Coulomb excitation

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 127, 191 (2015)	1-Jun-2014

Additional information 1.

Other measurements: 2001Il01, 1975Gr23, 1973Ei02, 1971Mc21 (superseded by 1973Be44, priv. comm. from authors), 1971Fo17, 1966St24, 1963St10, 1963El06, 1961Sk01, 1961Re02, 1960Mc13, 1960Du10, 1959St40, 1957Ne07, 1956Da40.

Ratios of experimental to theoretical Coul. ex. probabilities for the g.s. rotational band via (^{40}Ar,^{40}Ar′) were calculated by 1973Ei02.

Multiple Coul. ex. probabilities for ^{238}U(^{84}Kr,^{84}Kr′) and ^{238}U(^{40}Ar,^{40}Ar′) were calculated by 1974Le24 and by 1975Ma16, respectively.

Coulomb nuclear interference for ^{238}U(^{40}Ar,^{40}Ar′γ) see 1978Gu03.

Coul. ex. probability for K=0 octupole band was calculated for ^{238}U(^{40}Ar,^{40}Ar′) and ^{238}U(^{86}Kr,^{86}Kr′) by 1978Do11.

Polarization potential for ^{238}U(^{40}Ar,^{40}Ar′) was calculated by 1977Lo15.

Vacuum polarization corrections for ^{238}U(^{230}Th,^{230}Th′) were calculated by 1976Ra08.

Coul. ex. σ for pair production for ^{238}U(^{238}U,^{238}U′) was calculated by 1976Ob02.

B(E2) values to 2$^+$ states of K=0$^+$,2$^+$ vibrational bands, and B(E3) values to 3$^-$ states of octupole-vibrational bands (K=0$^-$,1$^-$,2$^-$) were calculated by 1971Ko31. B(E3) values to octupole-vibrational band were also calculated by 1970Ne08. See 1972Ab10 for calculated B(E2) values to K=0$^+$ bands.

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238U(x,x'γ)     x=207Pb,   E=1400 MeV                               (2010Zh09)
238U(x,x'γ)     x=α,  E=19 MeV.                                     (2001Ga55)
181Ta(x,x'γ)    x=238U,   E=6 MeV/u                                 (1997Di05)
238U(x,x'γ)     x=181Ta,   208Pb,   232Th,   E=5.8, 5.9, 5.95 MeV/u  (1997Ah04)
238U(x,x'γ)     x=209Bi,   E=1130, 1330 MeV                         (1996Wa11)
181Ta(x,x'γ)    x=238U,   E=6 MeV/u                                 (1996Ho18)
238U(x,x'γ)     x=α,  E=18 MeV                                      (1994Mc03)
238U(x,x'γ)     x=208Pb,   E=4.7, 5.3 MeV/u                         (1981Gr10)
238U(x,x'γ)     x=α,  E=16, 17 MeV: x=16O,   E=51.2, 52 MeV         (1981Al02)
238U(x,x')     x=α,  E=16-18 MeV                          (1973Be44,1974Mc15)
238U(x,x'γ)     x=20Ne,   32S,   40Ar                     (1966St24,1967Di07)
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^{238}U Levels

Assignment of rotational bands is that given in 1996Wa11, based on work of those authors and on earlier work referenced in 1996Wa11.

E(level)[†]	J$^\pi$	T$_{1/2}$[‡]	Comments
0.0[#]	0$^+$		
44.915[#] *13*	2$^+$	206 ps *3*	B(E2)↑=12.30 *15* (1973Be44) B(E2)↑: from 1973Be44. This value supersedes that of 11.70 *15* given in 1971Mc21 and 1971Fo17. Others: 13.2 *20* (1961Re02), 12.7 *7* (1961Sk01). T$_{1/2}$: from B(E2) with α=609. This value is the E2 theory value reduced by 2% (see 1987Ra01).
148.40[#] *4*	4$^+$		B(E4)↑=0.69 *37* (1973Be44)
307.3[#] *3*	6$^+$		
517.9[#] *4*	8$^+$	23 ps *3*	B(E2)(6$^+$ to 8$^+$)=4.7 *6* (1981Gr10).
680.17[@] *20*	1$^-$		B(E1)↑=0.00049 *17* (1981Al02) B(E1)↑: 1981Al02 give 0.00044 *13* for a positive M3/M1 matrix element, and 0.00053 *14* for a negative ratio.
732.06[@] *18*	3$^-$		B(E3)↑=0.57 *4* (1994Mc03)

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Coulomb excitation (continued)

^{238}U Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	Comments
			Other B(E3) values: 0.64 *6* (1974Mc15), 0.59 *5* (1981Al02).
775.7[#] *5*	10^+	9.0 ps *10*	B(E2)(8^+ to 10^+)=5.2 *6* (1981Gr10).
827.0[@] *5*	5^-		
927.3[g] *6*	(0^+)		
931.2[i] *4*	(1^-)		
950.5[&] *4*	2^-		
966.11[g] *4*	2^+		B(E2)=5.76×10^{-3} *35* (1994Mc03), 0.017 *7* (1974Mc15). J^π: Coulomb excitation. $\gamma(\theta)$(967γ,818γ) give J=2.
966.4[@] *4*	7^-		
997.23[h] *24*	0^+		E(level): 1994Mc03 report E=992 based on a weak 947γ assigned as the branch to the 45 level. 1967Di07 report E=993 based on Eγ=948, and E=993 for an E0 transition to the g.s. Given E(level)=997.23 as determined by 2001Ga55, one gets Eγ=952.3 for the transition to the 45 level. This transition would not be resolved from the 952 transition seen in β^- decay, Coulomb excitation, and (n,n$'\gamma$), but assigned to the 997.6 *3-* level. The 993 transition seen in the ce spectrum of 1967Di07 may correspond to the 992.3 E2+E0 transition from the 1037 *2+* level.
997.6[i] *3*	3^-		B(E3)↑=0.184 *18* (1994Mc03) B(E3)↑: other: 0.19 *3* (1981Al02), 0.24 *5* (1974Mc15).
1028[&]	4^-		
1037.24[h] *7*	2^+		B(E2)=0.066 *9* (1994Mc03), 0.063 *9* (1974Mc15) B(E2) others: 0.037 *15* (1981Al02); 0.048 *11*(1974ThZG). These authors do not include the E0 component in the 992γ. B(E2)(888.9γ)/B(E2)(1037.3γ)=1.50 *21* and B(E2)(992.3γ)/B(E2)(1037.3γ)<0.97 *11* (1981Al02).
1056[g]	4^+		
1060.27[d] *14*	2^+		B(E2)↑=0.133 *8*(1994Mc03) B(E2)↑: others: 0.145 *12* (1981Al02), 0.127 *9* (1974Mc15).
1076.4[#] *5*	12^+	4.4 ps *4*	B(E2)(10^+ to 12^+)=5.1 *5* (1981Gr10). $T_{1/2}$: weighted average of 4.5 ps *5* from B(E2) and 4.2 ps *6* from DSA (1981Gr10).
1105[c]	3^+		
1128.8[e] *3*	(2^-)		
1130.74[h] *24*	(4^+)		
1150.4[@] *5*	9^-		
1151[&]	6^-		
1163[d]	(4^+)		
1168	(4^+)		Assigned by 1994Mc04 as the 4^+ member of the K=2 γ-vibrational band; however, 1996Wa11 show that this band member has an energy of 1163.
1169.1[e] *3*	3^-		B(E3)↑=0.166 *23* (1994Mc03) B(E3)↑: others: 0.15 *2* (1981Al02), 0.28 *7* (1974Mc15).
1223.93 *25*	2^+		B(E2)↑=0.0123 *12* (1994Mc03) B(E2)↑: other: 0.022 *13* (1974Mc15). J^π: $\gamma(\theta)$(1224γ) gives J=2. Coulomb excitation.
1232[c]	5^+		
1269[h]	(6^+)		
1278.3	2^+		B(E2)↑=4.3×10^{-3} *4* (1994Mc03) J^π: $\gamma(\theta)$(1278γ, 1130γ) give J=2. Coulomb excitation.
1311[d]	6^+		
1318.0[&]	8^-		
1378.6[@] *5*	11^-		
1403[c]	7^+		
1414	2^+		B(E2)↑=5.5×10^{-3} *6* (1994Mc03) J^π: $\gamma(\theta)$(1414γ) gives J=2. Coulomb excitation.

