Coulomb excitation 1996Wu07,2001Wu03

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh, [1] and Jun Chen[2]	NDS 169,1 (2020)	15-Oct-2020

1996Wu07 (also 1984WuZX): (^{40}Ca,^{40}Ca′γ); (^{58}Ni,^{58}Ni′γ); (^{136}Xe,^{136}Xe′γ); (^{208}Pb,^{208}Pb′γ) E=3.3-4.8 MeV/nucleon ^{40}Ca beam from Rochester tandem, ^{58}Ni from Rochester and BNL, ^{136}Xe and ^{208}Pb from SuperHILAC at LBNL. Measured Eγ, γ-ray yields, $\gamma\gamma$-coin with Ge detectors. Deduced 37 matrix elements from 338 experimental γ-ray yields from 14 independent Coulomb excitation experiments. The analysis utilized four lifetimes, 11 branching ratios and three mixing ratios from literature.

Additional information 1.

2001Wu03: (^{58}Ni,^{58}Ni′γ) E=275 MeV. Measured lifetimes by recoil-distance Doppler shift method.

Other measurements:

1992St06 (also 1996St22,1998St15): (^{58}Ni,^{58}Ni′γ) E=150 MeV. Measured g factor of first 2^+ state.

1985St05 (also 1987St14,1984St11): (^{58}Ni,^{58}Ni′γ) E=220 MeV. Measured g factors of first 2^+, second 2^+ and first 4^+ states by transient-field technique.

1980Ba42 (also 1978BaYK): (α,$\alpha'\gamma$) E=14.5 MeV, (^{16}O,^{16}O′γ) E=48 MeV, (^{32}S,^{32}S′γ) E=62 MeV, at University of Pittsburgh. Measured particle-γ-coin, γ yields. Deduced static quadrupole moments.

1976Ba06: (α,α') E=13-24 MeV at Rutgers. Measured excitation functions. Deduced deformation parameters, transition strengths.

1972La16 (also1971LaZO): (α,$\alpha'\gamma$) E=10, 12 and 14 MeV, (^{16}O,^{16}O′γ) E=36, 42 and 48 MeV, (^{32}S,^{32}S′γ) E=48, 52 and 56 MeV, at University of Pittsburgh. Measured particle-γ-coin, γ yields. Deduced B(E2), static quadrupole moment.

1972Si43 (also 1972Si03,1972SiYG): (^{16}O,^{16}O′γ) E=36 MeV. Measured $\gamma(\theta$,H), g factor.

1971Mi08 (also 1968MiZZ): (p,p′γ) E=4.56, 4.96, 5.08 MeV; (^{4}He,^{4}He′γ) E= 15.0 MeV; (^{16}O,^{16}O′γ) E=42.0, 45.1 and 45.5 MeV at ORNL. Measured γ yields, $\gamma(\theta)$. Deduced B(E2) values.

1970Pr09: (α,α') E=12 MeV, (^{16}O,^{16}O′γ) E=42 and 53 MeV, at University of Pittsburgh. Measured elastic and inelastic cross sections. Deduced B(E2), quadrupole moment.

1969Ca19 (also 1967Ca08): (^{16}O,^{16}O′γ) E=42-80 MeV at WNSL of Yale. Measured γ, $\gamma\gamma$-coin, particle $\gamma(\theta)$. Deduced B(E2) values. Values from 1969Ca19 supersede those in 1967Ca08 if available in both 1969Ro03: (p,p′γ) E=4.56-5.08 MeV; (α,$\alpha'\gamma$) E=15 MeV; (^{16}O,^{16}O′γ) E=42-45.5 MeV. Measured γ, particle γ coin.

1967Gi02 (also 1970Be36,1967As03,1966Go06,1964De07): (^{16}O,^{16}O′γ) E=35.4 MeV. Measured g factor by $\gamma(\theta$,H).

