

$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ [1989Kr06](#), [1989Sa02](#), [1986Da13](#)

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	E. Achterberg, O. A. Capurro, G. V. Marti		NDS 110, 1473 (2009)	31-May-2008

- [1989Kr06](#): $^{169}\text{Tm}(^{12}\text{C},3n)$, $^{169}\text{Tm}(^{13}\text{C},4n)$, TANDAR tandem accelerator; $^{165}\text{Ho}(^{18}\text{O},5n)$, E=98 MeV. Measured $E\gamma$, $\gamma\gamma$ coin, $\gamma\gamma(\theta)$. Strassbourg Chateau de Crystal Compton-suppressed 11 Ge detector array, plus low-energy planar Ge detector.
- [1989Sa02](#): $^{169}\text{Tm}(^{13}\text{C},4n)$, E=70 MeV, $^{169}\text{Tm}(^{12}\text{C},3n)$, E=62 MeV. Excitation functions for the range 57-87 MeV. HPGe and Ge(Li) detectors. Measured $E\gamma$, $I\gamma$, $\gamma\gamma$ coin. Detected conversion electrons with a cooled Si(Li) detector, but due to the spectrum complexity no reliable information on γ -ray multipolarities could be obtained.
- [1986Da13](#): $^{169}\text{Tm}(^{12}\text{C},3n)$, E=60 MeV, $^{169}\text{Tm}(^{13}\text{C},4n)$, E=70 MeV, TANDAR tandem accelerator. Measured $E\gamma$, $\gamma\gamma$ coin, E(ce). Ge(Li) detectors, magnetic spectrometer.

^{178}Re Levels

E(level) [†]	J π [‡]	Comments
0.0+x [#]	5 ⁺	Additional information 1.
146.7+x ^{@ 23}	6 ⁺	
159.9+x ^{# 10}	7 ⁺	
227.3+x ^{@ 23}	7 ⁺	
339.4+x ^{@ 22}	8 ⁺	
423.1+x ^{# 15}	9 ⁺	
474.8+x ^{@ 22}	9 ⁺	
638.8+x ^{@ 21}	10 ⁺	
784.6+x ^{# 18}	11 ⁺	
818.1+x ^{@ 21}	11 ⁺	
1023.1+x ^{@ 21}	12 ⁺	
1233.8+x ^{# 20}	13 ⁺	
1248.5+x ^{@ 20}	13 ⁺	
1487.1+x ^{@ 20}	14 ⁺	
1740.1+x ^{@ 20}	15 ⁺	
1767.1+x ^{# 20}	15 ⁺	
2013.3+x ^{@ 23}	16 ⁺	
2297.1+x ^{@ 23}	17 ⁺	
2358.9+x ^{# 23}	17 ⁺	
2595.8+x ^{@ 25}	18 ⁺	
2912.4+x ^{@ 25}	19 ⁺	
3005.4+x ^{# 25}	19 ⁺	
3234+x ^{@ 3}	20 ⁺	
3585+x ^{@ 3}	21 ⁺	
3701+x ^{# 3}	21 ⁺	
3931+x ^{@ 3}	22 ⁺	
4309+x ^{@ 3}	23 ⁺	
4451+x ^{# 3}	23 ⁺	
4683+x ^{@ 3}	24 ⁺	
5076+x ^{@ 3}	25 ⁺	
0.0+y ^a	5 ⁻	Additional information 2.
54.3+y ^{a 8}	6 ⁻	
94.4+y ¹⁸	(7) ⁺	
120.4+y ^{a 8}	7 ⁻	

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$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ **1989Kr06,1989Sa02,1986Da13** (continued)

^{178}Re Levels (continued)

E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]	E(level) [†]	J ^π [‡]
133.2+y ^{&} 14	8 ⁻	854.1+y ^{&} 12	12 ⁻	2092.7+y ^a 15	17 ⁻	3744.9+y ^{&} 20	21 ⁻
220.4+y ^a 10	8 ⁻	1017.7+y ^a 13	13 ⁻	2327.8+y ^{&} 16	17 ⁻	3924.6+y ^a 20	22 ⁻
256.9+y ^{&} 13	9 ⁻	1107.5+y ^{&} 13	13 ⁻	2488.1+y ^a 16	18 ⁻	4108.9+y ^{&} 21	22 ⁻
321.5+y ^a 11	9 ⁻	1311.6+y ^a 13	14 ⁻	2674.9+y ^{&} 17	18 ⁻	4263.8+y ^a 23	23 ⁻
422.8+y ^{&} 13	10 ⁻	1385.2+y ^{&} 14	14 ⁻	2751.4+y ^a 17	19 ⁻	4710.7+y ^a 23	24 ⁻
483.7+y ^a 11	10 ⁻	1511.4+y ^a 14	15 ⁻	3023.6+y ^{&} 17	19 ⁻	5104.3+y ^a 25	25 ⁻
618.7+y ^a 12	11 ⁻	1682.2+y ^{&} 15	15 ⁻	3179.6+y ^a 18	20 ⁻	5998.7+y ^a (27 ⁻)	
624.5+y ^{&} 12	11 ⁻	1861.6+y ^a 15	16 ⁻	3388.3+y ^{&} 18	20 ⁻		
847.6+y ^a 12	12 ⁻	1999.3+y ^{&} 15	16 ⁻	3477.9+y ^a 20	21 ⁻		