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Coulomb excitation (continued)

^{238}U Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	Comments
1415.2[#] *6*	14^+	2.55 ps *20*	B(E2)(12^+ to 14^+)=5.1 *5* (1981Gr10). $T_{1/2}$: weighted average of 2.54 ps *23* from B(E2) and 2.56 ps *28* from DSA (1981Gr10).
1446[f]	(7^-)		
1504[d]	8^+		
1528[&]	10^-		
1530.1	2^+		B(E2)↑=1.05×10^{-2} *11* (1994Mc03) J^π: $\gamma(\theta)$(1382γ) gives J=2. Coulomb excitation.
1545.8[jk] *14*	8^+		
1619[c]	9^+		
1643[f]	(9^-)		
1649.0[@] *6*	13^-		
1741[d]	10^+		
1778[&]	12^-		
1782	2^+		B(E2)↑=0.0179 *18* (1994Mc03)
1786.7[jk] *15*	10^+		
1788.2[#] *7*	16^+	1.74 ps *13*	B(E2)(14^+ to 16^+)=3.9 *5* (1981Gr10). $T_{1/2}$: weighted average of 2.05 ps *27* from B(E2) and 1.66 ps *14* from DSA (1981Gr10).
1865[f]	(11^-)		
1875[c]	11^+		
1958.9[@] *6*	15^-		
2018[d]	12^+		
2033[b]	(12^+)		
2048.7[jk] *15*	12^+		
2066[&]	14^-		
2122[f]	(13^-)		
2170[c]	13^+		
2190.9[#] *7*	18^+	1.18 ps *11*	$T_{1/2}$: from DSA (1981Gr10).
2306.4[@] *7*	17^-		
2333[d]	14^+		
2346.4[jk] *16*	14^+		
2356[b]	(14^+)		
2389[&]	16^-		
2418[f]	(15^-)		
2502[c]	15^+		
2619.0[#] *8*	20^+	0.91 ps *8*	B(E2)(18^+ to 20^+)=4.4 *7* from yield data (1981Gr10). $T_{1/2}$: weighted average of 0.94 ps *13* from B(E2) and 0.90 ps *10* from DSA (1981Gr10).
2645[a]	(14^+)		
2675.2[jk] *17*	16^+		
2683[d]	16^+		
2689.0[@] *8*	19^-		
2712[b]	(16^+)		
2744[&]	18^-		
2751[f]	(17^-)		
2867[c]	17^+		
2991[a]	(16^+)		
3031.2[jk] *19*	18^+		
3065[d]	18^+		

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Coulomb excitation (continued)

^{238}U Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	Comments
3068.1[#] *9*	22$^+$	0.76 ps *10*	B(E2)(20$^+$ to 22$^+$)=3.9 *6* (1981Gr10). $T_{1/2}$: weighted average of 0.82 ps *13* from B(E2) and 0.69 ps *15* from DSA (1981Gr10).
3095[b]	(18$^+$)		
3104.0[@] *8*	21$^-$		
3120[f]	(19$^-$)		
3128[&]	20$^-$		
3264[c]	19$^+$		
3368[a]	(18$^+$)		
3411.2[jk] *22*	20$^+$		
3474[d]	20$^+$		
3502[b]	(20$^+$)		
3521[f]	(21$^-$)		
3535.1[#] *9*	24$^+$	0.51 ps *8*	B(E2)(22$^+$ to 24$^+$)=5.1 *8* (1981Gr10).
3538[&]	22$^-$		
3547.5[@] *9*	23$^-$		
3685[c]	21$^+$		
3773[a]	(20$^+$)		
3811.2[jk] *24*	22$^+$		
3906[d]	22$^+$		
3947[f]	(23$^-$)		
3971[&]	24$^-$		
4016[@]	25$^-$		
4017.9[#] *11*	26$^+$	0.40 ps *7*	B(E2)(24$^+$ to 26$^+$)=5.6 *10* (1981Gr10).
4127[c]	23$^+$		
4205[a]	(22$^+$)		
4232[jk] *3*	24$^+$		
4358[d]	24$^+$		E(level): autors (1996Wa11) show 4356 on the level scheme, but the only transition from this level is a 452γ to the 3906 level.
4393[f]	(25$^-$)		E(level): authors(1996Wa11) give E=4417; however, the deexciting transition to the 3947 level has Eγ=446, giving E(level)=4393.
4424[&]	26$^-$		
4503[@]	27$^-$		
4517.2[#] *14*	28$^+$	0.36 ps *9*	B(E2)(26$^+$ to 28$^+$)=5.1 *13* (1981Gr10).
4585[c]	25$^+$		
4677[jk] *3*	26$^+$		
4825[d]	26$^+$		E(level): authors show 4823 on the level scheme, but see comment on the 4359 level.
4895[&]	28$^-$		
5002[@]	29$^-$		
5034.9[#] *17*	30$^+$	<0.9 ps	B(E2)(28$^+$ to 30$^+$)>1.7 (1981Gr10).
5063[c]	27$^+$		
5144[jk] *3*	28$^+$		
5512[@]	31$^-$		
5581[#] *3*	32$^+$		E(level),J^π: From 2010Zh09.
6037[@] *3*	33$^-$		E(level),J^π: From 2010Zh09.
6146[#] *4*	34$^+$		E(level),J^π: From 2010Zh09.

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Coulomb excitation (continued)

^{238}U Levels (continued)

† 1997Ah04 and 1997Di05 both looked for evidence of internal pair production from levels with E≈1800. Neither sees evidence of ipc. 1997Ah04 report Eγ=1780 *2* with σ between 27 mb *3* and 34 mb *3* with a dependence on impact parameter and a variation with beam and target characteristic of Coulomb excitation. The cross section is about 8 times larger than that expected from the B(E2) given by 1994Mc03 for excitation of a 1782 *2+* level. 1997Di05 also see a γ peak at 1782; however, they report a σ of only 4.8 mb *8*. 1997Ah04 suggest that their 1782 peak may be a composite of several transitions to the g.s. band from a band with the same moment of inertia built on the 1782 level.

‡ From B(E2) data of 1981Gr10, except where noted otherwise.

Band(A): $K^{\pi}=0^{+}$ ground state band.

@ Band(B): $K^{\pi}=0^{-}$ octupole-vibrational band.

& Band(C): $K^{\pi}=1^{-}$. $\alpha=0$.

[a] Band(D): Unassigned, but possibly built on the 1414 or 1530 2^{+} levels.

[b] Band(E): Possibly associated with the 1037 *2+* level, assigned by 1994Mc03 as the second K=0 β-vibrational band.

[c] Band(F): $K^{\pi}=2^{+}$ γ-vibrational band. $\alpha=1$.

[d] Band(G): $K^{\pi}=2^{+}$ γ-vibrational band. $\alpha=0$.

[e] Band(H): $K^{\pi}=2^{-}$.

[f] Band(I): Probably associated with the octupole band built on the 1129 *2-* level, and thus probably $K^{\pi}=2^{-}$ with $\alpha=1$.

[g] Band(J): $K^{\pi}=0^{+}$.

[h] Band(K): $K^{\pi}=0^{+}$ second β-vibrational band.

[i] Band(L): $K^{\pi}=1^{-}$. $\alpha=1$.

[j] Band(M): band based on $J^{\pi}=8^{+}$, interpreted as a 2-phonon octupole band (2010Zh09).

[k] From 2010Zh09.

Coulomb excitation (continued)

$\gamma(^{238}U)$

E_γ[†]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	Comments
(41.4[&])		1169.1	3^-	1128.8	(2^-)	(E2)	Mult.: $\gamma(\theta)$ for the 1084 and 397 γ's from the 1129 *2-* level are consistent with the 1-3 correlation if the unobserved 41.4 transition is pure quadrupole.
44.915[c] *13*		44.915	2^+	0.0	0^+		
(51.8[b])		732.06	3^-	680.17	1^-		
(67.1[b])		997.6	3^-	931.2	(1^-)		
69		1232	5^+	1163	(4^+)		
78		1028	4^-	950.5	2^-		E_γ: shown in level scheme of 1996Wa11 with no energy label.
79		1311	6^+	1232	5^+		
92		1403	7^+	1311	6^+		
102		1504	8^+	1403	7^+		
103.50[c] *4*		148.40	4^+	44.915	2^+		
114		1619	9^+	1504	8^+		
122		1741	10^+	1619	9^+		
123		1151	6^-	1028	4^-		
127		1232	5^+	1105	3^+		
134		1875	11^+	1741	10^+		
143		2018	12^+	1875	11^+		
149		1311	6^+	1163	(4^+)		
153		2170	13^+	2018	12^+		
158.9[@] *4*	10.5 *11*	307.3	6^+	148.40	4^+		E_γ: other: 1994Mc03 report 158.8 *4*.
162		2333	14^+	2170	13^+		
163.9[h] *5*	3.3 *3*	1223.93	2^+	1060.27	2^+		E_γ,I_γ: not shown in 1994Mc03 but given in earlier private communication from the lead author.
167		1318.0	8^-	1151	6^-		
169		2502	15^+	2333	14^+		
170		1958.9	15^-	1788.2	16^+		
171		1403	7^+	1232	5^+		
172[a]	4.83	1169.1	3^-	997.6	3^-		
179[a]	5.14	1128.8	(2^-)	950.5	2^-		
182		2683	16^+	2502	15^+		
184[@]		1150.4	9^-	966.4	7^-		
184		2867	17^+	2683	16^+		
193		1504	8^+	1311	6^+		
197		1643	(9^-)	1446	(7^-)		
197		3065	18^+	2867	17^+		
198		1128.8	(2^-)	931.2	(1^-)		$I_{(\gamma+ce)}$: masked by an impurity line. $I\gamma(198\gamma)/I\gamma(1084\gamma)=0.18$ in ^{238}Pa β^- decay.
202.6[a]	1.83	1169.1	3^-	966.11	2^+	E1	
210		1528	10^-	1318.0	8^-		
210.6[@] *4*		517.9	8^+	307.3	6^+		
216		1619	9^+	1403	7^+		

Coulomb excitation (continued)

