	4^+	49.37	2^+	E2		6.82	
159.1‡ *5*		1042.6	7^-	883.5	5^-	E2			
171.1 *5*		333.2	6^+	162.12	4^+	E2			
206.5‡ *5*		1249.1	9^-	1042.6	7^-	E2			
223.5 *5*		556.9	8^+	333.2	6^+	E2			
243.1 *5*		2101.3	15^-	1858.3	16^+				
249.2‡ *5*		1498.4	11^-	1249.1	9^-	E2			
269.8 *5*		826.7	10^+	556.9	8^+	E2			
286.0‡ *5*		1784.4	13^-	1498.4	11^-	E2			
302.5 *5*		1784.4	13^-	1482.0	14^+				
310.2 *5*		1136.8	12^+	826.7	10^+	E2			
316.9‡ *5*		2101.3	15^-	1784.4	13^-	E2			
343.7‡ *5*		2445.0	17^-	2101.3	15^-	E2			
345.2 *5*		1482.0	14^+	1136.8	12^+	E2			
361.6‡ *5*		1498.4	11^-	1136.8	12^+				
367.8‡ *10*		2812.9	19^-	2445.0	17^-	E2			
376.3 *5*		1858.3	16^+	1482.0	14^+	E2			
390.6‡ *10*		3203.5	21^-	2812.9	19^-	E2			
≈395.3		1222	8^+	826.7	10^+				
403.9 *5*		2262.2	18^+	1858.3	16^+	E2			
412.6‡ *10*		3616.1	23^-	3203.5	21^-	E2			
422.4‡ *5*		1249.1	9^-	826.7	10^+				
428.9 *5*		2691.1	20^+	2262.2	18^+	E2			
433.8‡ *10*		4049.9	25^-	3616.1	23^-	E2			
452.7 *5*		3143.8	22^+	2691.1	20^+	E2			
456 *2*		4506	27^-	4049.9	25^-	E2			
466.1 *10*		1023.1	6^+	556.9	8^+	E2			B(E2)(466.1γ)/B(E2)(860.8γ)=12.7 *18*.
476 *1*		3620	24^+	3143.8	22^+	E2			
485.7‡ *5*		1042.6	7^-	556.9	8^+				
492.3 *10*		1049.9	6^+	556.9	8^+	E2			B(E2)(492.3γ)/B(E2)(888.8γ)>10.2.
497 *1*		4117	26^+	3620	24^+	E2			B(E2)=3.0 *12*.
516 *1*		4633	28^+	4117	26^+	(E2)			
≈524	7	1414	4^+	890.5	4^+	M1+E2@	1.4		
530.5 *20*		5163	(30^+)	4633	28^+	(E2)			
539.9 *10*		872.6	4^+	333.2	6^+	E2			B(E2)(539.9γ)/B(E2)(822.8γ)=10 *3*; the 539.9 γ ray was not reported in (n,n′γ).
550	19	1573	(6^+)	1023.1	6^+				

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Coulomb excitation: HI (continued)

