Coulomb excitation **1972Do01,1978Mc02,2011Di07**

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	C. M. Baglin[1], E. A. Mccutchan[2], S. Basunia[1]	NDS 153, 1 (2018)	1-Oct-2018

1972Do01: ^{170}Er(^{16}O,^{16}Oγ), E=59 MeV; measured σ(E), Iγ, $\gamma(\theta)$.
1977Ke06: ^{170}Er(^{56}Fe,^{56}Fe′γ), (^{84}Kr,^{84}Kr′γ), E(^{56}Fe)=232 MeV, E(^{84}Kr)=348 MeV; measured Eγ, Doppler-broadened lineshapes; comparison with rotational model value, deduced mult.
1978Mc02: ^{170}Er(α,$\alpha'\gamma$), E=14 MeV; measured Eγ, Iγ, $\gamma(\theta)$.
2011Di07: ^{170}Er(^{32}S,^{32}S′γ), E=117 MeV; beam produced at the Laboratori Nazionali di Legnaro, Italy; 1 mg/cm^2 ^{170}Er target; GASP γ-ray detector array (40 high-efficiency Compton-suppressed HPGe detectors with efficiency of ≈5.8% at 1.33 MeV); square double-sided Si strip detector for particle identification; measured Eγ, Iγ, particle-γ coin; deduced matrix elements using the coupled-channels code GOSIA. Compared results with collective model predictions. Previously known lifetimes of 934,2$^+$ and 960,2$^+$ levels and eight branching ratios from ENSDF database for ^{170}Er adopted dataset were used as input data for the GOSIA analysis.
Others: 1960El07, 1963Gr04, 1965Yo04, 1967Ku07, 1972Er04, 1974Ba81, 1983Hu01.

^{170}Er Levels

1978Mc02 do not observe levels (possibly 3$^-$) reported in (d,d′) at 1304 and 1575, but they note that upper limits on B(E3) deduced from their data are consistent with the (d,d′) data.

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
0.0[e]	0$^+$		
78.7[e]	2$^+$	1.896 ns *23*	B(E2)↑=5.81 *10* (1972Er04) g=0.329 *25* (1967Ku07); g=0.357 *15* (1970Be36) Q=−1.94 *23* (1973Lu02) B(E2)↑: 5.81 *10* (1972Er04), 5.44 *15* (1960El07), 6.1 *5* (1963Gr04), 6.70 *+25−45* from <2+$_g$ M(E2) 0+$_g$> =+2.59 *+5−9* (2011Di07). J$^\pi$: from excitation probability (1963Gr04). T$_{1/2}$: weighted average of 1.89 ns *3* (pulsed beam, 1967Ku07), 1.88 ns *5* (1968Ri09), 1.95 ns *8* (1969Av01), 1.91 ns *6* (from adopted B(E2) and Eγ). g(^{170}Er)/g(^{166}Er)=1.002 *13* (Mossbauer, 1969Wi04). Other Q: Q(^{170}Er)/Q(^{166}Er)=1.05 *16* (1969Wi04).
260.2[e]	4$^+$	111[@] ps *+14−5*	g=0.27 *4* B(E2)↑=3.44 *+14−43* B(E2)↑: from <4+$_g$ M(E2) 2+$_\gamma$> =+4.15 *+8−27* (2011Di07). g: from μ (1989Ra17) based on g from 1968De28 relative to g(4$^+$) for ^{166}Er. B(E4)=(0.24 *+14−18*)^2 (1972Er04).
540.6[e]	6$^+$	14.3[@] ps *+8−9*	B(E2)↑=3.03 *+19−17* B(E2)↑: from <6+$_g$ M(E2) 4+$_g$> =+5.23 *+16−15* (2011Di07).
890.8[b]	(0$^+$)	<0.2 ps	B(E2)↑=0.00032 *+18−14* B(E2)↑: from <0$^+$ M(E2) 2+$_g$> =+0.04 *1* (2011Di07).
914.6[e]	(8$^+$)	3.58 ps *26*	B(E2)↑=2.9 *+9−3* B(E2)↑: from <8+$_g$ M(E2) 6+$_g$> =+6.1 *+9−3* (2011Di07). T$_{1/2}$: other: 3.4 ps *+3−11* from B(E2) and adopted γ properties.
934.0[c]	2$^+$[&]	1.81[@] ps *6*	B(E2)↑=0.103 *3* Q=1.95 *33* B(E2)↑: weighted average of 0.103 *8* (2011Di07, 934γ), 0.102 *6* (1978Mc02), 0.107 *6* (1974Ba81), 0.100 *6* (1972Do01). Other: 0.10 *2* (1965Yo04). Q: from Coulomb excitation reorientation (1989Ra17 from 1983Hu01).
959.9[b]	2$^+$	10.1 ps *9*	B(E2)↑=0.0079 *9* (1978Mc02) T$_{1/2}$: weighted average of 9.9 ps *10* from B(E2)(700γ) and 12 ps *3* from B(E2)(960γ).
1010.3[c]	3$^+$	2.1 ps *+13−3*	

