Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 112,1115 (2011)	31-Oct-2010

Q(β^-)=1213 *9*; S(n)=5207 *8*; S(p)=4637 *5*; Q(α)=6800.7 *19* 2012Wa38
Note: Current evaluation has used the following Q record 1210 10 *5207* 8 *4637* 5 *6800.7 19* 2009AuZZ,2003Au03.
Additional information 1.
Calculations, compilations:
g.s. J^π with octupole deformation: 1988Sh01.
Level structure, odd-odd actinides: 1994So16.
n-p interaction energy: 1990Mo11.
Spontaneous emission of heavy ions: 1986Po06.

^{220}Fr Levels

The level scheme and all information on excited levels come from ^{224}Ac α decay.

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
0[@]	1^+	27.4 s *3*	%α=99.65 *5*; %β^-=0.35 *5* μ=−0.67 *1* (1985Co24,2005St24); Q=+0.47 *3* (1985Co24,2005St24) μ: Atomic beam laser spectroscopy (1985Co24); Collinear fast beam laser spectroscopy (1987Du13). Other: 1989Ra17. Q: Atomic beam laser spectroscopy (1985Co24). Other: 1989Ra17. J$^\pi$: Measured J=1 (1978Ek02); π=+ from α decay from 0^- ^{224}Ac. $T_{1/2}$: from 1974Ho27. Other: 27.5 s *15* (1951Me10). %β^-: From Iα(^{216}At)/Iα(^{216}Rn) (1971Br13,1973ChZH). Uncertainty assigned in 1997Ar04. %ε not determined. For log *ft*=6.5 (value for β^- branch to g.s.), %ε(g.s.)=0.025. Q: from 1987Co19, revised measurement of 1985Co24, based on the ratio of hyperfine constants relative to ^{212}Fr. Isotope shift: $\Delta<r^2>$=+0.86725 *45* relative to ^{212}Fr (1987Co19, corrected value of 1985Co24).
6.92[a] *6*	$(3)^+$		J$^\pi$: E1 γ ray from 2^- 156.8 level; α-particle branch from 0^- rules out 2^+; member of $K^\pi=2^+$ band. The inversion of the 2^+ and 3^+ members of this band cannot be due solely to Coriolis coupling with the $K^\pi=1^+$ band (1992Li31).
12.37[a] *5*	2^+		J$^\pi$: E1 γ ray from 1^- 140.7 level allows 0^+,1^+,2^+. Absence of α-particle branch from 0^- ^{224}Ac (HF>7000) rules out 1^+. See 156.8 level spin assignment.
19.89[a] *10*	$(4)^+$		J$^\pi$: E1 γ ray from $(4)^-$ 214.4 level; absence of α-particle branch from 0^- rules out 3^+ and 5^+; member of $K^\pi=2^+$ band.
48.38[@] *4*	2^+		J$^\pi$: M1 γ ray to 1^+ g.s.; E1 γ ray from 2^- 156.8 level; absence of α-particle branch from 0^- rules out 1^+.
55.83[a] *13*	(5^+)		J$^\pi$: γ ray to $(4)^+$ level; γ ray from $(4)^-$ 214.4 level; α-particle branch from 0^- allows 3^+,4^-,5^+; possible member of $K^\pi=2^+$ band.
72.99[@] *6*	$(3)^+$		J$^\pi$: E1 γ ray from 2^- 156.8 level; α-particle branch from 0^- ^{224}Ac rules out 2^+; member of $K^\pi=1^+$ g.s. band.
127.31[@] *11*	(4^+)		J$^\pi$: (M1) γ ray to $(3)^+$ level; absence of α-particle branch from 0^-; member of $K^\pi=1^+$ g.s. band.
140.72[&] *6*	1^-		J$^\pi$: E1 γ ray to 1^+ g.s.; absence of α-particle branch from 0^- ^{224}Ac rules out 0^- and 2^-.
156.82[&] *4*	2^-		J$^\pi$: E1 γ ray to 1^+ g.s., α-particle branch from 0^- ^{224}Ac allow 0^-,2^-. E1 γ ray to 12.4 rules out the combinations J^π(156.8):J^π(12.4)=0^-:0^+, 0^-:2^+ and 2^-:0^+.
177.18[&] *8*	$(3)^-$		J$^\pi$: E1 γ ray to 2^+ 12.4 level; absence of α-particle branch from 0^-; member of $K^\pi=1^-$ band.
200.21[@] *15*	(5^+)		J$^\pi$: γ ray to (4^+) level; γ from (4^-) level; α-particle branch from 0^- level; member of $K^\pi=1^+$ g.s. band.
214.43[&] *9*	$(4)^-$		J$^\pi$: E1 γ rays to $(4)^+$ 19.9 and $(3)^+$ 6.9 levels; α-particle branch from 0^- ^{224}Ac; member of