[†] The level energies are from a least-squares adjustment to the adopted γ -ray energies.

[‡] Levels have been interpreted in terms of rotational bands built on single particle excitations from the coupling of proton and neutron quasi-particle states. Spin and parity assignments are based on this interpretation, and on γ -ray multiplicities and decay patterns.

Band(A): $K^\pi=5^+$ rotational band. Configuration= π h9/2 \otimes v 1/2⁻ [521], doubly decoupled band (1989Kr06).

@ Band(B): $K^\pi=6^+$ rotational band. Configuration= π 5/2⁺ [402] \otimes v i13/2.

& Band(C): $K^\pi=8^-$ rotational band. Configuration= π 9/2⁻ [514] \otimes v i13/2.

^a Band(D): $K^\pi=5^-$ rotational band. Configuration= π h9/2 \otimes v i13/2, semidecoupled band (1989Kr06).

$\gamma(^{178}\text{Re})$

E_γ [†]	I_γ [‡]	E_i (level)	J_i^π	E_f	J_f^π	Mult. [#]	α ^{&}	Comments
38.8	100 [@] 23	133.2+y	8 ⁻	94.4+y	(7) ⁺	E1	0.967	$E_\gamma=38.8$ (1989Sa02).
54.4	42 [@] 17	54.3+y	6 ⁻	0.0+y	5 ⁻	M1	5.26	$E_\gamma=54.1$ (1989Sa02).
66.1	50 [@] 17	120.4+y	7 ⁻	54.3+y	6 ⁻	M1	2.97	$E_\gamma=65.9$ (1989Sa02).
80.7		227.3+x	7 ⁺	146.7+x	6 ⁺			
100.0	29 2	220.4+y	8 ⁻	120.4+y	7 ⁻	M1	5.17	$E_\gamma=99.7$ (1989Sa02).
101.2	29 2	321.5+y	9 ⁻	220.4+y	8 ⁻	M1	4.99	$E_\gamma=101.4$ (1989Sa02).
112.2		339.4+x	8 ⁺	227.3+x	7 ⁺			
120.3	17 [@] 6	120.4+y	7 ⁻	0.0+y	5 ⁻	E2	1.99	$E_\gamma=120.0$ (1989Sa02).
123.8	48 4	256.9+y	9 ⁻	133.2+y	8 ⁻	M1	2.81	$E_\gamma=123.3$ (1989Sa02).
134.9	23 2	618.7+y	11 ⁻	483.7+y	10 ⁻	M1	2.20	$E_\gamma=135.1$ (1989Sa02).
135.5		474.8+x	9 ⁺	339.4+x	8 ⁺			
140.5 ^b		624.5+y	11 ⁻	483.7+y	10 ⁻			
159.9	23 2	159.9+x	7 ⁺	0.0+x	5 ⁺	E2	0.695	$E_\gamma=159.7$ (1989Sa02).
161.9	31 4	483.7+y	10 ⁻	321.5+y	9 ⁻	M1	1.311	$E_\gamma=161.7$ (1989Sa02).
163.7		1017.7+y	13 ⁻	854.1+y	12 ⁻			
163.8		638.8+x	10 ⁺	474.8+x	9 ⁺			
166.1		220.4+y	8 ⁻	54.3+y	6 ⁻			E_γ : Misprinted as 161.1 in level scheme shown in 1989Kr06.
166.1	67 6	422.8+y	10 ⁻	256.9+y	9 ⁻	M1	1.219	$E_\gamma=165.9$ (1989Sa02).
170.0		1017.7+y	13 ⁻	847.6+y	12 ⁻			
179.3		818.1+x	11 ⁺	638.8+x	10 ⁺			
192.6		339.4+x	8 ⁺	146.7+x	6 ⁺			
196.1	52 6	618.7+y	11 ⁻	422.8+y	10 ⁻	M1	0.766	$E_\gamma=196.1$ (1989Sa02).
199.6		1511.4+y	15 ⁻	1311.6+y	14 ⁻			
201.1	19 6	321.5+y	9 ⁻	120.4+y	7 ⁻	E2	0.314	$E_\gamma=201.1$ (1989Sa02).
201.5	33 12	624.5+y	11 ⁻	422.8+y	10 ⁻	M1	0.710	$E_\gamma=202.1$ (1989Sa02).