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

E_γ[†]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	δ	Comments
550.4[‡] *5*		883.5	5^-	333.2	6^+			
558.1 *10*		890.5	4^+	333.2	6^+	E2		B(E2)(558.1γ)/B(E2)(841.3γ)=2.2 *7*; the 558γ was not reported in (n,n′γ).
≈585	34	1414	4^+	829.1	3^+	M1+E2[@]	<5	
612.0 *2*		774.1	3^-	162.12	4^+			
612.1[‡] *10*		773.8	2^+	162.12	4^+			
614	59	1573	(6^+)	959.3	5^+	M1+E2[@]	<6	
622.8 *10*		784.9	2^+	162.12	4^+			B(E2)(622.8γ)/B(E2)(784.8γ)=0.21 *10*.
628 *5*	59	1414	4^+	784.9	2^+	E2[@]		
637	63	1783.1	(8^+)	1146.1	7^+			
665.0 *2*		714.39	1^-	49.37	2^+			
680.6 *10*		730	0^+	49.37	2^+			
≈683	22	1573	(6^+)	890.5	4^+	(E2)[@]		
690.2 *10*		1023.1	6^+	333.2	6^+			
702.6[b] *10*		1258.7?	8^+	556.9	8^+			
≈710[b]		1042.6	7^-	333.2	6^+			B(E1)(485.9)/B(E1)(710)=0.02 *2* (1987Na05).
714.4 *2*		714.39	1^-	0	0^+			B(E1)(714.4)/B(E1)(665.0)=0.12 *2* (1987Na05).
716.3 *10*		1049.9	6^+	333.2	6^+			
≈722[b]		883.5	5^-	162.12	4^+			B(E1)(550.4)/B(E1)(722)=0.04 *3* (1987Na05).
724.7 *5*		774.1	3^-	49.37	2^+			B(E1)(724.7)/B(E1)(612.0)=0.08 *3* (1987Na05).
727.6 *10*		890.5	4^+	162.12	4^+			
735.5 *10*		784.9	2^+	49.37	2^+			
760	37	1783.1	(8^+)	1023.1	6^+	(E2)[@]		
773.4 *10*		773.8	2^+	0	0^+			
779.7		829.1	3^+	49.37	2^+			
784.8 *10*		784.9	2^+	0	0^+			
797.3 *10*		959.3	5^+	162.12	4^+			
812.7[b] *10*		1146.1	7^+	333.2	6^+			
812.7[b] *10*		1148.7		333.2	6^+			
822.8 *10*		872.6	4^+	49.37	2^+	E2		
841.3 *10*		890.5	4^+	49.37	2^+	E2		
860.8 *10*		1023.1	6^+	162.12	4^+	E2		
888.8 *10*		1049.9	6^+	162.12	4^+	E2		
888.8 *10*		1222	8^+	333.2	6^+			
≈912.5		1469?	10^+	556.9	8^+			
925.6[b] *10*		1258.7?	8^+	333.2	6^+			
986.6[b]		1148.7		162.12	4^+			
1003[b]		1052.6	(2)	49.37	2^+			
1022.0		1183.5	3^-	162.12	4^+			
1028.0		1077.6	1^-	49.37	2^+			Placed deexciting a 1078.4 (0^+) level by 1985Da21 in (n,n′γ).
1046.3		1208.4	(5^-)	162.12	4^+			
1057.8		1107.2	3^-	49.37	2^+			
1072.2		1121.7	(2^+)	49.37	2^+			
1077.9		1077.6	1^-	0	0^+			
1121.8		1121.7	(2^+)	0	0^+			
1133.5		1183.5	3^-	49.37	2^+			
1150.9		1484.1	(5^-)	333.2	6^+			
1166.5		1328.6		162.12	4^+			
1243.8		1293.2		49.37	2^+			

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Coulomb excitation: HI (continued)

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

† From 1982Ow01, unless otherwise specified. Others: 1975Jo07, 1976Gu12, 1977Br40.
‡ From 1982Si03 (quoted in 1999Co02). ΔE values have been estimated by evaluators.
# From 1993Ko42.
@ From $\gamma(\theta)$ (1993Ko42).
& Based on $\gamma(\theta)$ and γ yields in multipole Coul. ex.
a Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
b Placement of transition in the level scheme is uncertain.