Continued on next page (footnotes at end of table)

Coulomb excitation 1972Do01,1978Mc02,2011Di07 (continued)

^{170}Er Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
1103.0[b]	4+	0.96[@] ps *6*	
1127.3[c]	4+	8 ps *1*	
1236.4[c]	5+		
1332.0	2+	4.8[@] ps *7*	B(E2)↑=0.0074 *11* (1978Mc02)
1340.4[d]	3−		
1350.6[b]	6+		
1370.7[a]	(3−)		B(E3)↑=0.020 *3* (1978Mc02) Jπ: authors′ value based on direct E3 Coulomb excitation of level (1978Mc02).
1376.1[e]	(10+)	1.48 ps *10*	
1402.0[c]	6+		
1415.0	2+		Kπ=2+ (2011Di07).
1482.9[d]	5−		
1579.1	3−		Member of known Kπ=2− band.
1704.6[d]	7−		
1918.0[e]	(12+)	0.57 ps *3*	

[†] From least squares fit to Eγ, allowing 1 keV uncertainty In Eγ data for which the authors did not report an uncertainty.
[‡] Based on multiple Coulomb excitation and band configuration analyses for J>2 members of g.s. band, and on mult of deexciting γ rays and direct excitation in Coulomb excitation otherwise.
[#] From Doppler-broadened lineshape analysis of γ spectrum (1977Ke06), except as noted.
[@] From measured B(E2) and adopted γ properties.
[&] Level excited by direct E2 Coulomb excitation (1978Mc02).
[a] Existence of this level is questionable because it should also be excited strongly in (n,n′γ), yet it is absent in that reaction. No explanation of this discrepancy is available.
[b] Band(A): Kπ=0+ band.
[c] Band(B): Kπ=2+ γ-band.
[d] Band(C): Kπ=1− band.
[e] Band(D): Kπ=0+ g.s. band.

Coulomb excitation 1972Do01,1978Mc02,2011Di07 **(continued)**

$\gamma(^{170}Er)$

E2 and M1 reduced matrix elements are given in comments in units of eb and μN, respectively. B(E2) and B(M1) values were deduced by the evaluator from these matrix elements.