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$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ **1989Kr06,1989Sa02,1986Da13** (continued) $\gamma(^{178}\text{Re})$ (continued)

E_γ †	I_γ ‡	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. #	α &	Comments
204.9		1023.1+x	12 ⁺	818.1+x	11 ⁺			
223.2	27 4	847.6+y	12 ⁻	624.5+y	11 ⁻	M1	0.535	$E_\gamma=223.5$ (1989Sa02).
225.1		1248.5+x	13 ⁺	1023.1+x	12 ⁺			
229.0		847.6+y	12 ⁻	618.7+y	11 ⁻			
229.7		854.1+y	12 ⁻	624.5+y	11 ⁻			
231.2		2092.7+y	17 ⁻	1861.6+y	16 ⁻			
235.4		854.1+y	12 ⁻	618.7+y	11 ⁻			
238.7		1487.1+x	14 ⁺	1248.5+x	13 ⁺			
^x 243.0	21 2							Observed by 1989Sa02 only. Contaminated with lines from ^{179}Re ϵ decay.
247.5		474.8+x	9 ⁺	227.3+x	7 ⁺			
253.2 ^a	40 ^a 4	1740.1+x	15 ⁺	1487.1+x	14 ⁺			Placed in level scheme by 1989Kr06. $E_\gamma=253.7$ (1989Sa02).
253.3 ^a	40 ^a 4	1107.5+y	13 ⁻	854.1+y	12 ⁻			Placed in level scheme by 1989Kr06. $E_\gamma=253.7$ (1989Sa02). Contaminated with lines from ^{179}Re ϵ decay.
259.8		1107.5+y	13 ⁻	847.6+y	12 ⁻			
263 ^b		2751.4+y	19 ⁻	2488.1+y	18 ⁻			Shown, but not labeled, in level scheme by 1989Kr06.
263.1		483.7+y	10 ⁻	220.4+y	8 ⁻			
263.2	27 8	423.1+x	9 ⁺	159.9+x	7 ⁺	E2	0.1313	$E_\gamma=263.0$ (1989Sa02).
273.0 ^b		2013.3+x	16 ⁺	1740.1+x	15 ⁺			
277.7		1385.2+y	14 ⁻	1107.5+y	13 ⁻			
283.8 ^b		2297.1+x	17 ⁺	2013.3+x	16 ⁺			
289.4		422.8+y	10 ⁻	133.2+y	8 ⁻			
293.7		1311.6+y	14 ⁻	1017.7+y	13 ⁻			
296.7	42 4	618.7+y	11 ⁻	321.5+y	9 ⁻	E2	0.0911	$E_\gamma=296.8$ (1989Sa02).
296.7		1682.2+y	15 ⁻	1385.2+y	14 ⁻			
298 ^b		3477.9+y	21 ⁻	3179.6+y	20 ⁻			Shown, but not labeled, in level scheme by 1989Kr06.
299.4		638.8+x	10 ⁺	339.4+x	8 ⁺			
304.0		624.5+y	11 ⁻	321.5+y	9 ⁻			
316.9		1999.3+y	16 ⁻	1682.2+y	15 ⁻			
328.4		2327.8+y	17 ⁻	1999.3+y	16 ⁻			
343.4		818.1+x	11 ⁺	474.8+x	9 ⁺			
347.4		2674.9+y	18 ⁻	2327.8+y	17 ⁻			
348.8		3023.6+y	19 ⁻	2674.9+y	18 ⁻			
350.1		1861.6+y	16 ⁻	1511.4+y	15 ⁻			
361.5	17 2	784.6+x	11 ⁺	423.1+x	9 ⁺	E2	0.0514	$E_\gamma=360.8$ (1989Sa02).
361.9		618.7+y	11 ⁻	256.9+y	9 ⁻			
363.6		847.6+y	12 ⁻	483.7+y	10 ⁻			
364.6		3388.3+y	20 ⁻	3023.6+y	19 ⁻			
367.4		624.5+y	11 ⁻	256.9+y	9 ⁻			
370.3		854.1+y	12 ⁻	483.7+y	10 ⁻			
384.3		1023.1+x	12 ⁺	638.8+x	10 ⁺			
393.5		1017.7+y	13 ⁻	624.5+y	11 ⁻			
395.4		2488.1+y	18 ⁻	2092.7+y	17 ⁻			
398.8	38 4	1017.7+y	13 ⁻	618.7+y	11 ⁻	E2	0.0392	$E_\gamma=397.4$ (1989Sa02).
424.9		847.6+y	12 ⁻	422.8+y	10 ⁻			
428.3		3179.6+y	20 ⁻	2751.4+y	19 ⁻			
430.7		1248.5+x	13 ⁺	818.1+x	11 ⁺			
431.3		854.1+y	12 ⁻	422.8+y	10 ⁻			
449.1	15 2	1233.8+x	13 ⁺	784.6+x	11 ⁺	E2	0.0287	$E_\gamma=447.6$ (1989Sa02).
457.6		1311.6+y	14 ⁻	854.1+y	12 ⁻			
464		1248.5+x	13 ⁺	784.6+x	11 ⁺			
464.0		1487.1+x	14 ⁺	1023.1+x	12 ⁺			

