^{166}Er(α,3nγ) 1975Li03

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 191,1 (2023)	22-Aug-2023

1975Li03: E(α)=26-43 MeV from Stockholm 225 cm cyclotron. Target was metallic 96.24% enriched ^{166}Er of 10 mg/cm^2 thickness. Measured excitation functions, Eγ, Iγ, x rays, $\gamma\gamma$-coin with a resolving time of ≈90 ns, $\gamma(\theta)$ at four angles, level half-lives by $\alpha\gamma$(t) using two large Ge(Li) detectors and a small Ge detector for low-energy transitions. Comparison with particle-rotor model calculations.

Other:

1981Hj01: E(α)=51-55 MeV. Measured γ-ray multiplicities and side-feeding multiplicity distributions of continuum γ-ray spectroscopy at the Stockholm 225 cm cyclotron facility.

All data are from 1975Li03, unless otherwise stated.

^{167}Yb Levels

1975Li03 assigned $T_{1/2}$≤15 ns for all the excited states based on $\alpha\gamma$(t) data for all the transitions, placed in the level scheme or otherwise, with the exception of the unplaced 380.5γ, which was found to be delayed with $T_{1/2}$>15 ns.

E(level)[†]	J$^\pi$[‡]	Comments
0.0[#]	5/2$^-$	
29.6[@] *3*	5/2$^+$	
33.8[&] *3*	7/2$^+$	
58.4[@] *3*	9/2$^+$	
78.6 *4*	7/2$^-$	
125.8[&] *3*	11/2$^+$	
178.8[#] *3*	9/2$^-$	
185.8[@] *3*	13/2$^+$	
330.0[&] *3*	15/2$^+$	
407.5[@] *3*	17/2$^+$	
442.4[#] *3*	13/2$^-$	
571.7[a] *3*	(11/2$^-$)	E(level): based on the Adopted Levels, Gammas, where this level deexcited by intense γ rays of 445.6 and 513.1 keV, which were reported by 1975Li03 as unplaced γ rays, with nearly the same branching ratios. In 1975Li03, energy of this level is labeled as 'x'.
644.3[&] *3*	19/2$^+$	
721.1[@] *4*	21/2$^+$	
726.4[a] *4*	(13/2$^-$)	
783.8[#] *4*	17/2$^-$	
901.0[a] *5*	(15/2$^-$)	
1061.1[&] *4*	23/2$^+$	
1094.3[a] *5*	(17/2$^-$)	
1122.1[@] *4*	25/2$^+$	
1193.2[#] *4*	21/2$^-$	
1304.3[a] *6*	(19/2$^-$)	
1529.9?[a] *6*	(21/2$^-$)	
1569.9[&] *4*	27/2$^+$	
1602.0[@] *4*	29/2$^+$	
1657.5[#] *4*	25/2$^-$	
1758.4? *7*	(23/2$^-$)	Authors' tentative assignment as the 23/2 member of the ν11/2[505] band is inconsistent with 1771.6 level assigned as 23/2 member of the ν11/2[505] band, decaying by 240.7 and 466.5 γ rays. This level and

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^{166}Er(α,3nγ) 1975Li03 (continued)

^{167}Yb Levels (continued)

E(level)[†]	J$^\pi$[‡]	Comments
		the transitions of 228.6 and 454.0 keV from this level are not listed in the Adopted Levels, Gammas dataset.
2149.3[@] *4*	33/2$^+$	
2159.3[#] *5*	(29/2$^-$)	E(level): level population proposed from the Adopted Levels.
2160.0[&] *5*	31/2$^+$	

† From a least-squares fit to Eγ data.
‡ As assigned by 1975Li03, based on multipolarities of transitions and cascades of coincident γ rays into rotational bands.
# Band(A): ν5/2[523].
@ Band(B): ν5/2[642],α=+1/2.
& Band(b): ν5/2[642],α=−1/2.
a Band(C): Tentative ν11/2[505]. In Fig. 3 of 1975Li03, energy of the (11/2) bandhead is labeled as 'x'.

γ(^{167}Yb)

Placement of all the γ rays is based on $\gamma\gamma$-coin data as shown in Table 2 of 1975Li03.