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[@]	δ[#]	α[e]	Comments
78.7	2^+	78.63	100	0.0	0^+	E2		7.47	E_γ: rounded value from Adopted Gammas.
260.2	4^+	181.6	100	78.7	2^+	E2		0.348	E_γ: rounded value from Adopted Gammas. Mult.: γ from level excited primarily by E2-E2 multiple Coulomb excitation.
540.6	6^+	280.4	100	260.2	4^+	E2		0.0849	E_γ: rounded value from Adopted Gammas.
890.8	(0^+)	812[&]		78.7	2^+	(E2)			A_2=+0.02 *12*, A_4=−0.24 *19*, consistent with J=0 to 2, E2 transition (1972Do01).
914.6	(8^+)	374.0[b] *5*	100	540.6	6^+	(E2)		0.0361	Mult.: B(E2)(exp)/B(E2)(rot)=1.09 *8* (1977Ke06).
934.0	2^+	674[a]	1.28 *9*	260.2	4^+	E2			I_γ: other Iγ: 1.7 from thick target yield (1978Mc02). B(E2)=0.0016 *4* from $<2^+_\gamma$ M(E2) $4^+_g>$ =+0.09 *1* (2011Di07). Mult.: from 2011Di07.
		855[a]	100	78.7	2^+	E2(+M1)	<−70		B(E2)=0.0336 *+17−16* from $<2^+_\gamma$ M(E2) $2^+_g>$ =+0.41 *1* (2011Di07). A_2=−0.18 *4*, A_4=−0.51 *7* (1972Do01). W(0°)/W(90°)=0.913 *16* (1978Mc02). δ: from 1978Mc02. Other: δ=−57 *+41−∞* (1972Do01).
		934[a]	89.7 *24*	0.0	0^+	E2			B(E2)=0.0205 *13* from $<2^+_\gamma$ M(E2) $0^+_g>$ =+0.32 *1* (2011Di07). I_γ: weighted average of 92.6 *34* (1972Do01) and 87.8 *28* from (B(E2)↓ to g.s.)/(B(E2)↓ to 79 level)=0.566 *18* (1983Hu01). Others: 84 (1978Mc02), 98 *10* (2011Di07; for 934γ+932γ). W(0°)/W(90°)=1.42 *2* (1978Mc02).
959.9	2^+	69[&]	0.65[&] *13*	890.8	(0^+)	E2		12.69	I_γ: deduced from B(E2), half-life and conversion coefficient. B(E2)=0.73 *13* from $<2^+$ M(E2) $0^+(891)>$ =+1.91 *+16−18* (2011Di07).
		700[a]	79[c] *17*	260.2	4^+	E2			other Iγ: 95 from 1978Mc02. Mult.: from 2011Di07. B(E2)=0.0097 *+9−17* from $<2^+$ M(E2) $4^+_g>$ =+0.22 *+1−2* (2011Di07).
		881[a]	100[c]	78.7	2^+	E2+M1[a]	+1.7[a] *8*		B(M1)=0.0020 *4* from $<2^+$ M(M1) $2^+_g>$ =0.10 *1*; sign not determined (2011Di07). B(E2)=0.0005 *+8−4* from $<2^+$ M(E2) $2^+_g>$ =−0.05 *3* (2011Di07). δ: 0.37 *26* deduced by evaluator from E2 and M1 matrix elements. W(0°)/W(90°)=1.41 *16* (1978Mc02).
		960[a]	38[c] *9*	0.0	0^+	E2[a]			other Iγ: 65 from 1978Mc02. W(0°)/W(90°)=1.35 *20* (1978Mc02). B(E2)=0.0016 *4* from $<2^+$ M(E2) $0^+_g>$ =+0.09 *1* (2011Di07).
1010.3	3^+	750[&]	3.45[&] *26*	260.2	4^+	E2[d]			B(E2)=0.0146 *+71−17* from $<3^+_\gamma$ M(E2) $4^+_g>$ =−0.32 *+2−7* (2011Di07).
		932[&]	100[&] *7*	78.7	2^+	E2[d]			I_γ: for I(934γ)+I(932γ) doublet.