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$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ **1989Kr06,1989Sa02,1986Da13** (continued) $\gamma(^{178}\text{Re})$ (continued)

E_γ [†]	I_γ [‡]	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [#]	α ^{&}	Comments
464.1		1311.6+y	14 ⁻	847.6+y	12 ⁻			
483.1		1107.5+y	13 ⁻	624.5+y	11 ⁻			
491.5		1740.1+x	15 ⁺	1248.5+x	13 ⁺			
493.7	33 10	1511.4+y	15 ⁻	1017.7+y	13 ⁻	E2	0.0226	$E_\gamma=492.9$ (1989Sa02).
506.1		1740.1+x	15 ⁺	1233.8+x	13 ⁺			
518.4		1767.1+x	15 ⁺	1248.5+x	13 ⁺			
526.2		2013.3+x	16 ⁺	1487.1+x	14 ⁺			
531.2		1385.2+y	14 ⁻	854.1+y	12 ⁻			
533.5		1767.1+x	15 ⁺	1233.8+x	13 ⁺			
550.1		1861.6+y	16 ⁻	1311.6+y	14 ⁻			
557.0		2297.1+x	17 ⁺	1740.1+x	15 ⁺			
574.8		1682.2+y	15 ⁻	1107.5+y	13 ⁻			
581.3		2092.7+y	17 ⁻	1511.4+y	15 ⁻			
582.5		2595.8+x	18 ⁺	2013.3+x	16 ⁺			
591.8		2358.9+x	17 ⁺	1767.1+x	15 ⁺			
614.2		1999.3+y	16 ⁻	1385.2+y	14 ⁻			
615.3		2912.4+x	19 ⁺	2297.1+x	17 ⁺			
626.4		2488.1+y	18 ⁻	1861.6+y	16 ⁻			
638.6		3234+x	20 ⁺	2595.8+x	18 ⁺			
645.7		2327.8+y	17 ⁻	1682.2+y	15 ⁻			
646.5		3005.4+x	19 ⁺	2358.9+x	17 ⁺			
658.7		2751.4+y	19 ⁻	2092.7+y	17 ⁻			
672.5		3585+x	21 ⁺	2912.4+x	19 ⁺			
675.6		2674.9+y	18 ⁻	1999.3+y	16 ⁻			
691.5		3179.6+y	20 ⁻	2488.1+y	18 ⁻			
695.6		3023.6+y	19 ⁻	2327.8+y	17 ⁻			
696.0		3701+x	21 ⁺	3005.4+x	19 ⁺			
696.6		3931+x	22 ⁺	3234+x	20 ⁺			
713.5		3388.3+y	20 ⁻	2674.9+y	18 ⁻			
720.6		4108.9+y	22 ⁻	3388.3+y	20 ⁻			
721.3		3744.9+y	21 ⁻	3023.6+y	19 ⁻			
724.4		4309+x	23 ⁺	3585+x	21 ⁺			
726.5		3477.9+y	21 ⁻	2751.4+y	19 ⁻			
745.0		3924.6+y	22 ⁻	3179.6+y	20 ⁻			
749.3		4451+x	23 ⁺	3701+x	21 ⁺			
751.7		4683+x	24 ⁺	3931+x	22 ⁺			
766.4		5076+x	25 ⁺	4309+x	23 ⁺			
785.9		4263.8+y	23 ⁻	3477.9+y	21 ⁻			
786.1		4710.7+y	24 ⁻	3924.6+y	22 ⁻			
840.5		5104.3+y	25 ⁻	4263.8+y	23 ⁻			
895.0 ^b		5998.7+y?	(27 ⁻)	5104.3+y	25 ⁻			

[†] From $^{165}\text{Ho}(^{18}\text{O},5n\gamma)$ (1989Kr06). No uncertainties are reported by the authors.