1961Mc18: (α,$\alpha'\gamma$) E not given, at ORNL. Measured γ yields, $\gamma(\theta)$. Deduced B(E2), spin.

1961Mc01: (p,p′γ) E=4.5, 5.0 MeV at ORNL. Measured γ yields. Deduced B(E2).

1961Re02: (p,p′) E=4.8 MeV at Rice University. Measured E(ce), ce yields. Deduced B(E2), conversion coefficients.

1958Mc02 (p,p′γ) E=3.0 MeV at ORNL. Measured γ yields. Deduced B(E2).

1957Mc43 (p,p′γ) E=3.0 MeV at ORNL. Measured $\gamma(\theta)$. Deduced spin.

1958Ba43, 1957Ba11: (p,p′) and (α,α').

1975Ro24: Q measurement. (^{16}O,^{16}O′γ) E=40 MeV.

1964Sp09: measured Q.

Relative population in (^{58}Ni,^{58}Ni′) at 220 MeV (1985St05)

Level	Relative Population
187	100
548	77
558	42
912	0.6
955	12
1050	12
1474	4
1667	3

Coulomb excitation 1996Wu07,2001Wu03 (continued)

^{190}Os Levels

B(E2) values under comments as quoted from 1996Wu07 are deduced by evaluators from E2 matrix elements in 1996Wu07.

E(level)	J^{π}[†]	$T_{1/2}$[‡]	Comments
0.0[@]	0^+		
186.7[@]	2^+	371 ps *+5−9*	g=+0.346 *15* (1992St06) Q=−0.99 *13* (1970Pr09) B(E2)↑=2.37 *+6−3* B(E2)↑: weighted average of 2.341 *+62−34* (1996Wu07), 2.48 *25* (1972La16), 2.37 *13* (1971Mi08), 2.39 *6* (1970Pr09), 2.50 *37* (1967Ca08), 2.53 *25* (1961Mc01), 2.72 *27* (1961Mc18), 2.55 *26* (1958Mc02), 2.5 *7* (1957Ba11). Other: 3.4 *4* (1961Re02). J^{π}: $\gamma(\theta)$ indicates spin=2 (1957Mc43,1961Mc18). $T_{1/2}$: weighted average of 374 ps *25* from 2001Wu03 and 369 ps *+5−9* from B(E2)=2.37 *+6−3*. Other: 0.47 ns *2* from 1967As03 by recoil distance seems discrepant. g: from transient−field technique (1992St06). Others: +0.338 *10* (reevaluated by 1987St14 from 0.350 *11* given in their earlier work (1985St05)) (transient-field technique); 0.33 *3* (1970Be36,1967Gi02, 1966Go06), +0.39 *3* (1972Si43,1972Si03). Q: others: −0.99 *19* (1977RuZY), −0.95 21 (1972La16), −0.95 *30* (1980Ba42, relative to Q=−1.47 for first 2^+ state in ^{188}Os), −0.8 *3* (1980Ba42, relative to Q=−1.33 for first 2^+ state in ^{188}Os), 1.08 *10* (1975Ro24, relative to 1.0 for first 2^+ state in ^{188}Os), 1.03 *30* (1964Sp09, relative to 1.0 for the first 2^+ state in ^{192}Os). Static E2 matrix element (187 to 187)=−1.25 *+22−13* (1996Wu07). E2 matrix element (from g.s.,0^+)=(+)1.530 *+20−11* (1996Wu07).