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{220}Fr Levels (continued)

E(level)[†]	J$^\pi$[‡]	Comments
		$K^\pi=1^-$ band.
246.8[#] *10*		
257.0[#] *15*		
273.64 *11*	1^+	J$^\pi$: M1 γ rays to 1^+ g.s. and 2^+ 12.3 level; α-particle branch from 0^- ^{224}Ac.
276.02 *20*		J$^\pi$: suggested as the 3^- member of possible $K^\pi=2^-$ band (1992Li31).
290.8[&] *3*	(5^-)	J$^\pi$: no α-particle branch from 0^- level; γ rays to 4^+ levels; suggested member of the $K^\pi=1^-$ band.
299.91 *15*	$(1)^+$	J$^\pi$: M1 γ ray to 2^+ 48.4 level; (M1) γ ray to 1^+ g.s.; α-particle branch from 0^- ^{224}Ac rules out 2^+.
306.9[#] *15*		
314.8 *4*		J$^\pi$: suggested as the 4^- member of possible $K^\pi=2^-$ band (1992Li31); γ rays to (5^+) levels.
340.25[b] *12*	$(0)^-$	J$^\pi$: M1 γ ray to 1^- 140.7 level; α-particle branch from 0^- ^{224}Ac; member of $K^\pi=0^-$ band.
347.9 *4*		
355.13 *19*	$(0^-,2^-)$	J$^\pi$: (E1) γ rays to $(1)^+$ and $1^+,3^+$ levels; α-particle branch from 0^- ^{224}Ac rules out 1^-.
361.0 *4*		
364.16 *23*	$3^+,4^-$	J$^\pi$: γ rays to 4^+, $(3)^-$ and $(3)^+$ levels; α-particle branch from 0^- ^{224}Ac rules out 2^+, 3^-, 4^+.
376.49[b] *20*	(2^-)	J$^\pi$: γ ray to 2^+ level; α-particle branch from 0^-; member of possible $K^\pi=0^-$ band.
380.1[#] *10*		
414.6[#] *20*		
442.2[#] *15*		
452.4 *11*		J$^\pi$: possibly 4^- member of $K^\pi=0^-$ band, or (5^+) (1992Li31).
479.6[#] *20*		
501.1 *4*		
511.1 *10*		
579.9[#] *20*		

[†] From least squares fit to Eγ, unless otherwise noted.
[‡] Levels without spin assignments are all deduced from α decay; therefore, all have $J^\pi=0^-,1^+,2^-,3^+,4^-$ etc.
[#] From Eα.
[@] Band(A): $K^\pi=1^+$ g.s. rotational band.
[&] Band(B): $K^\pi=1^-$ band.
[a] Band(C): possible $K^\pi=2^+$ band.
[b] Band(D): possible $K^\pi=0^-$ band.

$\gamma(^{220}Fr)$

All γ-ray data are from ^{224}Ac α decay.

E$_i$(level)	J$_i^\pi$	E$_\gamma$	I$_\gamma$	E$_f$	J$_f^\pi$	Mult.	α[†]
6.92	$(3)^+$	(6.9)		0	1^+		
12.37	2^+	(12.4)		0	1^+		
19.89	$(4)^+$	(13.0)		6.92	$(3)^+$		
48.38	2^+	35.9[#] *1*	5[#] *3*	12.37	2^+		
		41.5 *1*	6 *2*	6.92	$(3)^+$		
		48.40 *5*	100 *8*	0	1^+	M1	24.7 *1*
55.83	(5^+)	35.9[#] *1*	100[#]	19.89	$(4)^+$		
72.99	$(3)^+$	24.6	≈22	48.38	2^+		
		53.1 *1*	22 *4*	19.89	$(4)^+$		
		60.67 *5*	100 *4*	12.37	2^+	M1	12.8

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

γ(^{220}Fr) (continued)