$^{170}_{68}Er_{102}$-3

Coulomb excitation **1972Do01,1978Mc02,2011Di07 (continued)**

$\gamma(^{170}Er)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[@]	δ[#]	α[e]	Comments
									B(E2)=0.037 *+5−14* from <3+$_\gamma$ M(E2) 2+$_g$> =−0.51 *+11−3* (2011Di07).
1103.0	4+	143[&]		959.9	2+	E2		0.797	B(E2)=1.07 *+29−38* from <4+ M(E2) 2+> =+3.1 *+4−6* (2011Di07).
		563[&][f]	<1.38[&]	540.6	6+				I_γ: limit from 2011Di07; γ not evident In spectrum In FIG.1 or level diagram In fig. 2 of 2011Di07.
		843[&]	100[&] *6*	260.2	4+	E2(+M1)	<−16		other Eγ: 840 from 1972Do01. δ: −38 *+22−∞* (1972Do01). δ: 2.67 *+19−26* deduced in 2011Di07 from matrix element for 2+ (K=0) to 2+$_g$ and equation 4-254 in Bohr and Mottelson′s book on Nuclear structure, volume II. A_2=−0.31 *7*, A_4=−0.62 *11* (1972Do01). B(E2)=0.102 *+11−8* from <4+ M(E2) 4+$_g$> =−0.96 *+4−5* (2011Di07).
		1024[&]	29.8[&] *21*	78.7	2+	E2			other Eγ: 1021 from 1972Do01. A_2=+0.43 *11*, A_4=−0.52 *19* (1972Do01). B(E2)=0.0121 *7* from <4+ M(E2) 2+$_g$> =+0.33 *1* (2011Di07).
1127.3	4+	193[&]		934.0	2+	E2		0.284	B(E2)=0.81 *+24−5* from <4+$_\gamma$ M(E2) 2+$_\gamma$> =+2.70 *+37−8* (2011Di07).
		587[&]	13.5[&] *15*	540.6	6+	E2		0.01101	B(E2)=0.0069 *+12−10* from <4+$_\gamma$ M(E2) 6+$_g$> =+0.25 *2* (2011Di07).
		867[&]	100[&] *7*	260.2	4+	E2+M1	−4.3 *+23−99*		other Eγ: 863 from 1972Do01. B(E2)=0.00028 *+132−24* from <4+$_\gamma$ M(E2) 4+$_\gamma$> =−0.05 *7* (2011Di07). A_2=−0.42 *12*, A_4=−0.66 *21* (1972Do01).
		1049[&]	73[&] *6*	78.7	2+	E2			B(E2)=0.0022 *3* from <4+$_\gamma$ M(E2) 2+$_g$> =+0.14 *1* (2011Di07). other Eγ: 1045 from 1972Do01. other Iγ: 88 *10* from 1972Do01. A_2=+0.58 *17*, A_4=−0.40 *25* (1972Do01).
1236.4	5+	696[&]	24[&] *15*	540.6	6+				
		976[&]	100[&] *10*	260.2	4+				
1332.0	2+	398[a]	87[c]	934.0	2+	M1+E2[a]	−0.40[a] *+15−20*	0.059 *5*	W(0°)/W(90°)=0.94 *13* (1978Mc02).
		1332[a]	100[c]	0.0	0+	E2[a]			
1340.4	3−	1080[&]	100[&] *8*	260.2	4+				
		1262[&]	<29[&]	78.7	2+				
1350.6	6+	810[&]	100[&]	540.6	6+				Eγ: 810γ+812γ unresolved by/2011Di07.
1370.7	(3−)	1292[a]	≈100[c]	78.7	2+				
1376.1	(10+)	461.5[b] *5*	100	914.6	(8+)	(E2)		0.0203	Mult.: B(E2)(exp)/B(E2)(rot)=0.91 *6* (1977Ke06).

$^{170}_{68}Er_{102}$-4

Coulomb excitation **1972Do01,1978Mc02,2011Di07 (continued)**

$\gamma(^{170}Er)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[@]	α[e]	Comments
1402.0	6^+	275[&]		1127.3	4^+	E2	0.0902	B(E2)=1.60 *+16−128* from <6+$_\gamma$ M(E2) 4+$_\gamma$> =+4.6 *+2−25* (2011Di07).
		861[&]		540.6	6^+			B(E2)=0.04 *+8−4* from <6+$_\gamma$ M(E2) 6+$_g$ (542)> =+0.7 *5* (2011Di07).
		1142[&]		260.2	4^+	E2		B(E2)=0.010 *+2−9* from <6+$_\gamma$ M(E2) 4+$_g$> =+0.36 *+3−27* (2011Di07).
1415.0	2^+	481[&]	100	934.0	2^+			I_γ: line may be contaminated by a γ in ^{181}Ta (2011Di07).
1482.9	5^-	942[&]		540.6	6^+			
		1223[&]		260.2	4^+			
1579.1	3^-	476[&]	<53[&]	1103.0	4^+			I_γ: 46 *7* from table 1 of 2011Di07, but line may be contaminated by a ^{181}Ta line, so Iγ given here as upper limit (2011Di07).
		569[&]	89[&] *11*	1010.3	3^+			
		645[&]	100[&] *11*	934.0	2^+			
1704.6	7^-	790[&]		914.6	(8^+)			
		1164[&]		540.6	6^+			
1918.0	(12^+)	541.9[b] *5*	100	1376.1	(10^+)	(E2)	0.01341	Mult.: B(E2)(exp)/B(E2)(rot)=1.05 *7* (1977Ke06).