Coulomb excitation: HI

Level Scheme

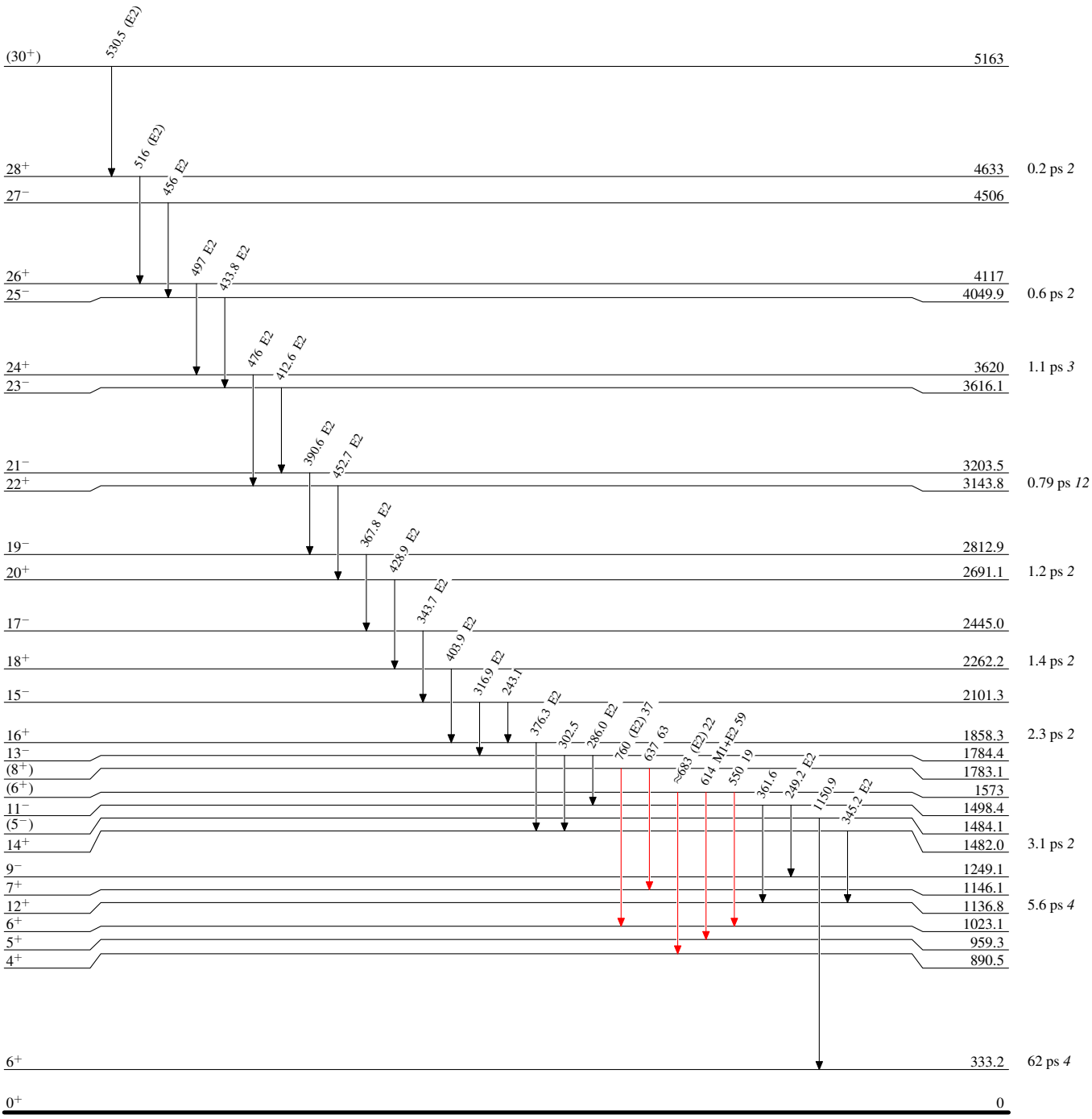
Intensities: Relative I_γ

Legend

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

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

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



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

Coulomb excitation: HI

Level Scheme (continued)