[‡] From $^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ (1989Sa02). Normalized to $I_\gamma=100$ for the 38.8 γ ray.

[#] From transition intensity balance deduced in γ -ray singles and coincidence measurements (1989Sa02).

[@] Lower limit from $\gamma\gamma$ coin (1989Sa02).

[&] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ -ray energies, assigned multiplicities, and mixing ratios, unless otherwise specified.

^a Multiply placed with undivided intensity.

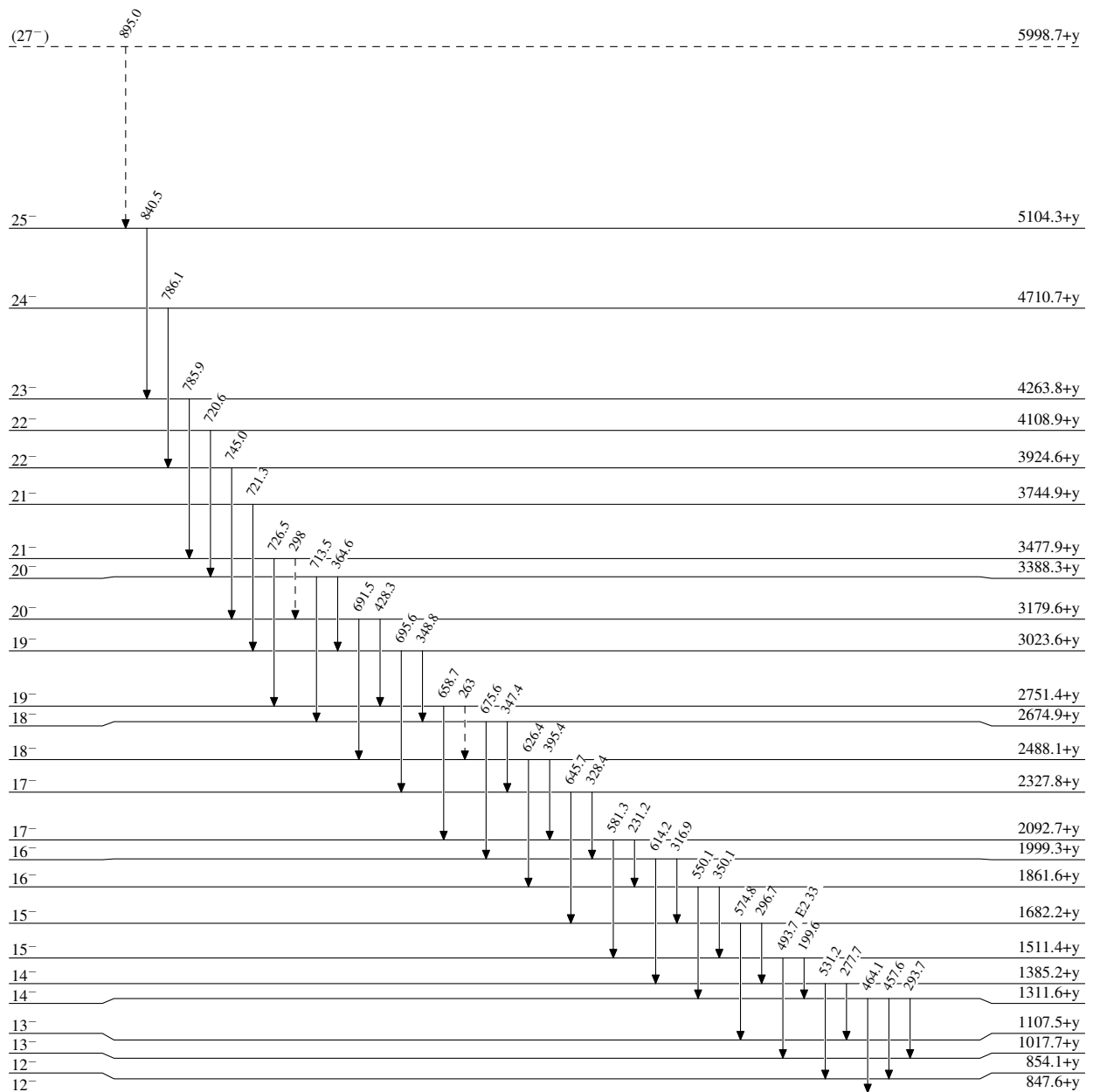
^b Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ 1989Kr06,1989Sa02,1986Da13