E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.	α[†]
72.99	(3)$^+$	66.0 *1*	50 *9*	6.92	(3)$^+$		
		72.9[#] *1*	11[#] *4*	0	1$^+$	(E2)	39.8 *3*
127.31	(4$^+$)	54.3 *1*		72.99	(3)$^+$	(M1)	17.7 *1*
140.72	1$^-$	92.34 *5*	14.6 *14*	48.38	2$^+$		
		128.4 *3*	23 *6*	12.37	2$^+$	E1	0.261 *2*
		140.7 *1*	100 *8*	0	1$^+$	E1	0.209
156.82	2$^-$	(16.1)		140.72	1$^-$		
		83.9 *2*	22.0 *12*	72.99	(3)$^+$	E1	0.173 *1*
		108.43 *5*	13.0 *12*	48.38	2$^+$	E1	0.395
		144.44 *5*	27.8 *25*	12.37	2$^+$	E1	0.196
		149.90 *5*	15.4 *25*	6.92	(3)$^+$	E1	0.179
		156.82 *5*	100 *6*	0	1$^+$	E1	0.161
177.18	(3)$^-$	(20.4)		156.82	2$^-$		
		49.8 *2*	8 *2*	127.31	(4$^+$)		
		104.4 *2*	26 *6*	72.99	(3)$^+$		
		128.9 *3*	72 *20*	48.38	2$^+$		
		164.8 *1*	100 *20*	12.37	2$^+$	E1	0.142
200.21	(5$^+$)	72.9[#] *1*	100[#]	127.31	(4$^+$)		
214.43	(4)$^-$	37.3 *1*	5.7 *10*	177.18	(3)$^-$		
		141.4 *1*	100 *19*	72.99	(3)$^+$		
		158.5 *2*	15 *4*	55.83	(5$^+$)		
		194.5 *3*	6.6 *19*	19.89	(4)$^+$	E1	0.095
		207.6 *2*	34 *9*	6.92	(3)$^+$	E1	0.0813
273.64	1$^+$	225.3 *2*	17 *5*	48.38	2$^+$	M1	1.51
		261.3 *2*	100 *8*	12.37	2$^+$	M1	1.00
		273.7 *4*	5.8 *16*	0	1$^+$	M1	0.882
276.02		263.1[@] *5*		12.37	2$^+$		
290.8	(5$^-$)	163.3 *5*	≈50	127.31	(4$^+$)		
		271.5 *4*	100 *30*	19.89	(4)$^+$		
299.91	(1)$^+$	251.6 *3*	100 *27*	48.38	2$^+$	M1	1.11
		287.6 *5*	27 *12*	12.37	2$^+$		
		300.0 *3*	65 *15*	0	1$^+$	(M1)	0.686
314.8		114.7 *5*	100 *60*	200.21	(5$^+$)		
		258.8 *5*	≈100	55.83	(5$^+$)		
340.25	(0)$^-$	40.4 *3*	8 *3*	299.91	(1)$^+$	(E1)	1.23 *2*
		66.6 *1*	100 *8*	273.64	1$^+$	E1	0.321 *3*
		199.5 *2*	50 *17*	140.72	1$^-$	M1	2.13
		340.3 *3*	8 *3*	0	1$^+$		
347.9		328.0[‡] *3*	100[‡]	19.89	(4)$^+$		
355.13	(0$^-$,2$^-$)	55.3 *2*	14 *4*	299.91	(1)$^+$	(E1)	0.529 *5*
		79.10 *5*	100 *11*	276.02			
		81.5 *3*	75 *7*	273.64	1$^+$	(E1)	0.187 *3*
		228[@]		127.31	(4$^+$)		
361.0		87.4 *3*		273.64	1$^+$		
364.16	3$^+$,4$^-$	73.6 *3*	100 *50*	290.8	(5$^-$)		
		186.8 *3*	100 *33*	177.18	(3)$^-$		
		357.0 *5*	≈50	6.92	(3)$^+$		
376.49	(2$^-$)	103.1 *4*	≈19	273.64	1$^+$		
		328.0[‡] *3*	33[‡] *14*	48.38	2$^+$		
		364.1 *3*	100 *14*	12.37	2$^+$		
452.4		97.3[@]		355.13	(0$^-$,2$^-$)		
501.1		48.6[@]		452.4			
		201.1 *4*	100 *50*	299.91	(1)$^+$		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

$\gamma(^{220}Fr)$ (continued)

E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π
501.1		227.7 *5*	100 *33*	273.64	1^+
511.1		491.2		19.89	$(4)^+$

† 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.
‡ Multiply placed with undivided intensity.
# Multiply placed with intensity suitably divided.
@ Placement of transition in the level scheme is uncertain.