E$_\gamma$[†]	I$_\gamma$[@]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[&]	α[a]	Comments
[x]7.5 *5*								
[x]8.4 *5*								
[x]9.6 *5*								
[x]12.0 *5*								
[x]15.6 *5*								
[x]16.2 *5*								
[x]19.0 *5*								
(24.63[‡] *1*)		58.4	9/2$^+$	33.8	7/2$^+$			
(28.88[‡] *1*)		58.4	9/2$^+$	29.6	5/2$^+$			
29.6 *5*		29.6	5/2$^+$	0.0	5/2$^-$	D		A$_2$=−0.11 *4*
33.8 *5*		33.8	7/2$^+$	0.0	5/2$^-$	D		A$_2$=−0.15 *8*
[x]38.2 *5*								
[x]39.2 *5*								
60.0 *5*		185.8	13/2$^+$	125.8	11/2$^+$			
61.2 *5*		1122.1	25/2$^+$	1061.1	23/2$^+$			
[x]65.2 *5*	5 *1*					D		A$_2$=−0.27 *6*
[x]66.9 *5*	5 *1*							
67.4 *1*	45 *5*	125.8	11/2$^+$	58.4	9/2$^+$	(M1+E2)	13 *3*	A$_2$=−0.73 *14*
[x]68.9 *1*	12 *2*					D		A$_2$=−0.17 *5*
[x]69.3 *5*	3 *1*							
[x]71.1 *5*	2 *1*					(M1+E2)	10.8 *18*	A$_2$=−0.33 *8*; A$_4$=+0.30 *10*
[x]72.9 *5*	3 *1*							
[x]75.0 *5*	6 *1*							
76.9 *5*	6 *1*	721.1	21/2$^+$	644.3	19/2$^+$	(M1+E2)	8.1 *10*	A$_2$=−0.24 *16*; A$_4$=+0.20 *19*
77.5 *1*	20 *2*	407.5	17/2$^+$	330.0	15/2$^+$	(M1)	7.03	A$_2$=−0.32 *14*; A$_4$=+0.19 *15* Mult.: E2 ruled out by RUL (see Adopted dataset).
78.6 *5*	8 *2*	78.6	7/2$^-$	0.0	5/2$^-$	(M1+E2)	7.5 *8*	A$_2$=−0.21 *8*; A$_4$=+0.13 *8*
[x]79.6 *5*	3 *1*							
[x]82.0 *5*	<1							
[x]84.5 *5*	≈1							
[x]85.1 *5*	≈2							

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^{166}Er(α,3nγ) 1975Li03 (continued)

$\gamma(^{167}Yb)$ (continued)