γ(^{238}U) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	Comments
218.6[a] *10*	2.53 *26*	950.5	2⁻	732.06	3⁻		
222		1865	(11⁻)	1643	(9⁻)		
228.1[@] *4*		1378.6	11⁻	1150.4	9⁻		
234		1649.0	13⁻	1415.2	14⁺		
234.5[a] *10*	3.0 *3*	966.11	2⁺	732.06	3⁻	(E1)	
237		1741	10⁺	1504	8⁺		
241[f]		1786.7	10⁺	1545.8	8⁺		
250		1778	12⁻	1528	10⁻		
251.1[a] *10*	2.52 *26*	931.2	(1⁻)	680.17	1⁻		
256		1875	11⁺	1619	9⁺		
257		2122	(13⁻)	1865	(11⁻)		
257.8[@] *4*		775.7	10⁺	517.9	8⁺		
258[a]	0.93	1223.93	2⁺	966.11	2⁺	(E2)	
259[f]		1786.7	10⁺	1528	10⁻		
262[f]		2048.7	12⁺	1786.7	10⁺		
270.3[a] *10*	2.3 *4*	950.5	2⁻	680.17	1⁻		
270.5[@] *4*		1649.0	13⁻	1378.6	11⁻		
271[f]		2048.7	12⁺	1778	12⁻		
273[a]	3.55	1223.93	2⁺	950.5	2⁻	E1	
277		2018	12⁺	1741	10⁺		
281[f]		2346.4	14⁺	2066	14⁻		
286.3[a] *10*	1.74 *14*	966.11	2⁺	680.17	1⁻	(E1)	
288		2066	14⁻	1778	12⁻		
293[a]	1.45	1223.93	2⁺	931.2	(1⁻)	E1	
296		1028	4⁻	732.06	3⁻		
296[a]	1.61	1223.93	2⁺	927.3	(0⁺)	E2	
296		2170	13⁺	1875	11⁺		
296		2418	(15⁻)	2122	(13⁻)		
298[f]		2346.4	14⁺	2048.7	12⁺		
300.6[@] *4*		1076.4	12⁺	775.7	10⁺		
302.3[@] *4*		1378.6	11⁻	1076.4	12⁺		E_γ: placement questioned by 1981Gr10 but confirmed by 1996Wa11.
305.5[a] *6*	8.8 *4*	1037.24	2⁺	732.06	3⁻	E1	
309.9[@] *4*		1958.9	15⁻	1649.0	13⁻		
315		2333	14⁺	2018	12⁺		
318.0[a] *10*	5.7 *3*	997.6	3⁻	680.17	1⁻	E2	
323		2356	(14⁺)	2033	(12⁺)		
323		2389	16⁻	2066	14⁻		
324		1151	6⁻	827.0	5⁻		
329[f]		2675.2	16⁺	2346.4	14⁺		

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Coulomb excitation (continued)

$\gamma(^{238}U)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]
332		2502	15+	2170	13+	
333		2751	(17−)	2418	(15−)	
338.8[@] 4		1415.2	14+	1076.4	12+	
346		2991	(16+)	2645	(14+)	
347.5[@] 4		2306.4	17−	1958.9	15−	
350		2683	16+	2333	14+	
352		1318.0	8−	966.4	7−	
354[a]	0.49	1414	2+	1060.27	2+	E2
355		2744	18−	2389	16−	
356		2712	(16+)	2356	(14+)	
356[f]		3031.2	18+	2675.2	16+	
357.5[a] 6	7.1 3	1037.24	2+	680.17	1−	
365		2867	17+	2502	15+	
368[f]		2675.2	16+	2306.4	17−	
369		3120	(19−)	2751	(17−)	
372.9[@] 4		1788.2	16+	1415.2	14+	
374.8[@] 4		1150.4	9−	775.7	10+	
377		1528	10−	1150.4	9−	
377		3368	(18+)	2991	(16+)	
380[f]		3411.2	20+	3031.2	18+	
382		3065	18+	2683	16+	
382.7[@] 4		2689.0	19−	2306.4	17−	
383		3095	(18+)	2712	(16+)	
384		3128	20−	2744	18−	
387[f]		2346.4	14+	1958.9	15−	
397.0[a] 10	3.75 19	1128.8	(2−)	732.06	3−	
397		3264	19+	2867	17+	
399		1778	12−	1378.6	11−	
400[f]		2048.7	12+	1649.0	13−	
400[f]		3811.2	22+	3411.2	20+	
400.6[a]	0.68	1530.1	2+	1128.8	(2−)	
401		3521	(21−)	3120	(19−)	
402.6[@] 4		2190.9	18+	1788.2	16+	
405		3773	(20+)	3368	(18+)	
408[f]		1786.7	10+	1378.6	11−	
408		3502	(20+)	3095	(18+)	
409		3474	20+	3065	18+	
410		3538	22−	3128	20−	
415.1[@] 4		3104.0	21−	2689.0	19−	

$^{238}_{92}U_{146}$-8

Coulomb excitation (continued)

γ(²³⁸U) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ	Comments
421		3685	21+	3264	19+			
421[f]		4232	24+	3811.2	22+			
426		3947	(23−)	3521	(21−)			
427.9[@] 4		2619.0	20+	2190.9	18+			
432		3906	22+	3474	20+			
432		4205	(22+)	3773	(20+)			
433		3971	24−	3538	22−			
437.0[a] 4	10.9 5	1169.1	3−	732.06	3−	M1+E2	+0.23 +12−9	δ: From 1994Mc03.
441		4127	23+	3685	21+			
443.6[@] 4		3547.5	23−	3104.0	21−			
445[f]		4677	26+	4232	24+			
446		4393	(25−)	3947	(23−)			
448.3[a] 4	14.4 6	1128.8	(2−)	680.17	1−			
448.9[@] 4		3068.1	22+	2619.0	20+			
449		966.4	7−	517.9	8+			
452		4358	24+	3906	22+			
453		4424	26−	3971	24−			
459		4585	25+	4127	23+			
467.0[@] 4		3535.1	24+	3068.1	22+			
467		4825	26+	4358	24+			
467[f]		5144	28+	4677	26+			
469		4016	25−	3547.5	23−			
471		4895	28−	4424	26−			
473		2122	(13−)	1649.0	13−			
477		5063	27+	4585	25+			
479		3547.5	23−	3068.1	22+			
480		1446	(7−)	966.4	7−			
481		4016	25−	3535.1	24+			
482.8[@] 6		4017.9	26+	3535.1	24+			
485		3104.0	21−	2619.0	20+			
487		1865	(11−)	1378.6	11−			
487		4503	27−	4016	25−			
489.0[a] 10	2.55 20	1169.1	3−	680.17	1−	E2		
493		1643	(9−)	1150.4	9−			
498.3[@]		2689.0	19−	2190.9	18+			E_γ: placement questioned by 1981Gr10, but confirmed by 1996Wa11.
499		5002	29−	4503	27−			
499.3[@] 8		4517.2	28+	4017.9	26+			
510		5512	31−	5002	29−			
517.7[@] 10		5034.9	30+	4517.2	28+			
518.3[@] 4		2306.4	17−	1788.2	16+			

$^{238}_{92}U_{146}$-9

Coulomb excitation (continued)

$\gamma(^{238}U)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	Comments
520.0[a] *6*	6.9 *4*	827.0	5^-	307.3	6^+	E1	
524[f]		6037	33^-	5512	31^-		
[x]530							
542[f]		5581	32^+	5034.9	30^+		
543.7[@] *4*		1958.9	15^-	1415.2	14^+		
546.7[a]	1.90	1278.3	2^+	732.06	3^-	E1	
564[a]	1.42	1530.1	2^+	966.11	2^+	(E2)	
565[f]		6146	34^+	5581	32^+		
572.4[@] *4*		1649.0	13^-	1076.4	12^+		
583.7[a] *3*	250 *5*	732.06	3^-	148.40	4^+	E1	α(K)exp=0.0053 *13* (2001Ga55) I_γ: Iγ/Iγ(687γ)=0.817 *11* (1981Al02).
599[a]	3.33	1530.1	2^+	931.2	(1^-)	E1	
602.9[@] *4*		1378.6	11^-	775.7	10^+		
632.6[@] *4*		1150.4	9^-	517.9	8^+		
635.3[a] *3*	48.9 *10*	680.17	1^-	44.915	2^+	[e]	α(K)exp=0.016 *4* (2001Ga55)
636[f]		1786.7	10^+	1150.4	9^-		
659.1 *2*		966.4	7^-	307.3	6^+		E_γ: from (n,n′γ). E=659 in Coulomb excitation, but no uncertainties are available for transitions from the 7^- level. Uncertainties are available for transitions from both lower and higher band members.
670[f]		2048.7	12^+	1378.6	11^-		
677		2867	17^+	2190.9	18^+		
678.4[a] *6*	13.7 *8*	827.0	5^-	148.40	4^+	E1	
680.2[a] *5*	38.6 *19*	680.17	1^-	0.0	0^+	[e]	α(K)exp=0.016 *5* (2001Ga55)
687.3[a] *3*	307 *6*	732.06	3^-	44.915	2^+	E1	
698[f]		2346.4	14^+	1649.0	13^-		
713		2502	15^+	1788.2	16^+		
716[f]		2675.2	16^+	1958.9	15^-		
724[f]		3031.2	18^+	2306.4	17^-		
749[a]	1.42	1056	4^+	307.3	6^+	E2	
749		3368	(18^+)	2619.0	20^+		
755		2170	13^+	1415.2	14^+		
793		1311	6^+	517.9	8^+		
798		1875	11^+	1076.4	12^+		
798.4[a]	1.91	1530.1	2^+	732.06	3^-	E1	
800		2991	(16^+)	2190.9	18^+		
818.1[a] *4*	21.6 *9*	966.11	2^+	148.40	4^+	(E2)	α(K)exp=0.012 *8* (2001Ga55) Mult.: α(K)exp agrees with mult=E2, but does not exclude E1.
843		1151	6^-	307.3	6^+		
843		1619	9^+	775.7	10^+		

From ENSDF

Coulomb excitation (continued)