Intensities: Relative I_γ

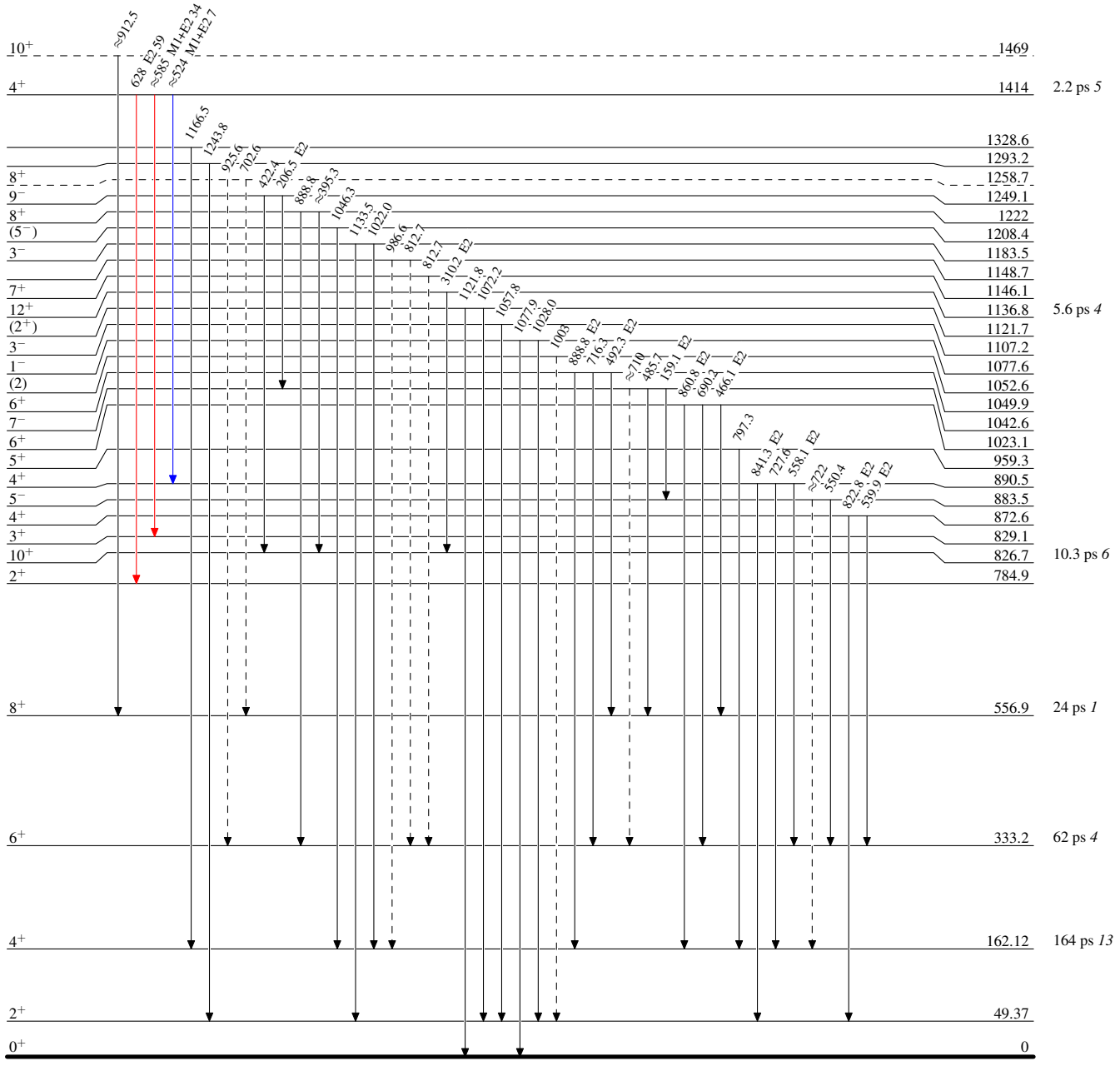
Legend

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

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

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

γ Decay (Uncertain)

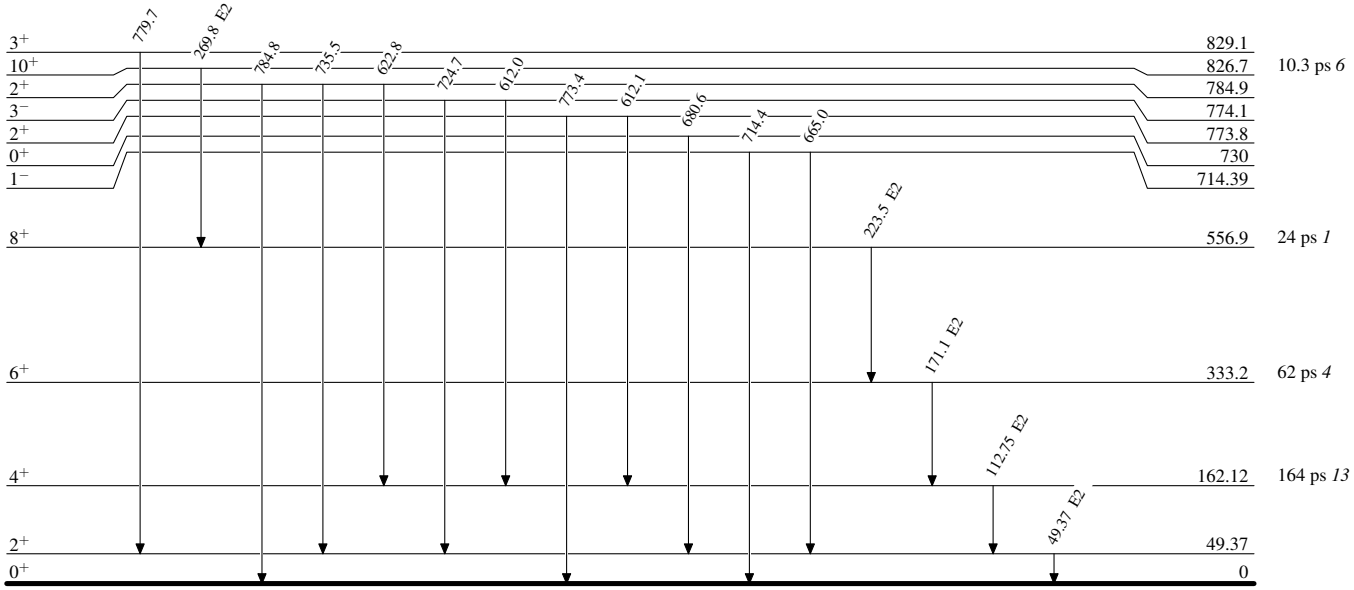


$^{232}_{90}Th_{142}$

Coulomb excitation: HI

Level Scheme (continued)

Intensities: Relative I_γ



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