E_γ[†]	I_γ[@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	α[a]	Comments
[x]89.9 *5*	3 *1*							
[x]90.8 *5*	2 *1*							
91.9 *5*	8 *2*	125.8	11/2$^+$	33.8	7/2$^+$			
[x]93.3 *5*	6 *1*							
[x]96.1 *5*	<1							
[x]98.0 *5*	<1							
[x]98.6 *5*	≈1							
100.1 *5*	≈2	178.8	9/2$^-$	78.6	7/2$^-$			
[x]115.3 *5*	≈1							
120.2 *5*	4 *1*	178.8	9/2$^-$	58.4	9/2$^+$			
[x]126.3 *5*	≈1							
127.3 *1*	39 *4*	185.8	13/2$^+$	58.4	9/2$^+$			
[x]130.4 *5*	<1							
[x]133.7 *5*	≈2					D		A_2=−0.28 *7*
[x]135.3 *5*	≈1							
144.2 *1*	38 *4*	330.0	15/2$^+$	185.8	13/2$^+$	(M1+E2)	1.01 *18*	A_2=−0.67 *19*; A_4=+0.25 *20*
144.9 *5*	6 *1*	178.8	9/2$^-$	33.8	7/2$^+$			
[x]154.0 *5*	≈1							
154.7 *1*	10 *1*	726.4	(13/2$^-$)	571.7	(11/2$^-$)			E_γ: placement as shown in level-scheme Fig. 3 of 1975Li03. In authors′ Table 154.0γ appears assigned as transition from the 13/2$^-$ level, and 154.7γ as unplaced.
[x]156.2 *5*	≈1							
[x]162.0 *5*	≈1							
[x]165.3 *5*	<1							
174.6 *5*	<9	901.0	(15/2$^-$)	726.4	(13/2$^-$)			
178.8 *5*	7 *2*	178.8	9/2$^-$	0.0	5/2$^-$			
[x]182.1 *5*	1.0 *5*							
[x]189.0 *5*	1.0 *5*							
193.1 *5*	7 *2*	1094.3	(17/2$^-$)	901.0	(15/2$^-$)			E_γ: 193.1γ mixed with a line from ^{19}F.
204.3 *1*	53 *5*	330.0	15/2$^+$	125.8	11/2$^+$	(E2)	0.250	A_2=+0.31 *7*; A_4=+0.03 *9*
[x]207.8 *5*	3 *1*							
210.0 *5*	4 *1*	1304.3	(19/2$^-$)	1094.3	(17/2$^-$)			
[x]213.2 *5*	3 *1*							
[x]216.7 *5*	1.0 *5*							
221.7 *1*	52 *5*	407.5	17/2$^+$	185.8	13/2$^+$	(E2)	0.191	A_2=+0.27 *9*; A_4=−0.01 *9*
[x]222.7 *5*	7 *2*							
225.9[c] *5*	3 *1*	1529.9?	(21/2$^-$)	1304.3	(19/2$^-$)			E_γ: from an unplaced γ in Table 1 in 1975Li03; placement from a 225.7γ shown in authors′ level-scheme Fig. 3.
228.6[c] *5*	2 *1*	1758.4?	(23/2$^-$)	1529.9?	(21/2$^-$)			This γ is not listed in the Adopted Levels, Gammas dataset.
[x]235.8 *5*	2 *1*							
236.7 *1*	13 *1*	644.3	19/2$^+$	407.5	17/2$^+$	(M1+E2)	0.227 *73*	A_2=−0.77 *44*; A_4=+0.30 *38*
[x]239.1 *5*	7 *2*							
[x]240.5 *5*	2 *1*							
[x]243.6 *5*	6 *1*							
263.6 *1*	11 *1*	442.4	13/2$^-$	178.8	9/2$^-$	(E2)	0.1100	A_2=+0.38 *14*; A_4=+0.07 *16*
[x]279.0 *5*	2 *1*							
[x]297.8 *5*	6 *1*							
[x]305.6 *1*	10 *1*					(M1+E2)	0.110 *40*	A_2=+0.36 *7*; A_4=+0.10 *9*
313.6 *1*	62 *6*	721.1	21/2$^+$	407.5	17/2$^+$	(E2)	0.0647	A_2=+0.41 *9*; A_4=+0.10 *13*
314.3 *1*	53 *5*	644.3	19/2$^+$	330.0	15/2$^+$			
316.8[#] *5*	6 *1*	442.4	13/2$^-$	125.8	11/2$^+$			

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^{166}Er(α,3nγ) 1975Li03 (continued)

$\gamma(^{167}Yb)$ (continued)