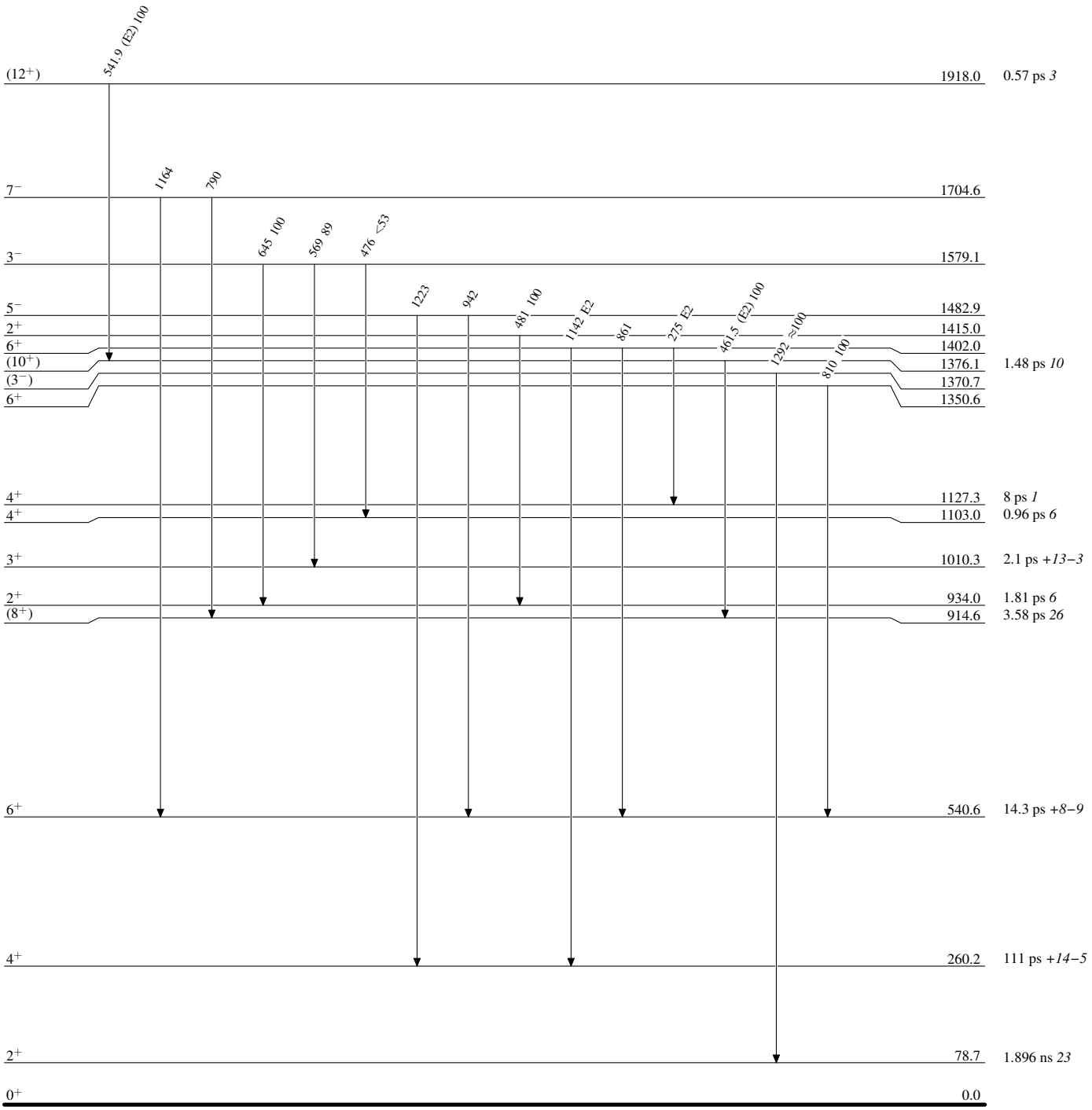
[†] From 1972Do01, except as noted. Authors estimate ΔE=0.5 keV; however, comparison with adopted values shows Eγ from 1972Do01 to be low by 1.5 to 4 keV. Eγ values from 1978Mc02 (ΔE unstated) deviate from adopted values by≤0.4 keV.
[‡] Photon branching from level, relative to 100 for strongest γ.
[#] Based on $\gamma(\theta)$ measurements. From 1972Do01, unless noted otherwise.
[@] Based on $\gamma(\theta)$ and/or Coulomb excitation yields, except as noted.
[&] From 2011Di07. authors do not state uncertainty In Eγ and round values to nearest keV.
[a] From 1978Mc02.
[b] From 1977Ke06.
[c] From thick target yield (1978Mc02).
[d] Dominantly E2 from Adopted Gammas but small M1 admixture may be present.
[e] 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.
[f] Placement of transition in the level scheme is uncertain.