547.8[@]	4^+	13.6 ps *+4−7*	g=+0.39 *5* (1985St06) B(E2)↑=1.11 *+8−3* B(E2)↑: from 187,2^+, weighted average of 1.12 *+8−3* (1996Wu07), 1.19 *12* (1971Mi08), and 1.07 *10* (1969Ca19). $T_{1/2}$: weighted average of 12.8 ps *7* from 2001Wu03 by recoil distance, and 14.2 ps *+4−10* from B(E2)=1.11 *+8−3*. g: from ($\gamma(\theta$,H), transient fields) in 1985St05. Since the measurement was relative to g factor (187 level), value of 0.396 *47* given by 1985St05 has been adjusted (evaluators) for revised g factor(187 level)=0.346 (1992St06). Static E2 matrix element (548 to 548)=−1.28 *+27−19* (1996Wu07). E2 matrix element (from 187,2^+)=(+)2.37 *+8−3* (1996Wu07).
557.9[&]	2^+	14.9 ps *+7−8*	g=+0.34 *4* (1985St05) B(E2)↑=0.205 *+8−6* $T_{1/2}$: weighted average of 15.2 ps *14* from 2001Wu03 by recoil distance, and 14.8 ps *+7−8* from B(E2)(from g.s.)=0.205 *+8−6* and branching ratio %I(γ+ce)=57.9 *20* for 558γ deduced from the Adopted Iγ values. B(E2)↑: from g.s.,0^+, weighted average of 0.197 *+8−6*, 0.234 *14* (1971Mi08), 0.220 *20* (1969Ca19), B(E2)(from 187,2^+)=0.227 *+8−16* (1996Wu07), 0.270 *20* (1971Mi08), 0.245 *22* (1969Ca19). B(E2)(from 548,4^+)=0.004 *+7−3* (1996Wu07). E2 matrix element (from g.s.,0^+)=+0.444 *+9−7* (1996Wu07). E2 matrix element (from 187,2^+)=(+)1.065 *+20−37* (1996Wu07). E2 matrix element (from 548,4^+)=+0.19 *+12−9* (1996Wu07). Static E2 matrix element (558 to 558)=+1.53 *+6−31* (1996Wu07), +1.2 *5* (1980Ba42). g: from ($\gamma(\theta$,H), transient fields) in 1985St05. Since the measurement was relative to g factor (187 level), value of 0.344 *43* given by 1985St05 has been adjusted (evaluator) for revised g factor(187 level)=0.346 (1992St06). Q=0.9 *4* or 0.55 *30* from 1980Ba42, using Q(187 level)=−0.8.
756.0[&]	3^+		
911.7	0^+	14[#] ps *+4−3*	B(E2)(from 558,2^+)=0.030 *5* (1996Wu07). E2 matrix element (from 558,2^+)=(+)0.384 *+37−32* (1996Wu07).