E_γ [†]	I_γ [@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[&]	α[a]	Comments
x321.4 5	1.0 5							
x325.6 5	1.0 5							
329.4 5	1.0 5	901.0	(15/2$^-$)	571.7	(11/2$^-$)			
339.8 5	6 1	1061.1	23/2$^+$	721.1	21/2$^+$			E_γ: placement shown in level-scheme Fig. 3 of 1975Li03. Unplaced in authors' Table 1.
341.4 1	14 2	783.8	17/2$^-$	442.4	13/2$^-$	(E2)	0.0504	A_2=+0.16 9; A_4=−0.07 9
x359.7 5	3 1							
x363.2 5	2 1							
367.8 5	≈3	1094.3	(17/2$^-$)	726.4	(13/2$^-$)			
x380.5 1	11 1							A_2=+0.26 7 Delayed transition with $T_{1/2}$>15 ns from $\alpha\gamma$(t).
x400.5 1	14 2							A_2=+0.35 6
401.0 1	37 4	1122.1	25/2$^+$	721.1	21/2$^+$	(E2)	0.0320	A_2=+0.32 4
403.6 5	≤4	1304.3	(19/2$^-$)	901.0	(15/2$^-$)			
409.4 1	14 2	1193.2	21/2$^-$	783.8	17/2$^-$	(E2)	0.0302	A_2=+0.35 6
416.8 1	33 3	1061.1	23/2$^+$	644.3	19/2$^+$	(E2)	0.0288	A_2=+0.34 6; A_4=−0.07 15
x421.3 5	6 1							
435.5[c] 5	2 1	1529.9?	(21/2$^-$)	1094.3	(17/2$^-$)			E_γ: from Table 1 in 1975Li03, Eγ=436.5 in authors' Fig. 3.
445.8[#] 1	12 1	571.7	(11/2$^-$)	125.8	11/2$^+$	D		A_2=−0.15 7
447.7 5	2 1	1569.9	27/2$^+$	1122.1	25/2$^+$	(M1+E2)	0.039 16	A_2=−0.60 20
454.0[c] 5	5 1	1758.4?	(23/2$^-$)	1304.3	(19/2$^-$)			This γ may be from 783.7, 17/2$^-$ level, as in the Adopted Levels, Gammas dataset.
464.3 1	10 1	1657.5	25/2$^-$	1193.2	21/2$^-$	(E2)	0.0216	A_2=+0.25 10
479.9 1	29 3	1602.0	29/2$^+$	1122.1	25/2$^+$	(E2)	0.0198	A_2=+0.43 4; A_4=+0.08 5 E_γ: from Table 1 in 1975Li03, Eγ=479.7 in authors' Fig. 3. Positive A_4 is inconsistent with ΔJ=2, quadrupole transition.
x487.4 5	3 1							
x490.6 5	1.0 5							
x495.0 1	11 1							
501.9[#] 5	7 2	2159.3	(29/2$^-$)	1657.5	25/2$^-$			
508.8 1	20 2	1569.9	27/2$^+$	1061.1	23/2$^+$			E_γ,I_γ: includes contribution from ^{166}Yb. Eγ=508.9 in Fig. 3 of 1975Li03.
513.3[#] 1	16 2	571.7	(11/2$^-$)	58.4	9/2$^+$			
547.3 1	14 2	2149.3	33/2$^+$	1602.0	29/2$^+$			
549.1[#] 5	7 2	1193.2	21/2$^-$	644.3	19/2$^+$			
558.7 5	2 1	2160.0	31/2$^+$	1602.0	29/2$^+$			E_γ: from Table 1 in 1975Li03, Eγ=558 in authors' Fig. 3.
x559.6 5								
x579.6 5	6 1							
x584.5 5	1.0 5							
589.3[b#] 5	8[b] 2	2159.3	(29/2$^-$)	1569.9	27/2$^+$			
589.3[b] 5	8[b] 2	2160.0	31/2$^+$	1569.9	27/2$^+$			
x599.8 5	5 1							
x602.5 5	8 2							
x609.2 5	2 1							

[†] 1975Li03 state ΔEγ=0.1 keV for intense, well-resolved lines. Evaluator assign 0.1 keV uncertainty for well-resolved γ rays with

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^{166}Er(α,3nγ) 1975Li03 (continued)

$\gamma(^{167}Yb)$ (continued)

I$\gamma\geq$10, and 0.5 keV for others.

‡ From the Adopted Gammas.

Placement suggested by evaluators from the Adopted Levels, Gammas. This γ unplaced in Table 1 of 1975Li03.

@ Relative intensities are for Eα=39 MeV. 1975Li03 state 10% uncertainty for intense, well-resolved lines. Evaluator assign 10% uncertainty for well-resolved γ rays with I$\gamma\geq$10, and 20-50% for weaker γ rays.

& From $\gamma(\theta)$ distributions and RUL, considering all the levels with measured $T_{1/2}<15$ ns, stretched quadrupole transitions based on large positive A_2 values were assigned (E2), and $\Delta J=1$ or 0, transitions based on negative A_2 values, and in some cases positive A_4 values were assigned (M1+E2), except that in five cases mult=dipole was assigned when the transition could be pure E1 or M1 from negative A_2 coefficient.