Legend

Level Scheme

Intensities: Relative I_γ -----► γ Decay (Uncertain) $^{178}_{75}\text{Re}_{103}$

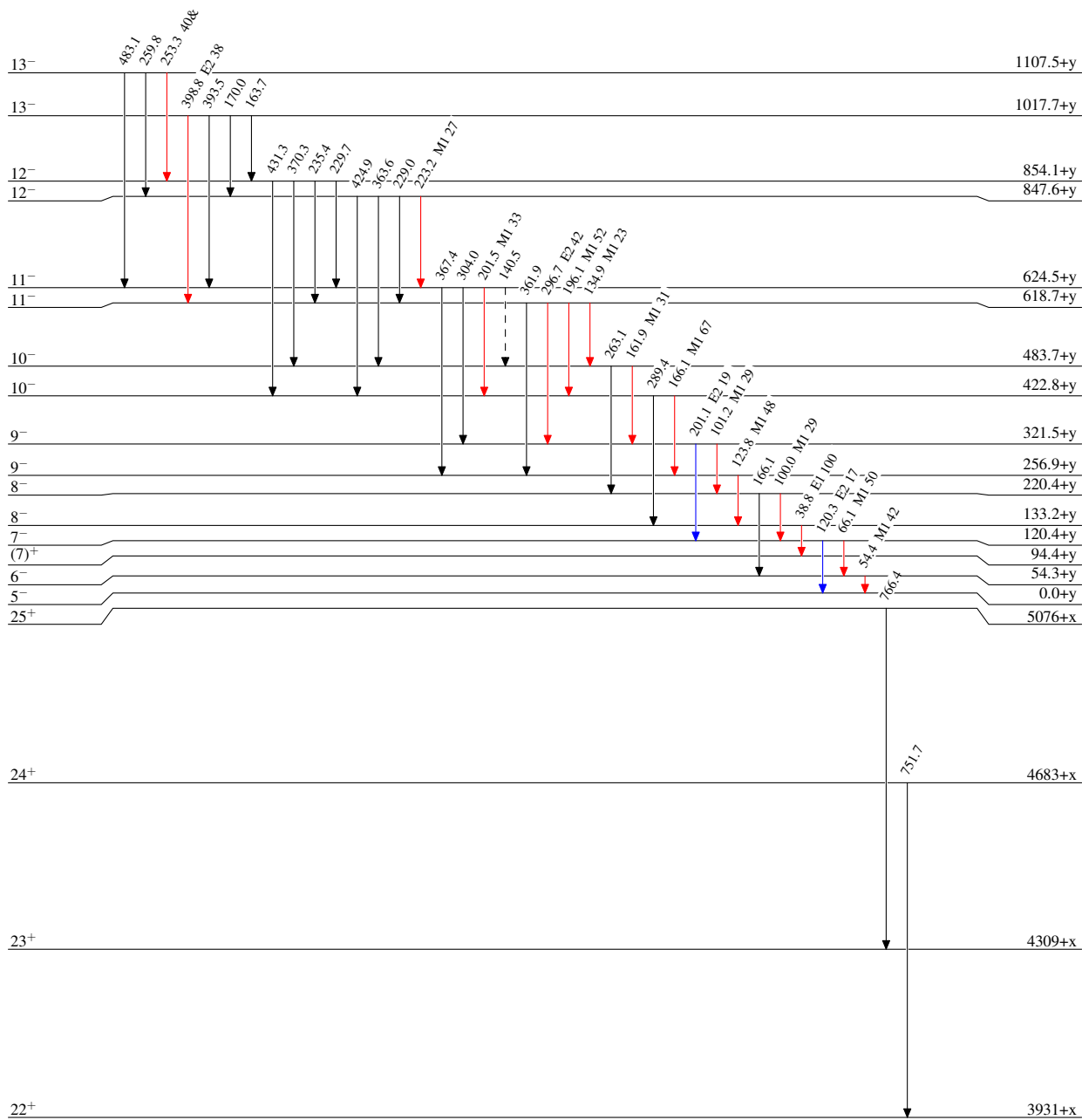
$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ 1989Kr06,1989Sa02,1986Da13

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)