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Coulomb excitation 1996Wu07,2001Wu03 (continued)

^{190}Os Levels (continued)

E(level)	J^{π}[†]	$T_{1/2}$[‡]	Comments
			E2 matrix element (from 187,2^+)=0.119 *10* (1996Wu07) obtained by using branching ratios from literature.
955.3[&]	4^+	7.7 ps *6*	$T_{1/2}$: others: 6.7 ps *4* from B(E2)(from 558,2^+)=0.70 *3* and 7.5 ps *6* from B(E2)(from 187,2^+)=0.0082 *+6−5*, with %I(γ+ce) branching ratios for 397γ and 769γ deduced from the Adopted Iγ values. B(E2)(from 187,2^+)=0.0082 *+6−5* (1996Wu07), 0.0187 *37* (1969Ca19). B(E2)(from 558,2^+)=0.70 *3* (1996Wu07), 0.88 *18* (1969Ca19). B(E2)(from 548,4^+)=0.229 *14* (1996Wu07), 0.36 *7* (1969Ca19). E2 matrix element (from 187,2^+)=+0.230 *7* (1996Wu07). E2 matrix element (from 548,4^+)=+1.44 *4* (1996Wu07). E2 matrix element (from 558,2^+)=(+)1.87 *4* (1996Wu07). Static E2 matrix element (955 to 955)=−1.29 *+20−25* (1996Wu07).
1050.3[@]	6^+	2.36 ps *14*	$T_{1/2}$: other: 2.60 ps *11* from B(E2)=0.98 *+4−3* from 1996Wu07. B(E2)(from 548,4^+)=0.98 *+4−3* (1996Wu07). Other: 1.50 *23* (1969Ca19). B(E2)(from 955,4^+)=0.048 *+46−11* (1996Wu07). Static E2 matrix element (1050 to 1050)=−0.91 *+24−15* (1996Wu07). E2 matrix element (from 548,4^+)=(+)2.97 *+6−4* (1996Wu07). E2 matrix element (from 955,4^+)=+0.66 *+26−8* (1996Wu07).
1163.1	4^+	8.6 ps *16*	$T_{1/2}$: other: 6.2 ps *+11−8* from B(E2)(from 558,2^+)=0.119 *15* and adopted branching ratios. B(E2)(from 187,2^+)=0.00054 *+11−13* (1996Wu07). B(E2)(from 548,4^+)=0.0044 (1996Wu07). B(E2)(from 558,2^+)=0.119 *15* (1996Wu07). B(E2)(from 955,4^+)=0.28 *+4−6* (1996Wu07). E2 matrix element (from 187,2^+)=+0.052 *+5−7* (1996Wu07). E2 matrix element (from 548,4^+)=[−0.2,0.2] (1996Wu07). E2 matrix element (from 558,2^+)=(+)0.77 *5* (1996Wu07). E2 matrix element (from 756,3^+)=(−)1.55 *+7−40* (1996Wu07) obtained by using branching ratio in literature. E2 matrix element (from 955,4^+)=+1.59 *+11−17* (1996Wu07). Static E2 matrix element (1163 to 1163)=+1.02 *+18−4* (1996Wu07).
1474.1[&]	(6^+)	2.78 ps *25*	$T_{1/2}$: other: 2.3 ps *+6−4* from B(E2)(from 955,4^+)=0.75 *+7−10* and adopted branching ratios. B(E2)(from 548,4^+)=0.0042 *40* (1996Wu07). B(E2)(from 955,4^+)=0.75 *+7−10* (1996Wu07). B(E2)(from 1050,6^+)=0.24 *+6−4* (1996Wu07). E2 matrix element (from 548,4^+)=+0.20 *7* (1996Wu07). E2 matrix element (from 955,4^+)=(+)2.60 *+12−16* (1996Wu07). E2 matrix element (from 1050,6^+)=+1.76 *+20−15* (1996Wu07). Static E2 matrix element (1474 to 1474)=−0.80 *+47−27* (1996Wu07).
1666.6[@]	8^+	0.71 ps *10*	$T_{1/2}$: 0.78 ps *4* from B(E2). B(E2)(from 1050,6^+)=1.06 *+6−5* (1996Wu07). Static E2 matrix element (1667 to 1667)=−0.94 *+49−41* (1996Wu07). E2 matrix element (from 1050,6^+)=(+)3.72 *10* (1996Wu07).
1836.3	(6^+)		
2090.1[&]	(8^+)	1.6[#] ps *+3−4*	B(E2)(from 1474,6^+)=0.52 *+15−7* (1996Wu07). E2 matrix element (from 1474,6^+)=(+)2.60 *+39−19* (1996Wu07). Static E2 matrix element (2090 to 2090)=−1.05 *+62−38* (1996Wu07).
2357.5[@]	(10^+)	0.48[#] ps *+11−9*	B(E2)(from 1667,8^+)=0.93 *+22−17* (1996Wu07). E2 matrix element (from 1667,8^+)=(+)3.98 *4* (1996Wu07). Static E2 matrix element (2357 to 2357)=[−1.9,−0.7] (1996Wu07).
2772.1[&]	(10^+)		
3011.5	(12^+)	<1.9[#] ps	B(E2)(from 2357,10^+)=0.32 to 0.76 (1996Wu07). E2 matrix element (from 2357,10^+)=[2.6,4.0] (1996Wu07).