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 Multiply placed with undivided intensity.

c Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

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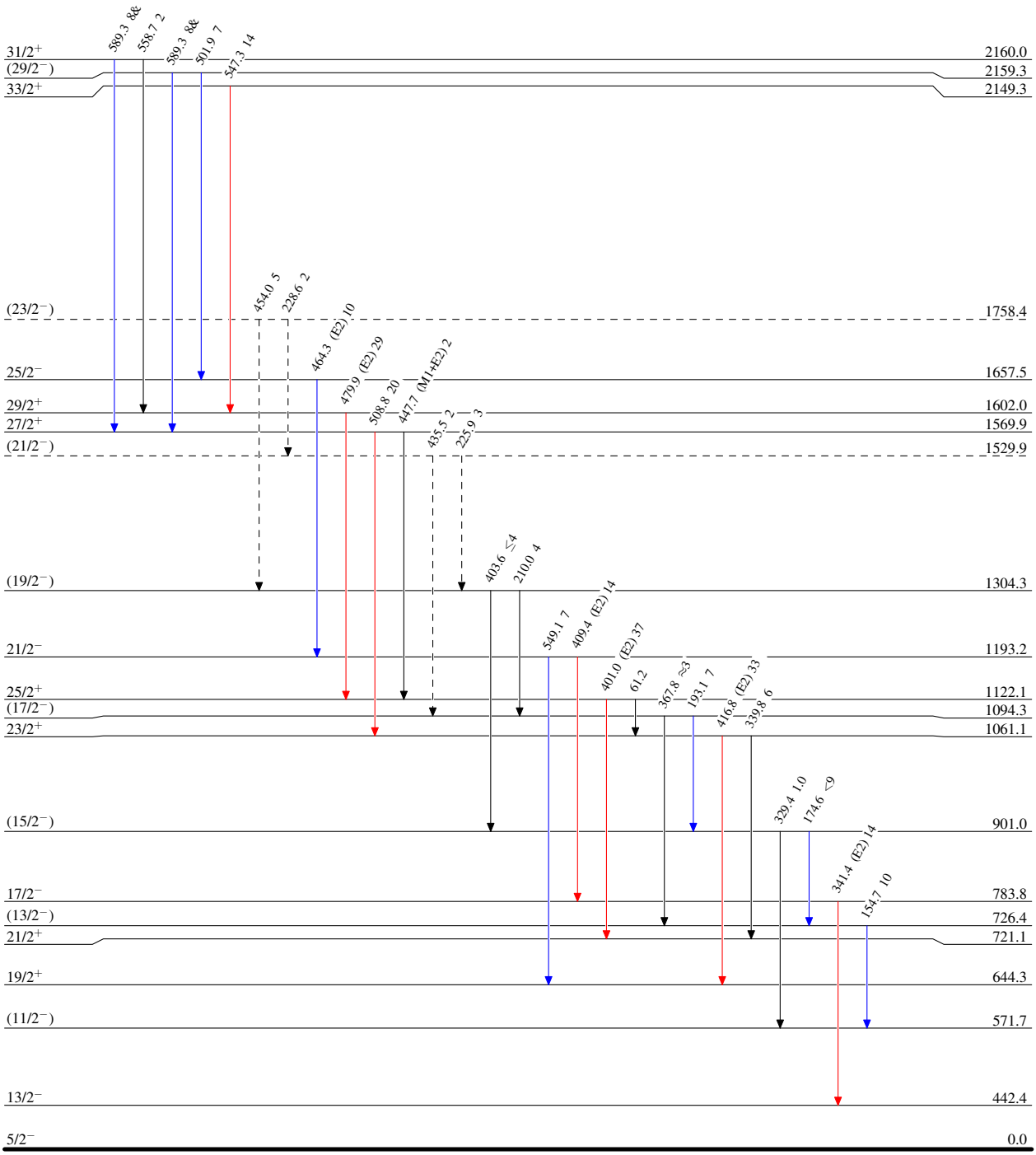
Level Scheme