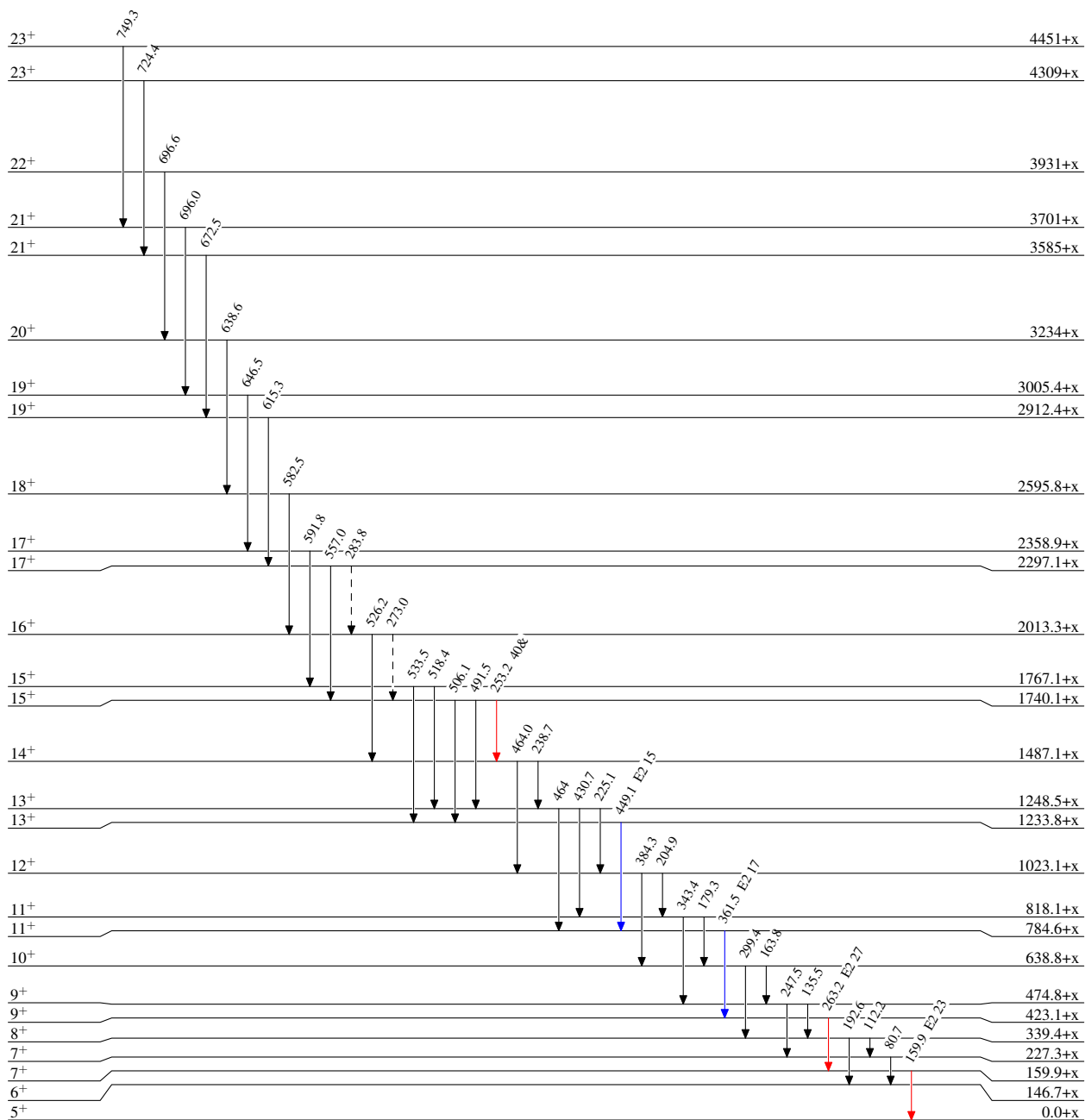
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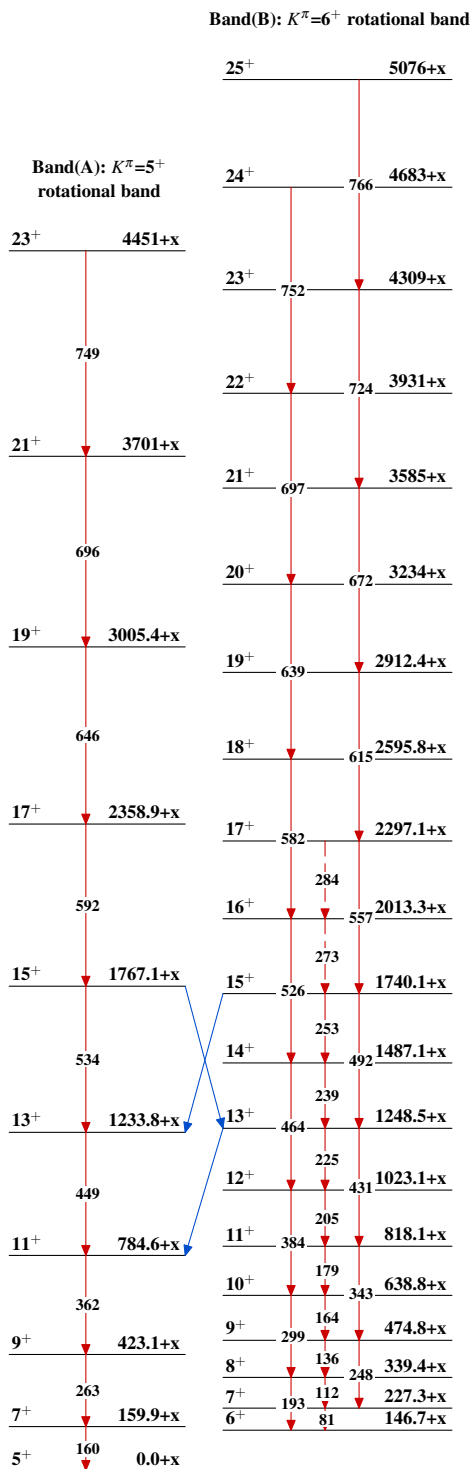
Level Scheme (continued)