$\gamma(^{238}U)$ (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[g]	Comments
849.1[a] *4*	71.3 *22*	997.6	3^-	148.40	4^+	E1		α(K)exp=0.0046 *27* (2001Ga55) Mult.: from α(K)exp.
855		1163	(4^+)	307.3	6^+			
857		2645	(14^+)	1788.2	16^+			
861[a]	1.22	1168	(4^+)	307.3	6^+	E2		
880		1028	4^-	148.40	4^+			
882		3502	(20^+)	2619.0	20^+			
882.3[a] *6*	4.2 *4*	927.3	(0^+)	44.915	2^+	E2		
885		1403	7^+	517.9	8^+			
886.6[a] *6*	19.1 *8*	931.2	(1^-)	44.915	2^+			
888.9[a] *3*	53.6 *11*	1037.24	2^+	148.40	4^+	E2		I_γ: $I\gamma/I\gamma(1037\gamma)$=0.69 *10* (1981Al02).
904		3095	(18^+)	2190.9	18^+			
905.8[a] *6*	4.8 *3*	950.5	2^-	44.915	2^+	E1		
908[a]	0.58	1056	4^+	148.40	4^+			
911.9[a] *4*	15.8 *9*	1060.27	2^+	148.40	4^+	E2		
921.19[d] *3*	13.0 *6*	966.11	2^+	44.915	2^+	E0+M1+E2	0.23 *4*	α(K)exp=0.191 *30* (2001Ga55) α: from α(K)exp and α/α(K)=1.19 (E0 theory). ρ^2=0.0099 *18* (2001Ga55). δ: δ(E2/M1)=+4.1 *+6−5* or −0.185 from $\gamma(\theta)$ (1994Mc03). Mult.: from α(K)exp and $\gamma(\theta)$.
924		2712	(16^+)	1788.2	16^+			
925		1232	5^+	307.3	6^+			
931[f]		2346.4	14^+	1415.2	14^+			
931.5[a] *6*	4.81 *24*	931.2	(1^-)	0.0	0^+			
941		2356	(14^+)	1415.2	14^+			
952.6[a] *4*	40.5 *9*	997.6	3^-	44.915	2^+	E1		α(K)exp=0.0045 *60* α(K)exp: private communication from the lead author of 2001Ga55. I_γ: $I\gamma(953\gamma)/I\gamma(849\gamma)$=0.71 *7* (1981Al02). Note that the B(E1) ratio given by the author is a misprint. The ratio should be inverted.
957		1105	3^+	148.40	4^+			
957		2033	(12^+)	1076.4	12^+			
962		1269	(6^+)	307.3	6^+			E_γ: reported only by 1967Di07 the evaluator has increased the author′s value by 2 keV. This adjustment is based on a comparison of other values of these authors compared with those of 1994Mc03.
966.5[a] *8*	5.9 *3*	966.11	2^+	0.0	0^+			
973[f]		2048.7	12^+	1076.4	12^+			
982.44[d] *24*		1130.74	(4^+)	148.40	4^+			E_γ: 1996Ho18 report 982.2 *4*.
992.31[d] *7*	54.5 *11*	1037.24	2^+	44.915	2^+	E0+M1+E2	0.78 *4*	α(K)exp=0.653 *33* (2001Ga55) Mult.: from α(K)exp and $\gamma(\theta)$. α: from α(K)exp and α/α(K)=1.19 (E0 theory).

$^{238}_{92}U_{146}$-11

Coulomb excitation (continued)

γ(^{238}U) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	Comments
								δ: δ(E2/M1)=+3.50 *+20−25* from γ(θ) (1994Mc03). ρ^2=0.175 *26* (2001Ga55), 0.176 *34* (1994Mc03). I_γ: Iγ/Iγ(1037γ)=0.70 *8* (1981Al02). This is the authors value from their B(E2) ratios as corrected for the M1 component of the 992γ.
997.23[d] *24*		997.23	0^+	0.0	0^+	E0		E_γ: from E(ce(K) to g.s.)-E(ce(K) 992.31γ from 1037 level)=4.92 *23* (2001Ga58). 1996Ho18 report 996.7 *6*. Mult.: seen in ce spectrum but not in photon spectrum (private communication from the lead author of 2001Ga55).
1004		1311	6^+	307.3	6^+			
1011[f]		1786.7	10^+	775.7	10^+			
1015		1163	(4^+)	148.40	4^+			
1015.3[a] *2*	443 *9*	1060.27	2^+	44.915	2^+	M1+E2	+10.0 *+15−14*	α(K)exp=0.0075 *7* (2001Ga55) Mult.: from α(K)exp and γ(θ). δ: δ=+10.0 *+15−14* or −0.34 from γ(θ) (1994Mc03). α(K)exp rules out the small solution. E_γ: 2001Ga55 also report 1015.2 *3*.
1019[a]	9.03	1168	(4^+)	148.40	4^+			
1021[a]	5.41	1169.1	3^-	148.40	4^+	E1		
1028[f]		1545.8	8^+	517.9	8^+			
1037.3[a] *3*	74.8 *16*	1037.24	2^+	0.0	0^+	E2		
1060		1105	3^+	44.915	2^+			
1060.3[a] *2*	309 *6*	1060.27	2^+	0.0	0^+	E2		I_γ: Iγ/Iγ(1015γ)=0.735 *26* (1981Al02).
1076[a]	0.63	1223.93	2^+	148.40	4^+	E2		
1084.0[a] *4*	11.6 *5*	1128.8	(2^-)	44.915	2^+	E1		
1084		1232	5^+	148.40	4^+			
1123	0.61	1168	(4^+)	44.915	2^+	E2		
1123[a]	2.94	1169.1	3^-	44.915	2^+	E1		
1130[a]	3.53	1278.3	2^+	148.40	4^+	E2		
1154		3773	(20^+)	2619.0	20^+			
1177		3368	(18^+)	2190.9	18^+			
1179.2[a] *4*	19.2 *8*	1223.93	2^+	44.915	2^+	M1+E2		δ: δ=+7.0 *+14−10* or −0.295 from γ(θ) (1994Mc03).
1203		2991	(16^+)	1788.2	16^+			
1223.7[a] *4*	20.0 *8*	1223.93	2^+	0.0	0^+	E2		
1233[a]	7.08	1278.3	2^+	44.915	2^+			
1278[a]	2.23	1278.3	2^+	0.0	0^+	E2		
1370[a]	11.3	1414	2^+	44.915	2^+			
1382[a]	7.98	1530.1	2^+	148.40	4^+	E2		
1414[a]	1.75	1414	2^+	0.0	0^+	E2		
1485[a]	3.03	1530.1	2^+	44.915	2^+	M1+E2		δ: δ=−30 *10* or −0.51 from γ(θ) (1994Mc03).
1530[a]	0.90	1530.1	2^+	0.0	0^+	E2		
1737[a]	9.72	1782	2^+	44.915	2^+	M1+E2	+11 *+19−4*	δ: From 1994Mc03.
1782[a]	7.86	1782	2^+	0.0	0^+			

$^{238}_{92}U_{146}$-12

Coulomb excitation (continued)

$\gamma(^{238}U)$ (continued)

† From 1996Wa11, unless otherwise noted.

‡ From 1994Mc03. Authors values of I(γ+ce) in units of excitations per nanocurie have been converted by the evaluator to photon intensities. The ΔJ=0,1, $\Delta\pi$=no transitions have been taken as E2, except where δ is known (priv comm from lead author). Uncertainties, where given, are from a 1987 priv. Comm. From the lead author. Other Iγ values, available as branching ratios from B(E2) ratios by 1981Al02, are included as comments. Additional branching ratios have been communicated to the evaluators by the lead author of 2001Ga55. These data are preliminary. For the 966 *2+* level, Iγ(818γ):Iγ(921γ):Iγ(967γ)=(21.6 *9*):11.1 *7*:8.5 *14*. For the 997 *3-* level, Iγ(953γ)/Iγ(849γ)=0.642 *32*. For the 1037 *2+* level, Iγ(889γ):Iγ(992γ):Iγ(1037γ)=46.6 *18*:62.1 *12*:(74.8 *19*). For the 1060 level, Iγ(912γ):Iγ(1015γ):Iγ(1060γ)=≤30:(443 *17*):267 *9*.

From $\gamma(\theta)$ of 1994Mc03, unless otherwise noted. The α(K)exp data are from 2001Ga55 based on relative Iγ and ICE(k) data normalized to α(K)(687γ, E1)=0.0060 *9*, α(K)(889γ, E2)=0.014 *5*, and α(K)(1060γ, E2)=0.0063 *7*.

@ From 1981Gr10.

& Not directly observed, but required to account for the yield of transitions from the J-1 member of this band (1994Mc03). Eγ is a rounded-off value based on adopted level energies.

[a] From 1994Mc03. Uncertainties, where given, are from a 1987 priv comm from the lead author.

[b] Not directly observed, but required to account for the yield of transitions from the J-2 member of this band (1994Mc03). Eγ is a rounded-off value based on adopted level energies 1987 private communication from the lead author.

[c] From adopted gammas. 1981Gr10 report 44.9 *4* and 103.5 *4* for the 2^+ to g.s. and 4^+ to 2^+ transitions, respectively. Adopted values are used so that advantage can be taken of the accurate Eγ values of 2001Ga55 for transitions to the 2^+ and 4^+ levels.

[d] From 2001Ga55.

[e] Anomalous E1 transition. α(K)exp is larger than E1 theory and agrees with E2 theory. Similar anomalous E1 transitions have been observed in ^{236}U. See 1983Fa15.

[f] From 2010Zh09.

[g] 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.