Intensities: Relative I_γ
& Multiply placed: undivided intensity given

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)



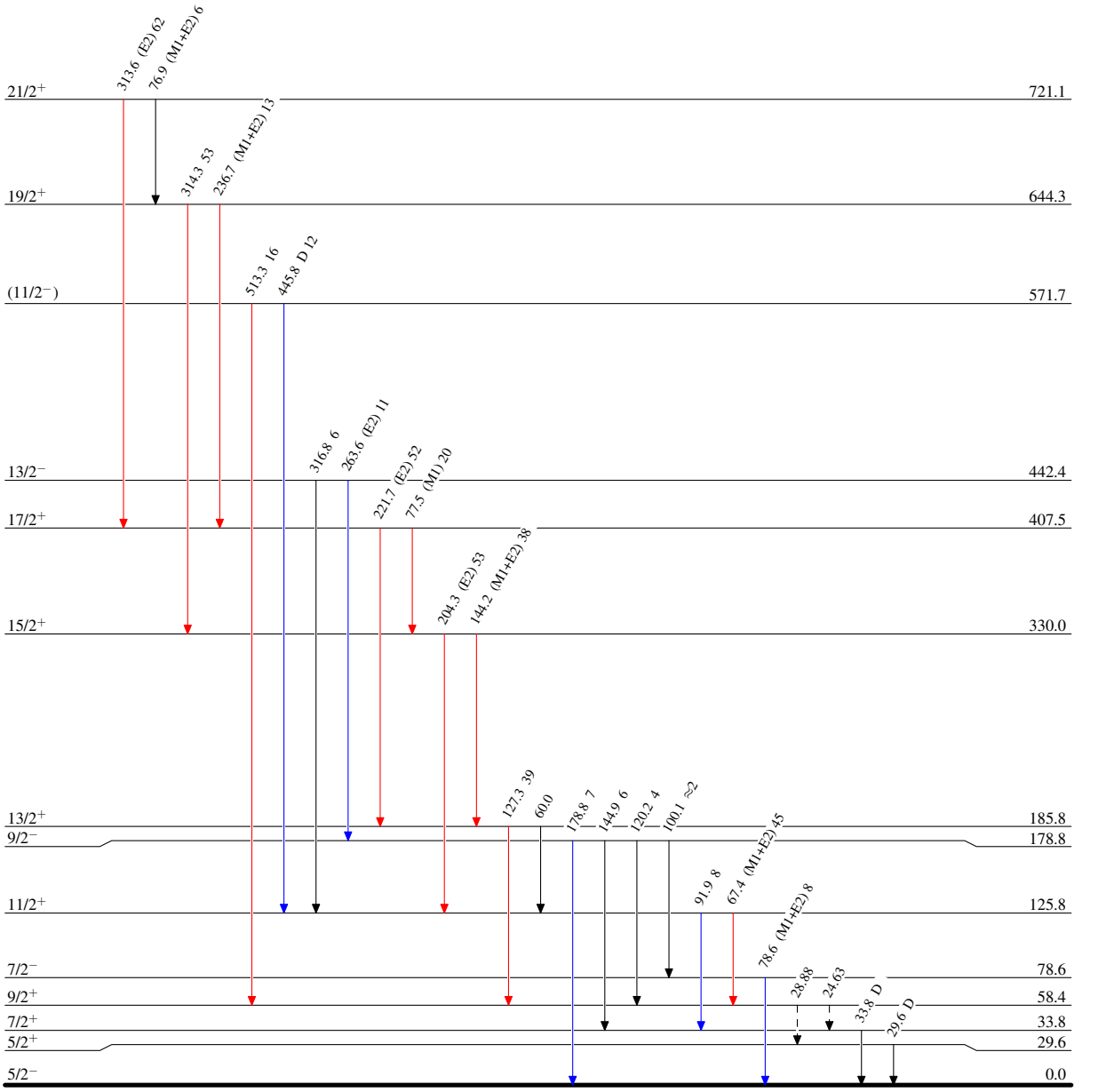
$^{167}_{70}Yb_{97}$

^{166}Er(α,3nγ) 1975Li03

Level Scheme (continued)