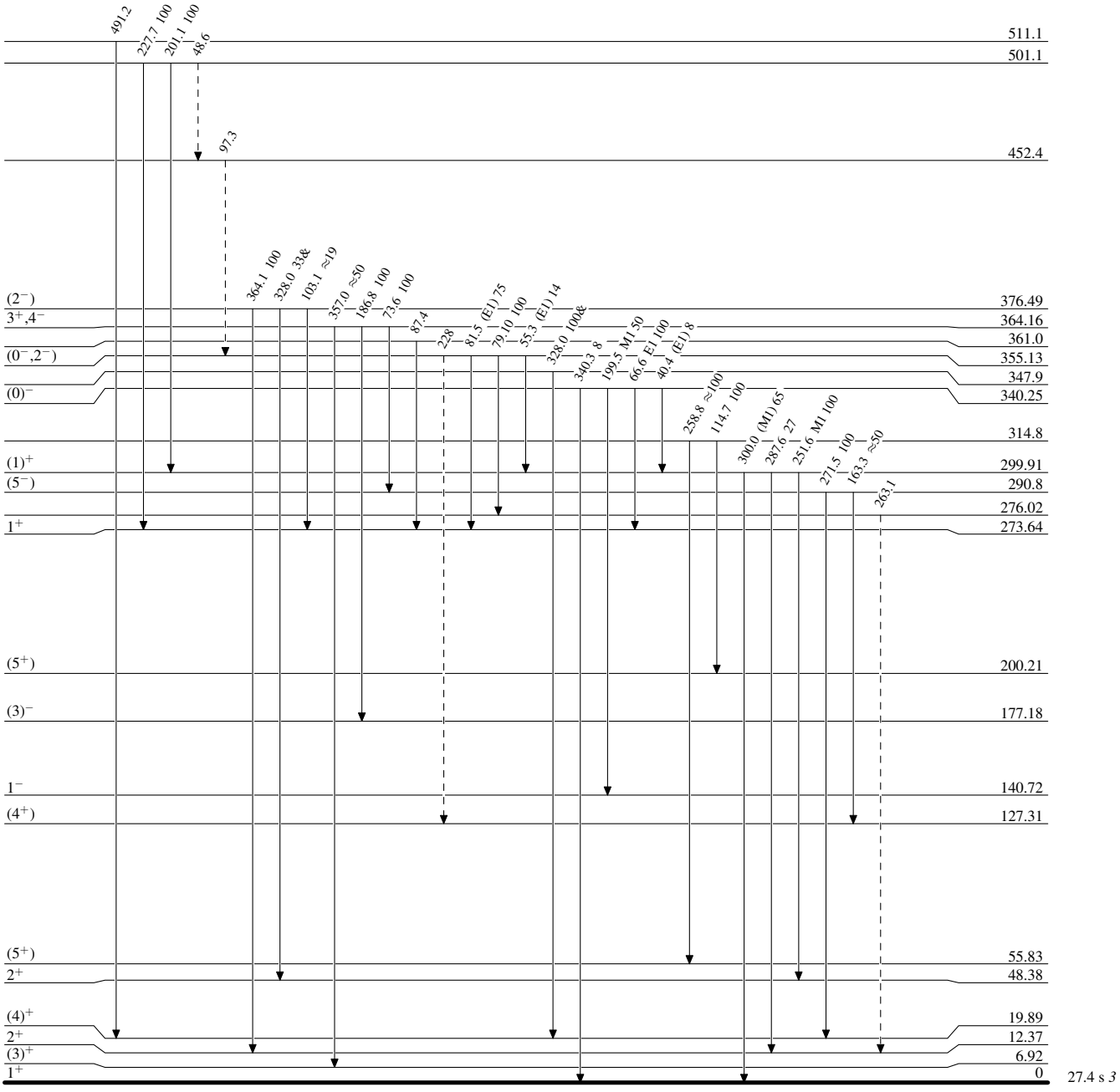
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given

– – – – – – ► γ Decay (Uncertain)