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

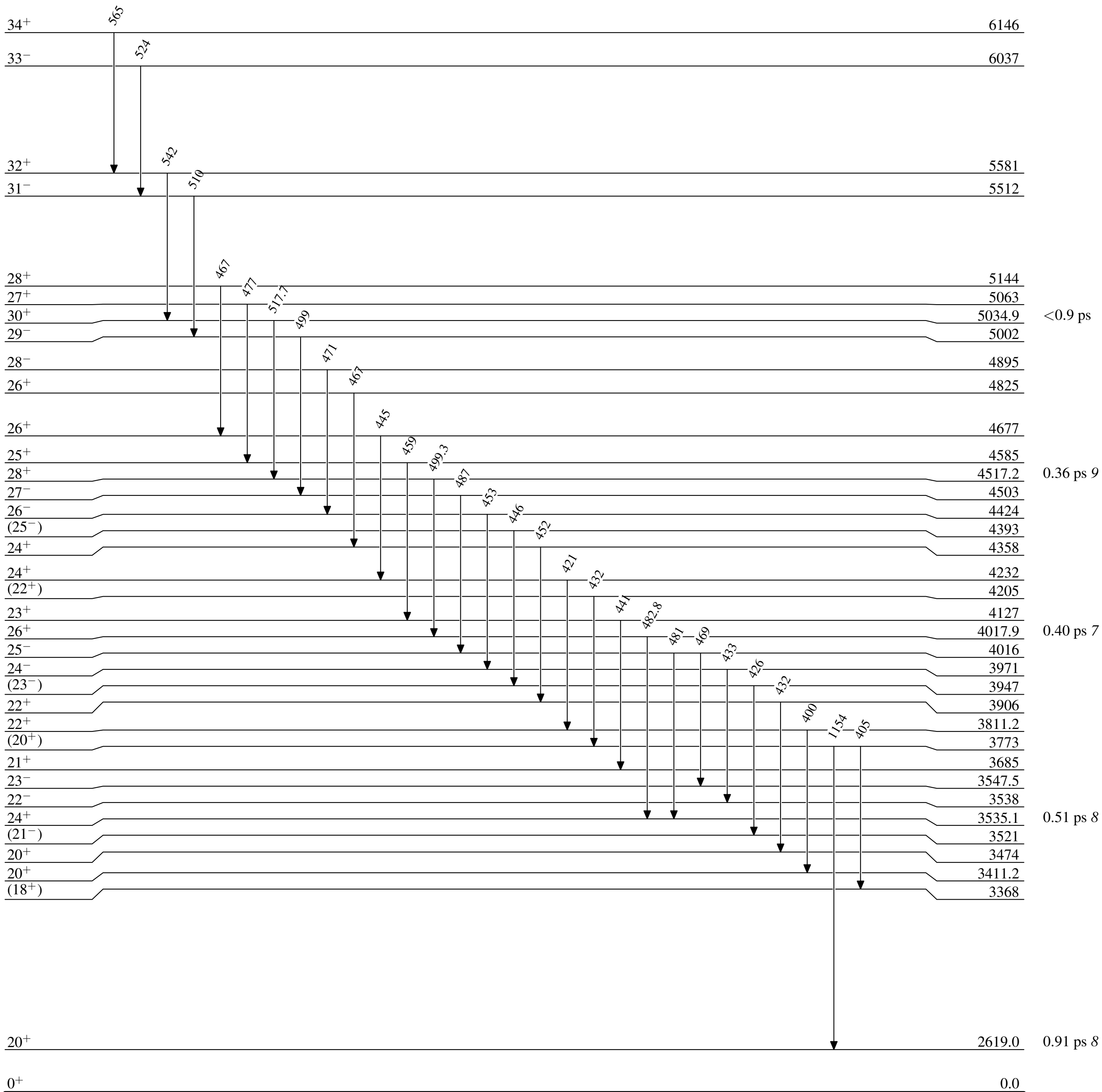
[x] γ ray not placed in level scheme.

$^{238}_{92}U_{146}$-13

Coulomb excitation

Level Scheme

Intensities: Relative I_γ

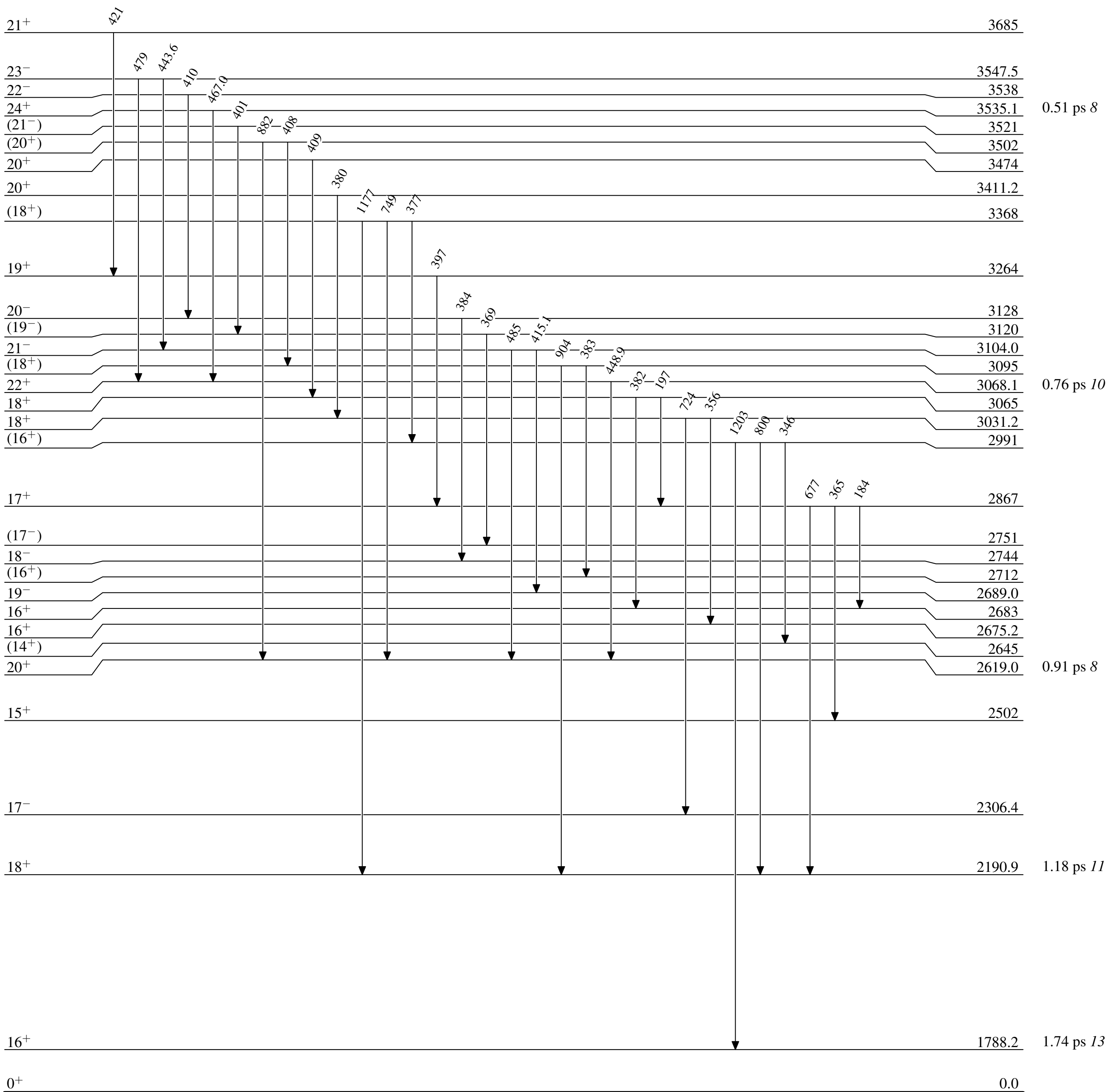


$^{238}_{92}U_{146}$

Coulomb excitation

Level Scheme (continued)

Intensities: Relative I_γ

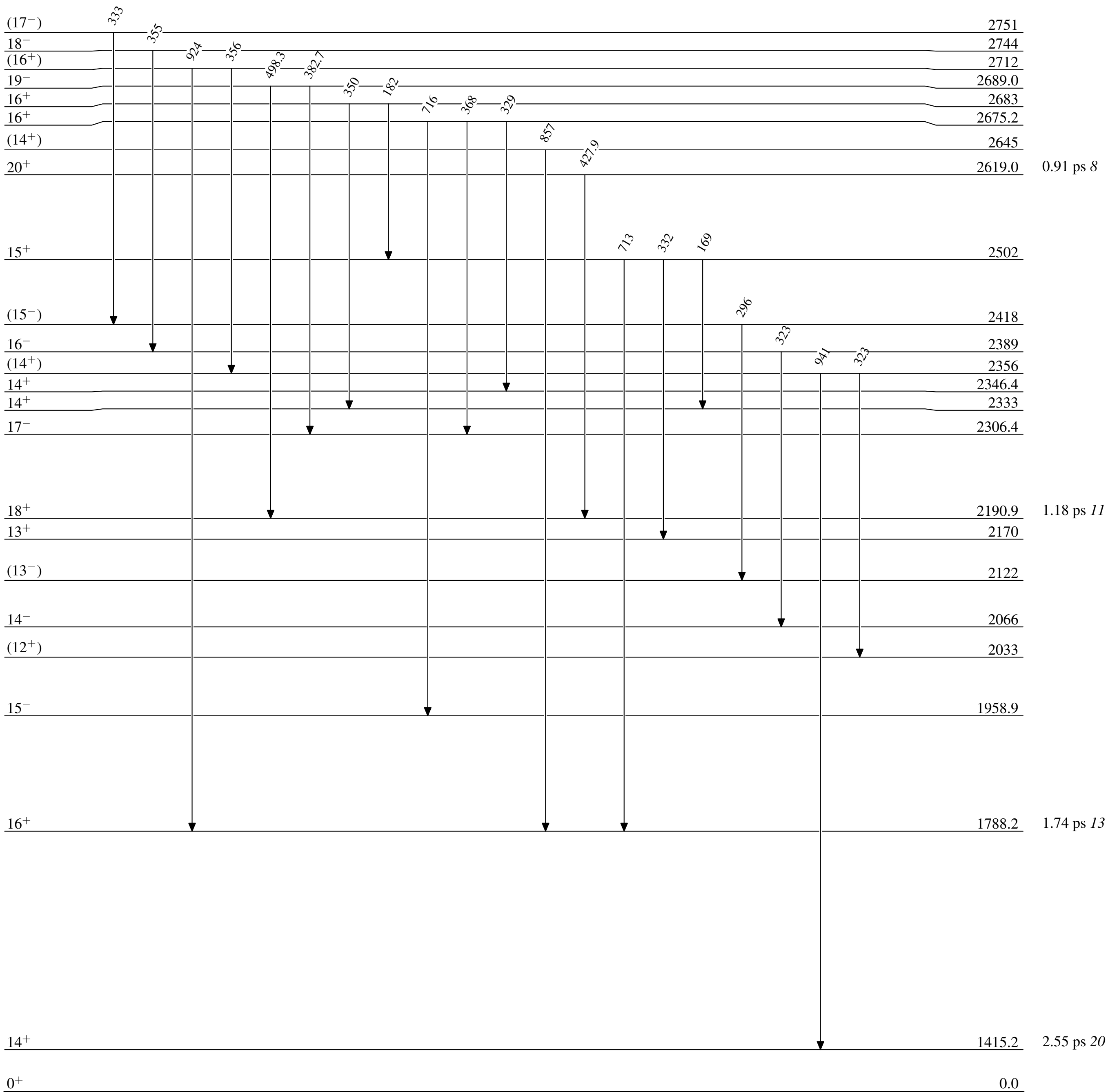


$^{238}_{92}U_{146}$

Coulomb excitation

Level Scheme (continued)