$^{170}_{68}Er_{102}$-5

Coulomb excitation 1972Do01,1978Mc02,2011Di07

Level Scheme

Intensities: Relative photon branching from each level



$^{170}_{68}Er_{102}$

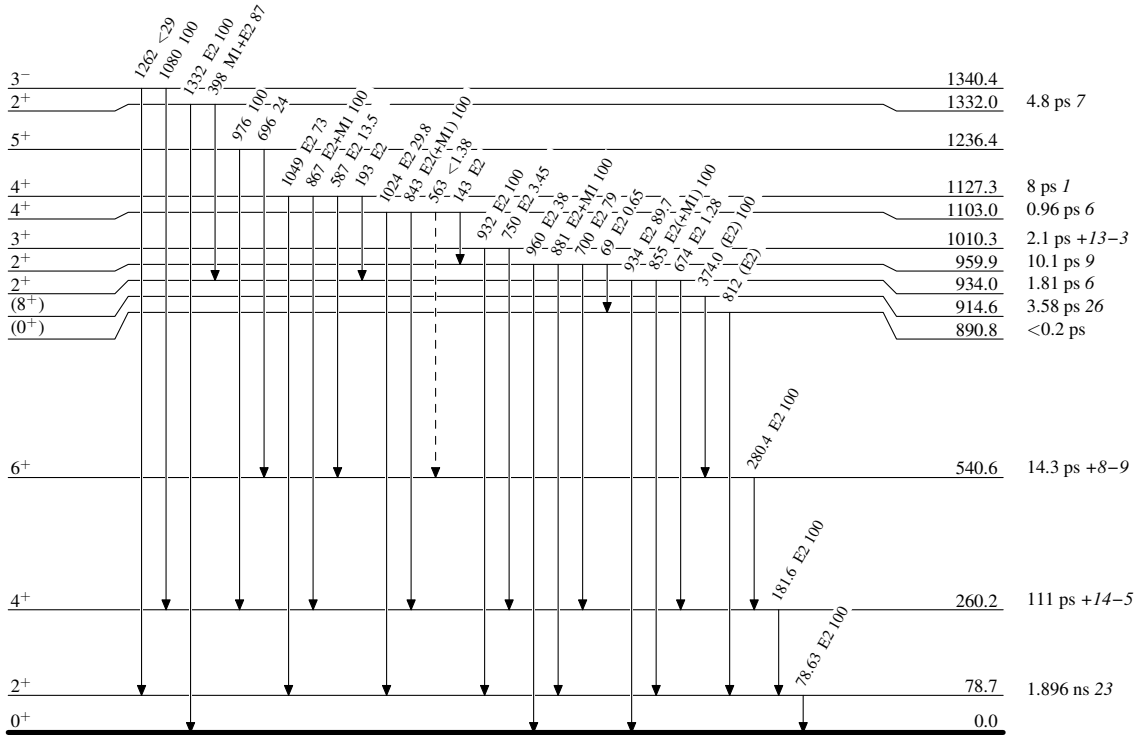
Coulomb excitation 1972Do01,1978Mc02,2011Di07

Legend

Level Scheme (continued)