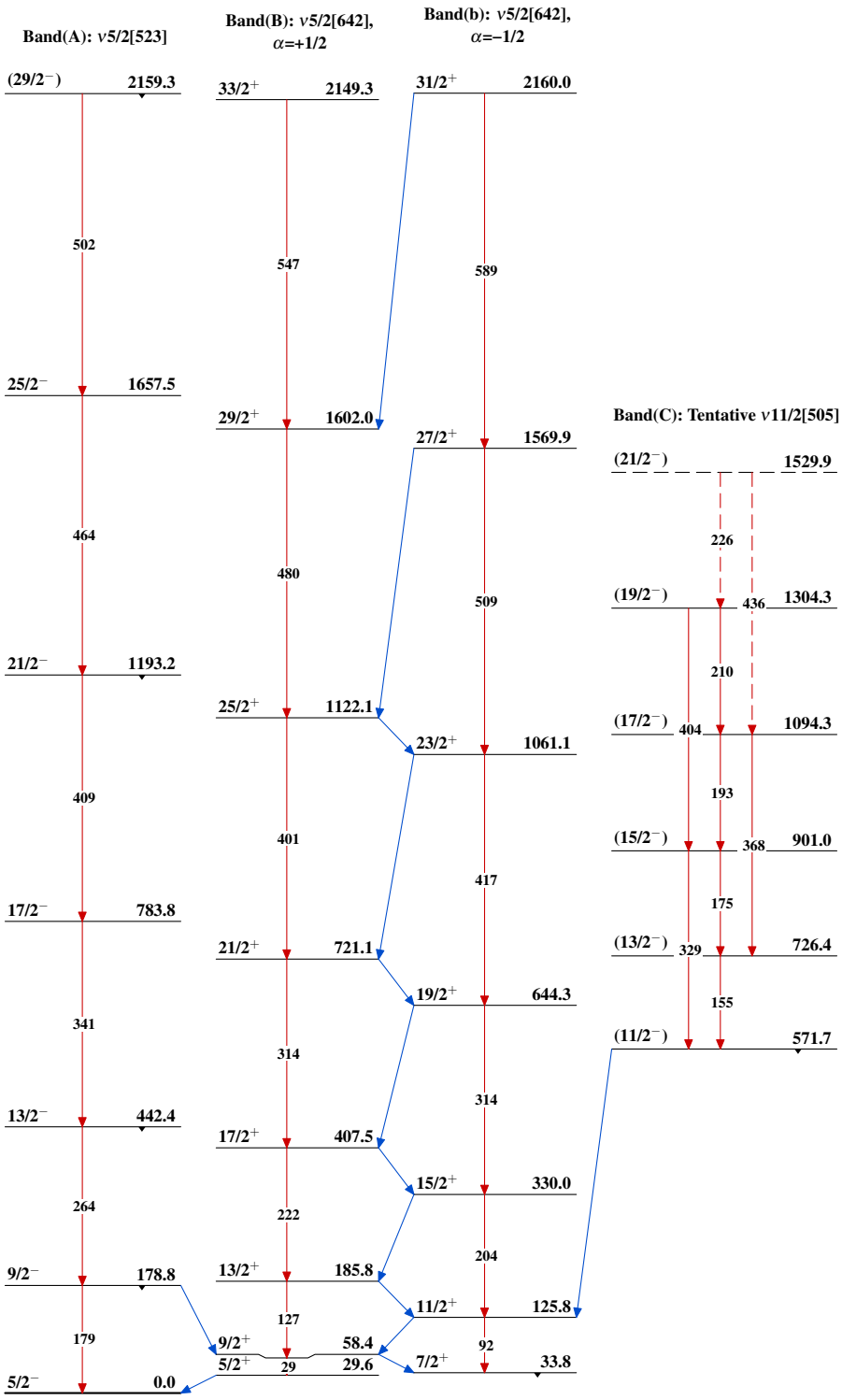
Intensities: Relative I_γ
& Multiply placed: undivided intensity given

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)



$^{167}_{70}Yb_{97}$

^{166}Er(α,3nγ) 1975Li03



$^{167}_{70}Yb_{97}$