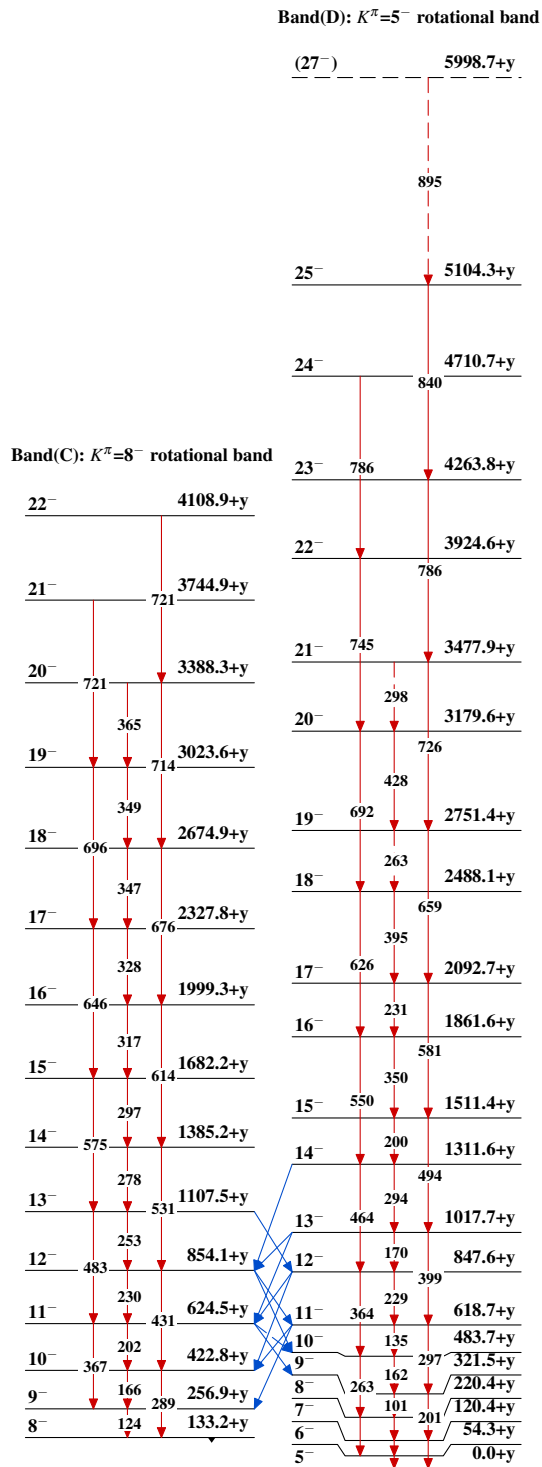
Intensities: Relative I_γ
& Multiply placed: undivided intensity given

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)

 $^{178}_{75}\text{Re}_{103}$

$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ 1989Kr06,1989Sa02,1986Da13 $^{178}_{75}\text{Re}_{103}$

$^{165}\text{Ho}(^{18}\text{O},5n\gamma), ^{169}\text{Tm}(^{13}\text{C},4n\gamma)$ 1989Kr06,1989Sa02,1986Da13 (continued) $^{178}_{75}\text{Re}_{103}$