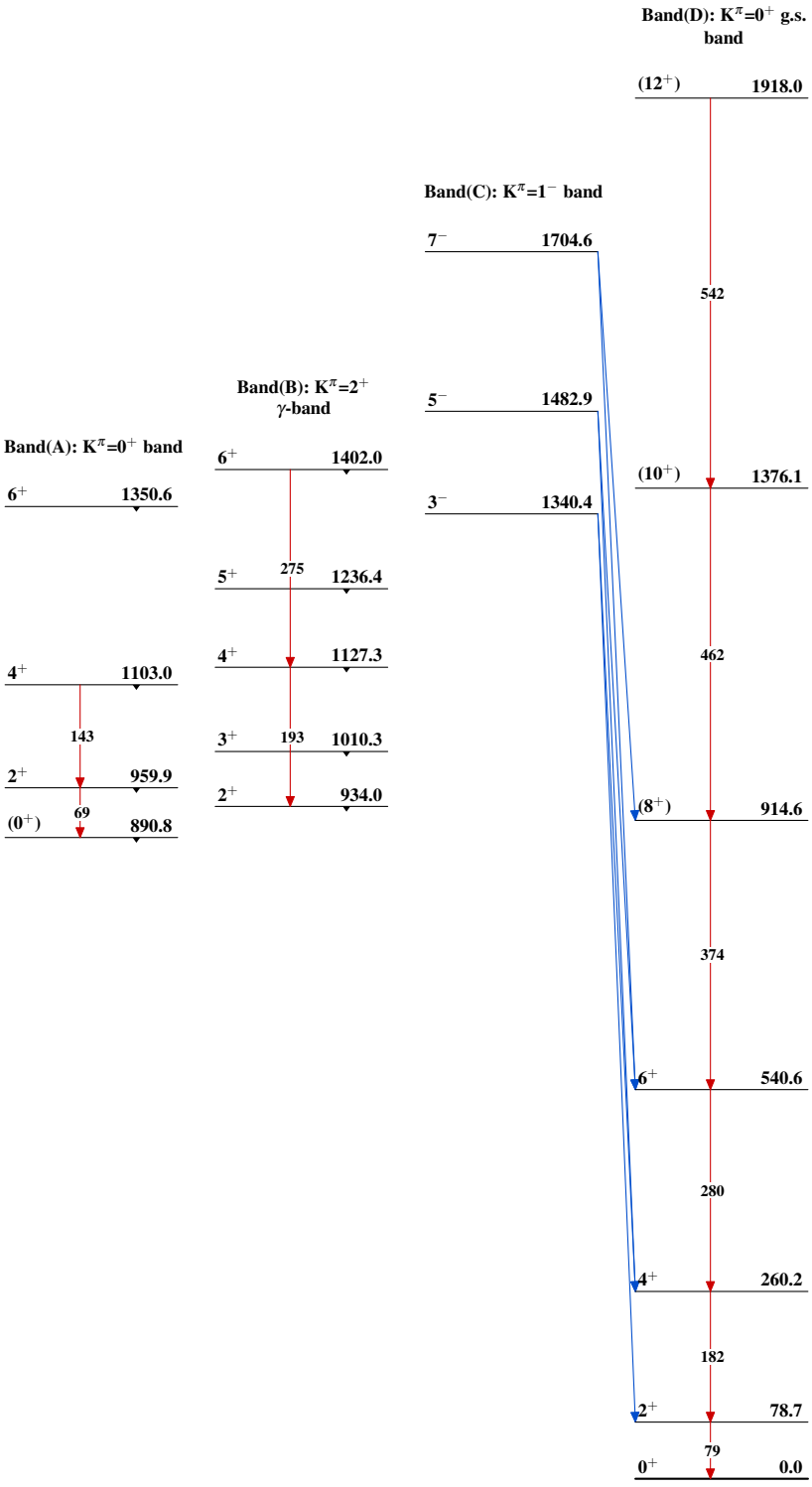
Intensities: Relative photon branching from each level

– – – – – – ► γ Decay (Uncertain)



$^{170}_{68}Er_{102}$

Coulomb excitation 1972Do01,1978Mc02,2011Di07



$^{170}_{68}Er_{102}$