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Coulomb excitation 1996Wu07,2001Wu03 (continued)

^{190}Os Levels (continued)

E(level)	J^{π}[†]	$T_{1/2}$[‡]	Comments
			$T_{1/2}$: 0.7 ps to 1.9 ps from B(E2).
3126.5[@]	(12^+)	<4.8[#] ps	B(E2)(from 2357,10^+)=0.048 to 0.55 (1996Wu07). E2 matrix element (from 2357,10^+)=[1.0,3.4] (1996Wu07). $T_{1/2}$: 0.4 ps to 4.8 ps from B(E2).

[†] From the Adopted Levels.
[‡] From recoil-distance Doppler-shift attenuation method (2001Wu03), unless otherwise stated.
[#] Deduced from B(E2) and adopted branching ratios.
[@] Band(A): g.s. band.
[&] Band(B): γ band.

Coulomb excitation **1996Wu07,2001Wu03 (continued)**

$\gamma(^{190}Os)$

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]	δ[#]	α[&]	Comments
186.7	2^+	186.7		0.0	0^+	E2		0.425	Mult.: MK/L=1.23 *20*; (M+N)/L=0.30 *6* (1961Re02). A_2=+0.330 *15* (1957Mc43). $\gamma(\theta)$ is also measured but data are given by 1961Mc18.
547.8	4^+	361.1		186.7	2^+	E2		0.054	
557.9	2^+	(10.1)		547.8	4^+	[E2]		7.0×10^4	Iγ(10.1γ)/Iγ(558)<7×10^{-10}.
		371.2	75 *4*	186.7	2^+	E2+M1	−11 *+6−4*	0.051 *3*	δ: from A_2=−0.28 *5*, A_4=−0.47 *7* (1969Ca19). Others: −8.6 *+11−23* from E2 and M1 matrix elements (1996Wu07), −8.5 *+3−2* from A_2=−0.156 *18* (1971Mi08). B(M1)=0.00029 *+6−10* (1996Wu07), 0.00036 *+25−16* (1971Mi08); M1 matrix element (from 558,2^+ to 187,2^+)=−0.038 *+4−7* (1996Wu07).
		557.9	100	0.0	0^+	E2			Iγ(558)/Iγ(371)=1.38 *7* (1969Ca19), 1.27 (1985St05).
756.0	3^+	569.3		186.7	2^+				
911.7	0^+	353.9		557.9	2^+	(E2)		0.06	
		725.0		186.7	2^+	E2			
955.3	4^+	397.4	100 *4*	557.9	2^+	E2		0.042	Iγ(397)/Iγ(371)=0.17 *5* (1969Ca19).
		407.5	72 *4*	547.8	4^+	M1+E2	−3.4 *+6−9*	0.045 *3*	Iγ(407)/Iγ(371)=0.14 *4* (1969Ca19). δ: from the Adopted Gammas. Other: −3.5 *+7−19* from E2 and M1 matrix elements of 1996Wu07. B(M1)(925,4^+ to 548,4^+)=0.0022 *+10−13* (1996Wu07). M1 matrix element (from 925,4^+ to 548,4^+)=−0.14 *+3−5* (1996Wu07).
		768.6	31 *2*	186.7	2^+	E2			Iγ(769)/Iγ(407)/Iγ(397)=16/35/49 (1985St05). Iγ(769)/Iγ(371)=0.098 (1969Ca19).
1050.3	6^+	(95.0)	0.0012 *7*	955.3	4^+	[E2][@]		5.5	
		502.5	100 *4*	547.8	4^+	E2			
1163.1	4^+	207.9	2.0 *4*	955.3	4^+	[E2][@]		0.29	
		407.1	60 *15*	756.0	3^+	E2+M1[@]	−2.6 *+8−14*	0.049 *9*	
		605.2	100 *13*	557.9	2^+	E2			
		615.4	7.2	547.8	4^+	[E2][@]			
		976.4	5.0 *11*	186.7	2^+				
1474.1	(6^+)	423.8	17 *3*	1050.3	6^+	[E2][@]		0.035	
		518.8	100 *12*	955.3	4^+	[E2]			
		926.3	<20	547.8	4^+				
1666.6	8^+	616.3		1050.3	6^+	E2			
1836.3	(6^+)	673.2		1163.1	4^+				
2090.1	(8^+)	616		1474.1	(6^+)	[E2]			
2357.5	(10^+)	690.9		1666.6	8^+	[E2]			
2772.1	(10^+)	682		2090.1	(8^+)				