Intensities: Relative I_γ

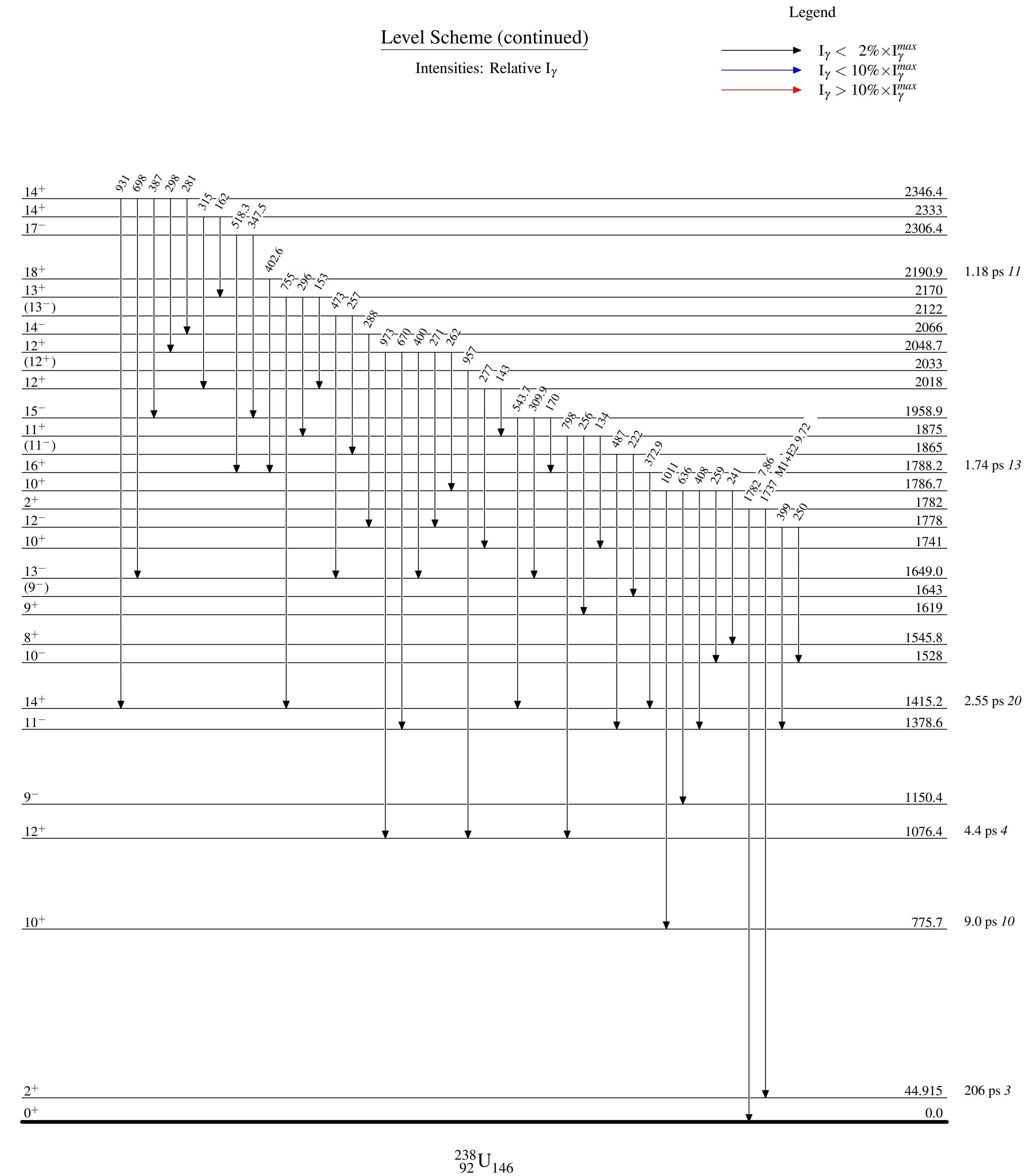


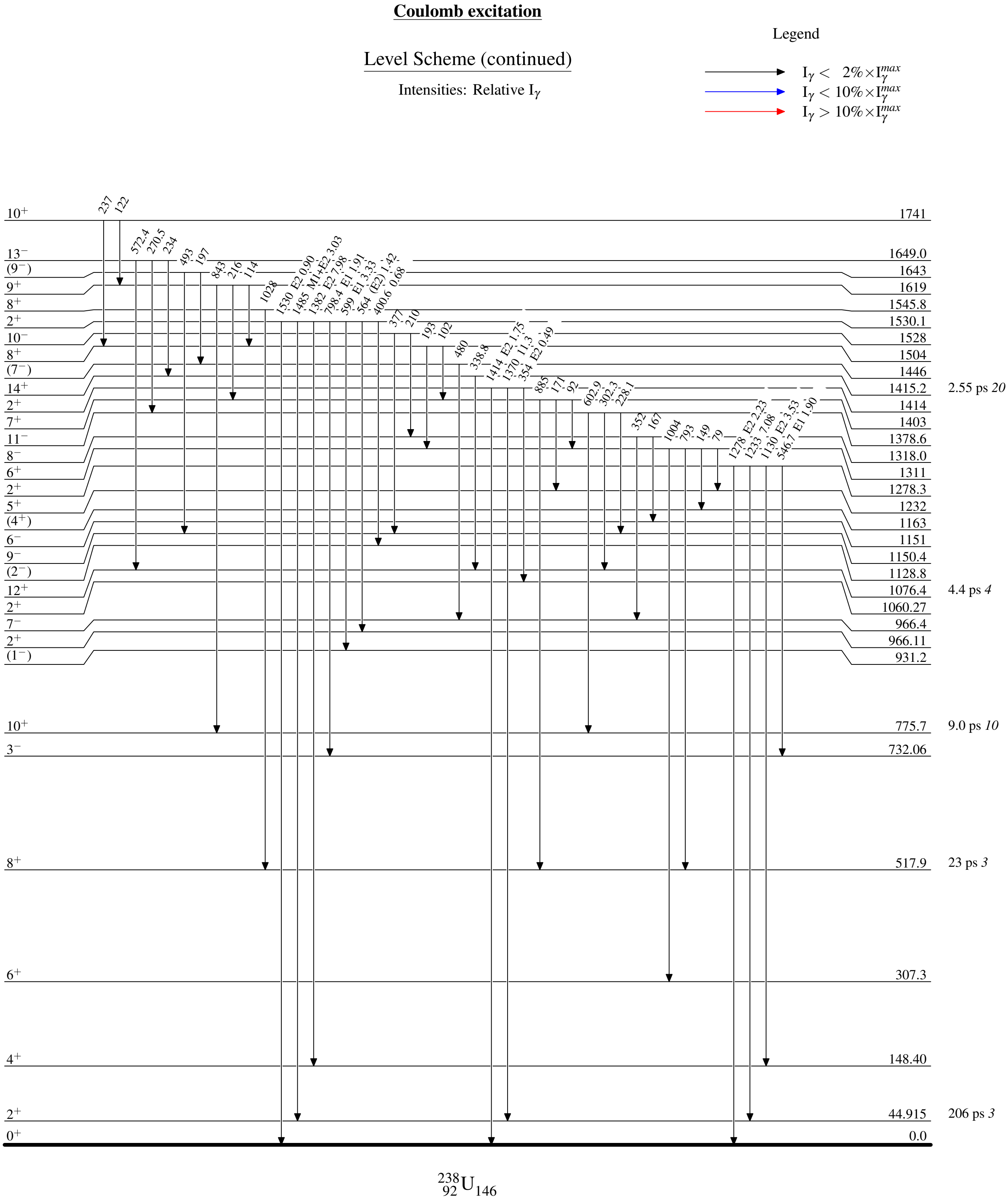
$^{238}_{92}U_{146}$

Coulomb excitation

Level Scheme (continued)