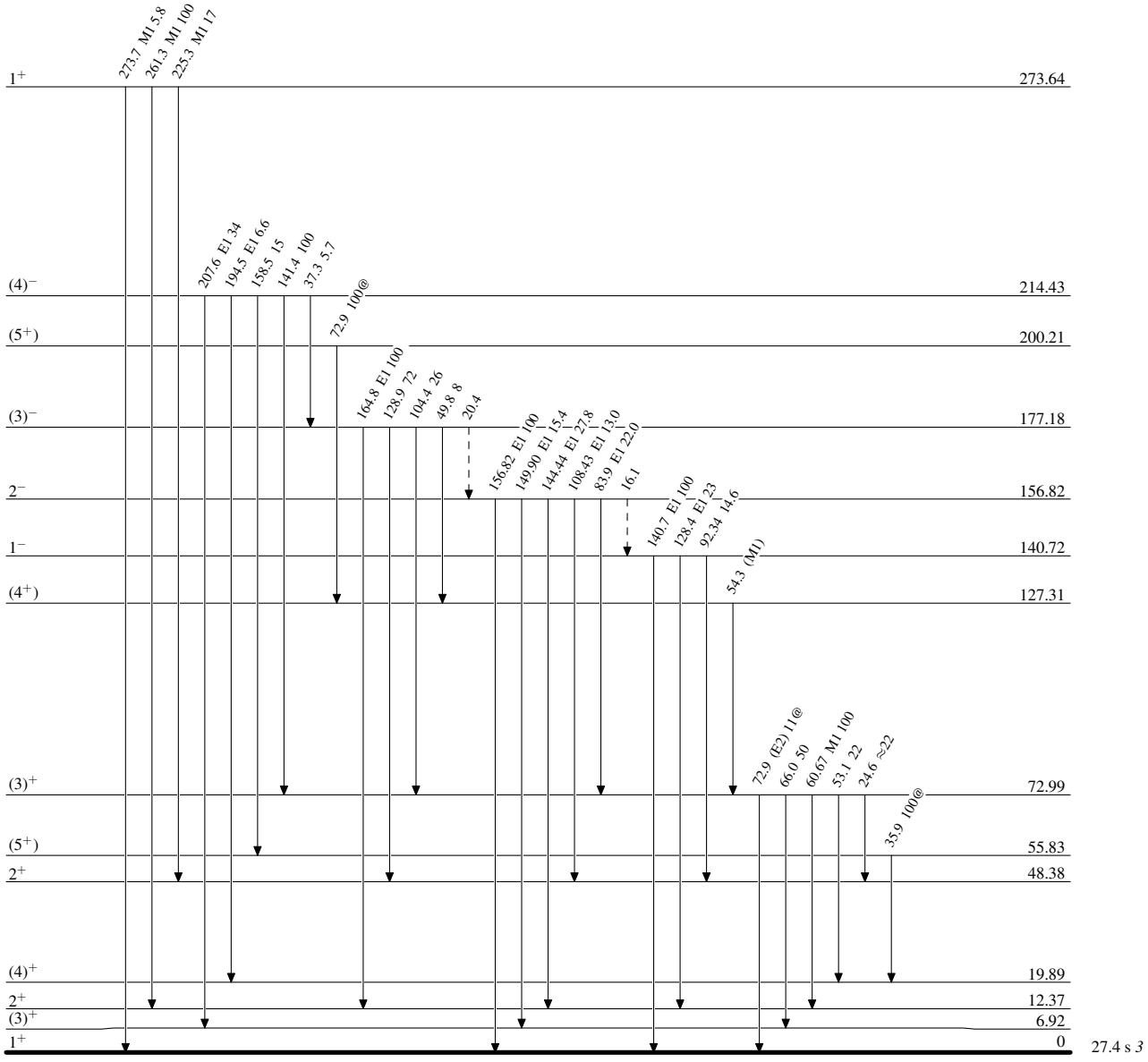
$^{220}_{87}Fr_{133}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend
- - - - - - ► γ Decay (Uncertain)



$^{220}_{87}Fr_{133}$

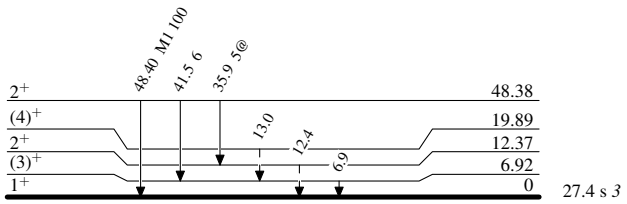
Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