From ENSDF

$^{190}_{76}Os_{114}$-5

Coulomb excitation **1996Wu07,2001Wu03** **(continued)**

$\gamma(^{190}Os)$ (continued)

E_i(level)	J_i^π	E_γ[†]	E_f	J_f^π
3011.5	(12^+)	654	2357.5	(10^+)
3126.5	(12^+)	769	2357.5	(10^+)

[†] From 1996Wu07.
[‡] Deduced (by evaluators) from E2 matrix elements of 1996Wu07, assuming E2 for ΔJ=0, 1 transitions when δ is unknown. It should be pointed out, however, that some of the branching ratios given here may not be independent since 1996Wu07 used previously known branching ratios for some of the levels and therefore are not considered in the Adopted Gammas.
[#] From the Adopted Gammas, unless otherwise stated.
[@] Level $T_{1/2}$ (2001Wu03), B(E2)↑ (1996Wu07) and adopted branching ratio consistent with E2, but mixing ratio could not be calculated.
[&] 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.

From ENSDF

$^{190}_{76}Os_{114}$-6

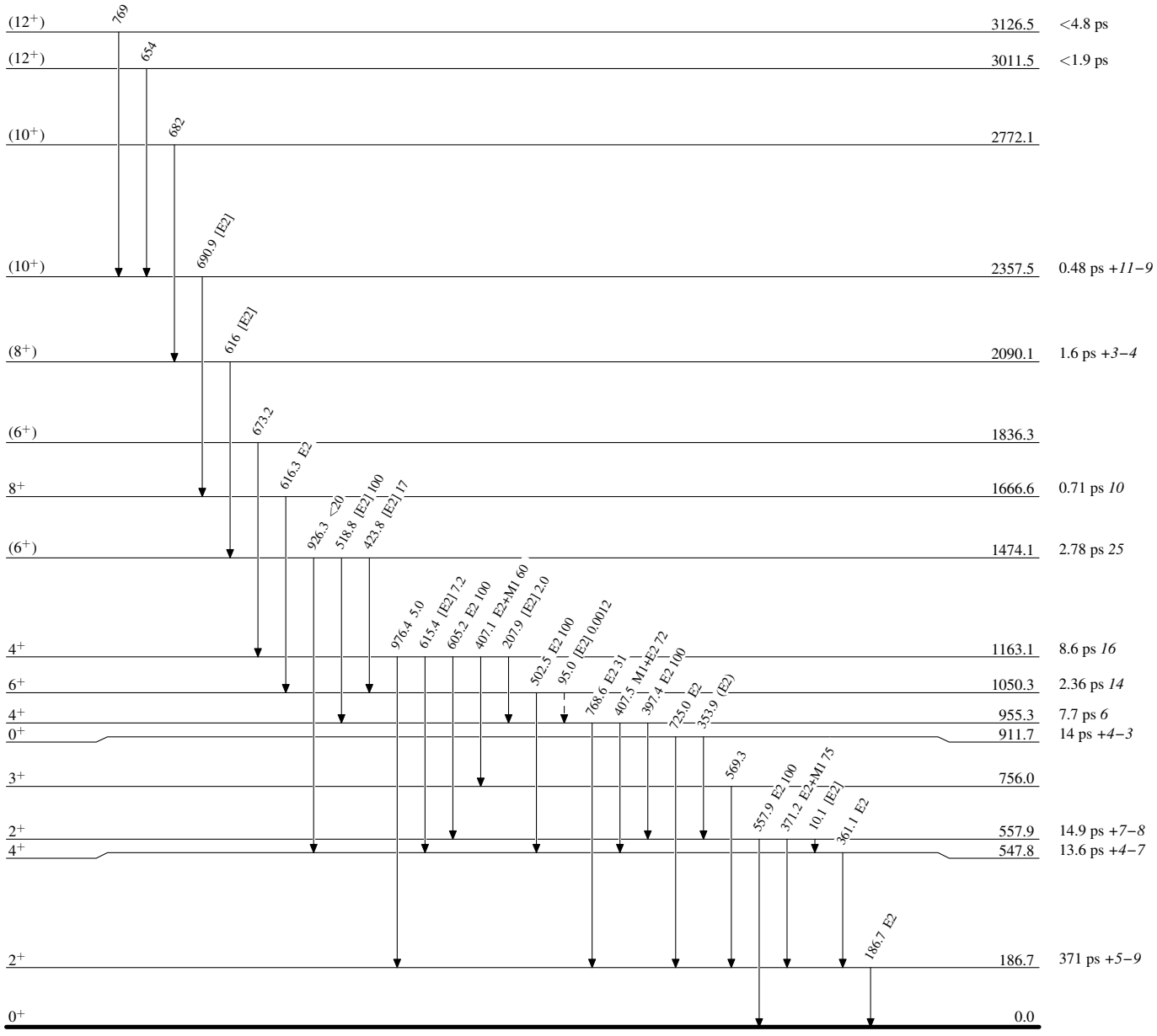
Coulomb excitation 1996Wu07,2001Wu03

Legend

Level Scheme

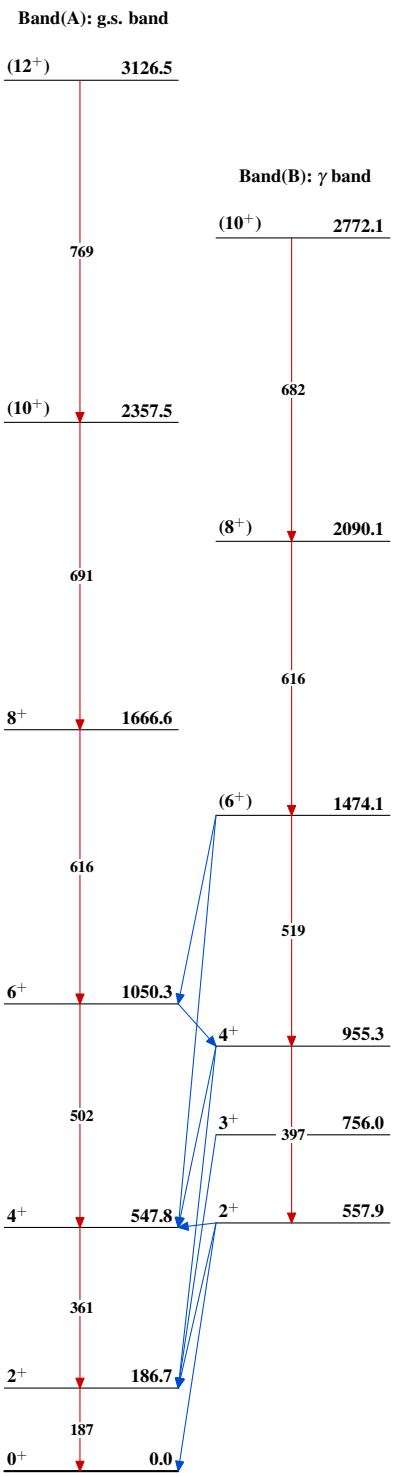
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{190}_{76}Os_{114}$

Coulomb excitation 1996Wu07,2001Wu03



$^{190}_{76}Os_{114}$