Intensities: Relative I_γ



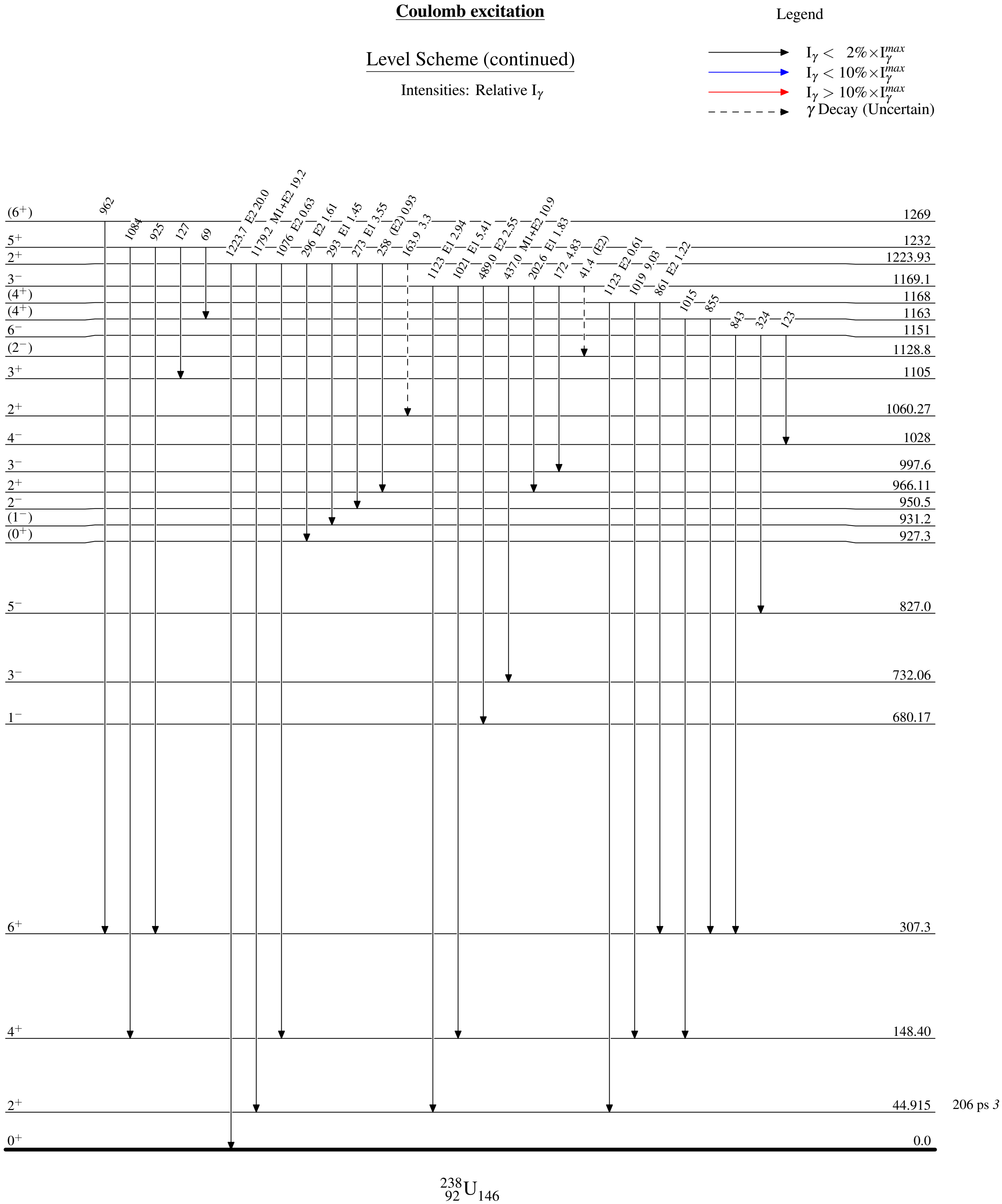

Coulomb excitation
Level Scheme (continued)
Intensities: Relative Iγ
Legend
Iγ < 2%×Iγmax
Iγ < 10%×Iγmax
Iγ > 10%×Iγmax
10+ 1741
13− 1649.0
(9−) 1643
9+ 1619
8+ 1545.8
2+ 1530.1
10− 1528
8+ 1504
(7−) 1446
14+ 1415.2 2.55 ps 20
2+ 1414
7+ 1403
11− 1378.6
8− 1318.0
6+ 1311
2+ 1278.3
5+ 1232
(4+) 1163
6− 1151
9− 1150.4
(2−) 1128.8
12+ 1076.4 4.4 ps 4
2+ 1060.27
7− 966.4
2+ 966.11
(1−) 931.2
10+ 775.7 9.0 ps 10
3− 732.06
8+ 517.9 23 ps 3
6+ 307.3
4+ 148.40
2+ 44.915 206 ps 3
0+ 0.0
237
122
572.4
270.5
234
493
197
843
216
114
1028
1530 E2 0.90
1485 M1+E2 3.03
1382 E2 7.98
798.4 E1 1.91
599 E1 3.33
564 (E2) 1.42
400.6 0.68
377
210
193
102
480
338.8
1414 E2 1.75
1370 11.3
354 E2 0.49
885
171
92
602.9
302.3
228.1
352
167
1004
793
149
79
1278 E2 2.23
1233 7.08
1130 E2 3.53
546.7 E1 1.90

$^{238}_{92}U_{146}$

Coulomb excitation

Level Scheme (continued)

Intensities: Relative I_γ



Coulomb excitation

Level Scheme (continued)

Intensities: Relative I_γ

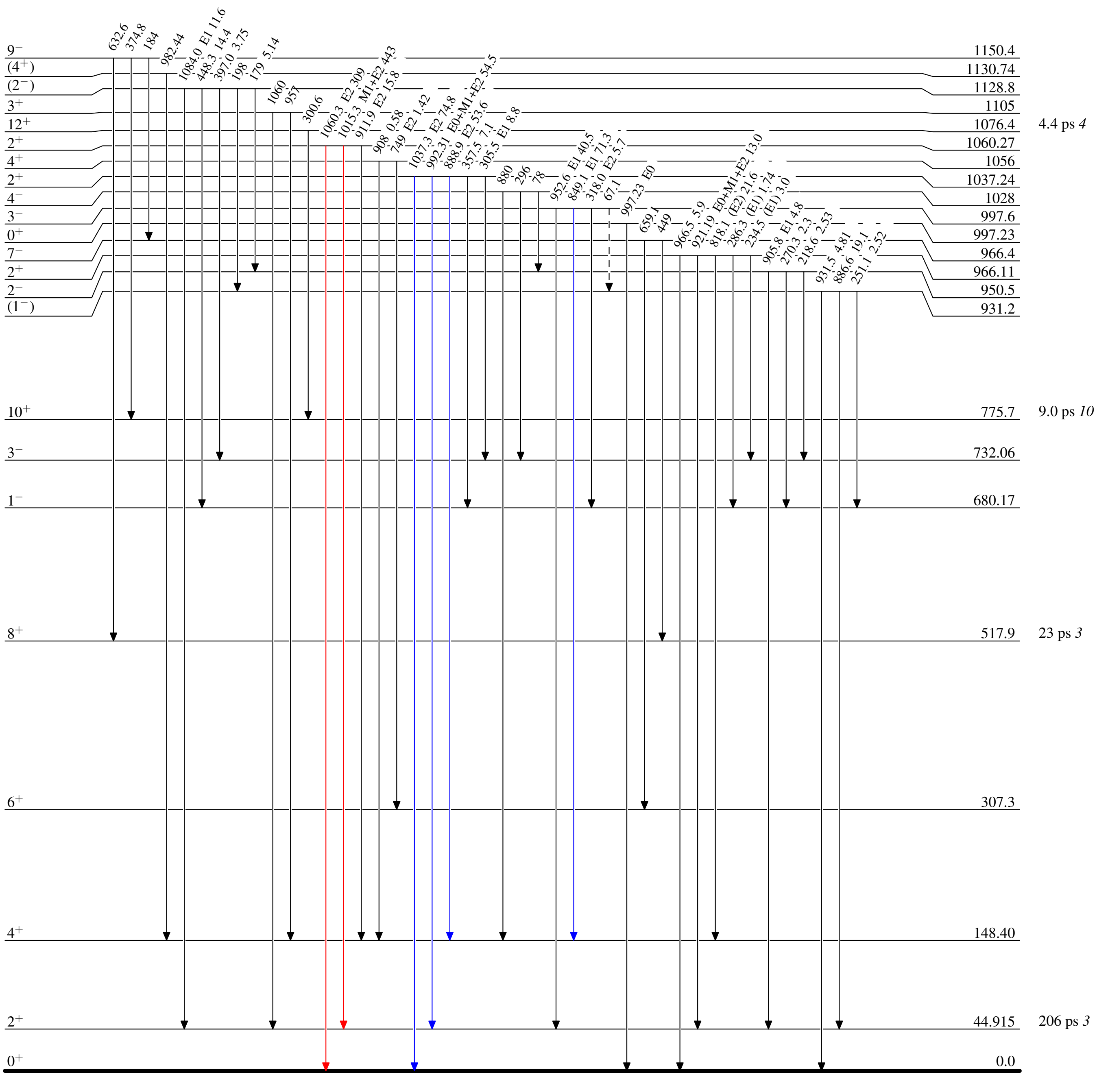
Legend

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

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

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

γ Decay (Uncertain)



$^{238}_{92}U_{146}$

Coulomb excitation

Legend

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

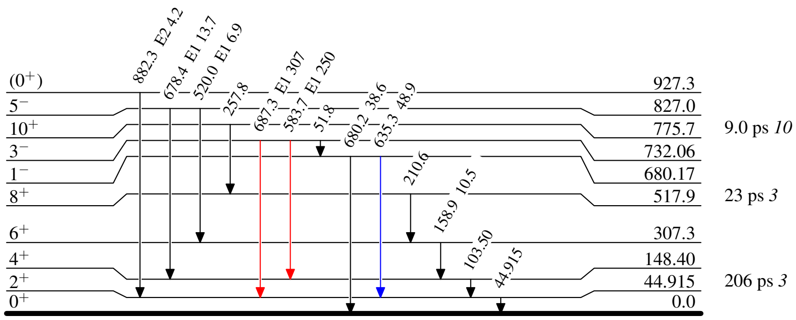
$I_\gamma < 10\% \times I_\gamma^{max}$

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

γ Decay (Uncertain)