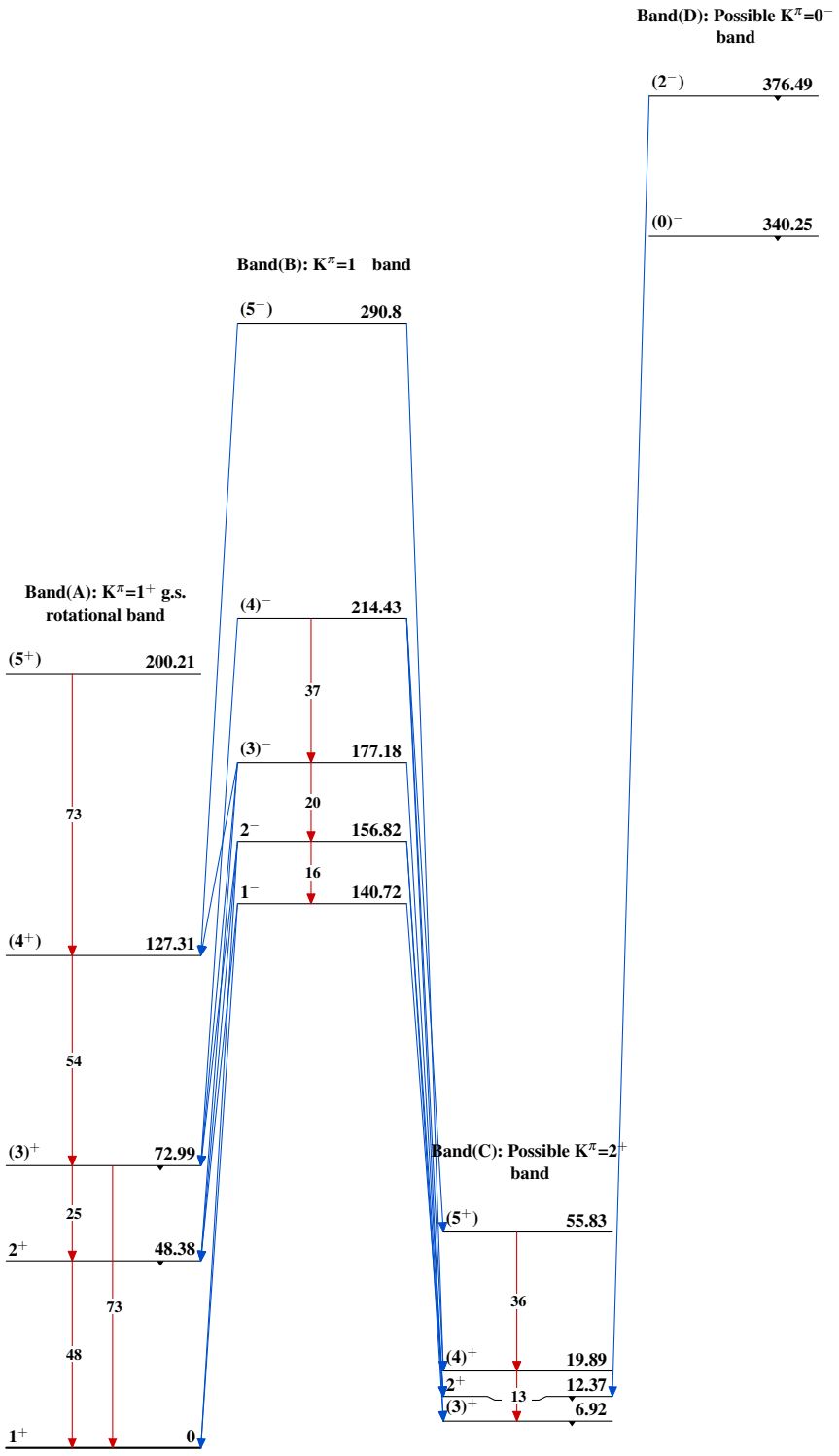
Legend

– – – – – – ► γ Decay (Uncertain)



$^{220}_{87}Fr_{133}$

Adopted Levels, Gammas



$^{220}_{87}Fr_{133}$