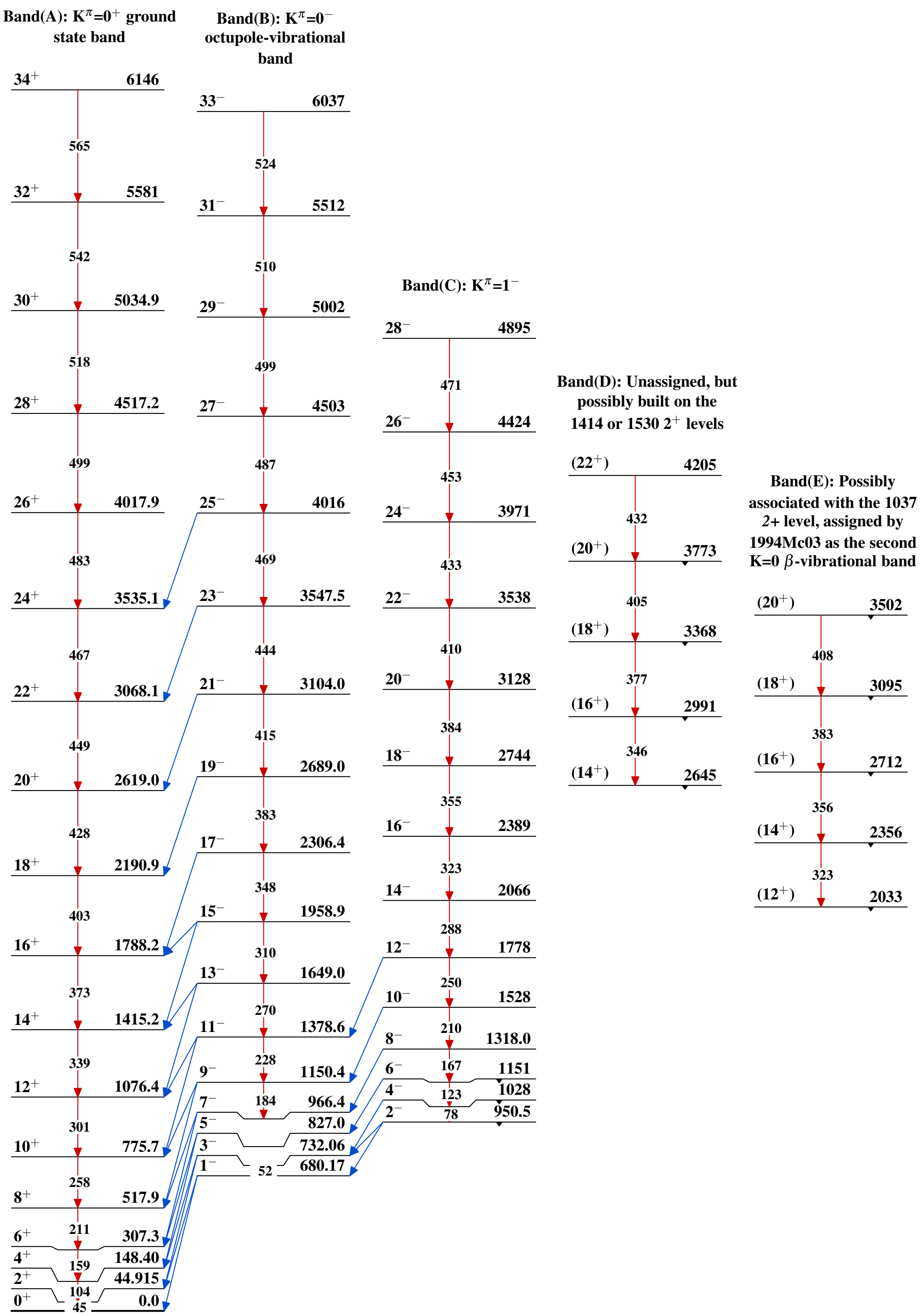
Level Scheme (continued)

Intensities: Relative I_γ



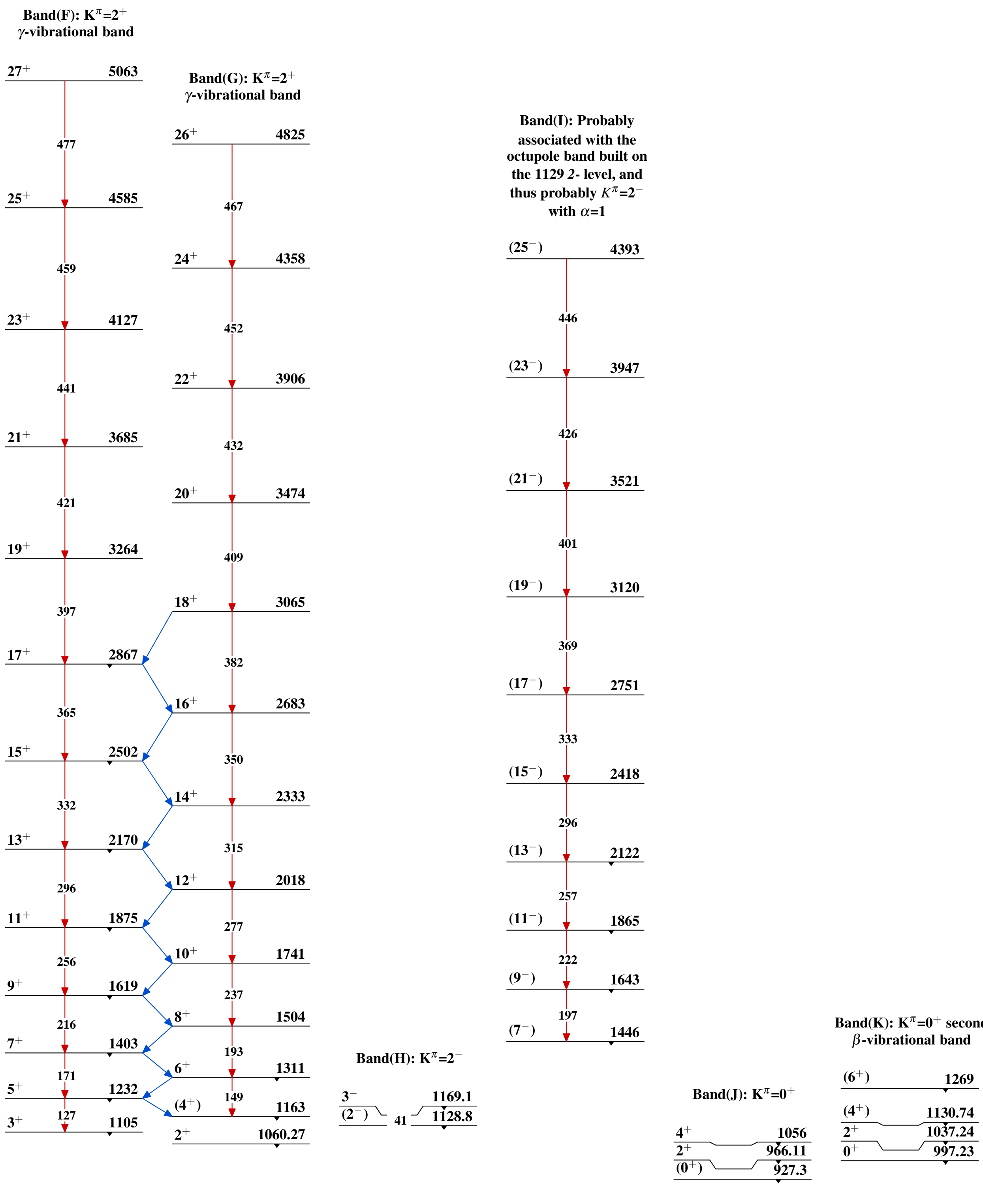
$^{238}_{92}U_{146}$

Coulomb excitation



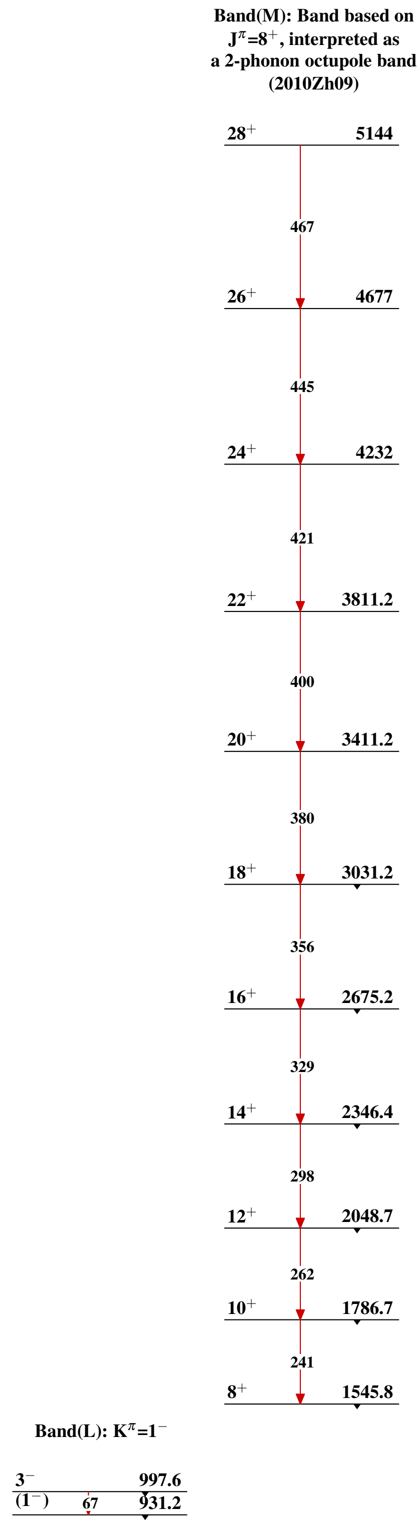
$^{238}_{92}U_{146}$

Coulomb excitation (continued)



$^{238}_{92}U_{146}$

Coulomb excitation (continued)



$^{238}_{92}U_{146}$