Coulomb excitation **1977Ta10,1999Ro03**

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 109, 2033 (2008)	15-Jun-2008

Others: 1955He64, 1956Hu49, 1958Ma36, 1960Be16, 1960Na13, 1960Ol02, 1961Po08, 1964Ho18, 1964Ho25, 1965As03, 1965De05, 1966Bo16, 1979Wa15.
1958Ch36: E(p)=3.7 MeV.
1960Bl10: E(p)=2.5 MeV.
1963De25: E(^{16}O)=44 MeV.
1963Di09: E(^{16}O)=60 MeV.
1965As03: E(α)=3.1 MeV.
1967Se09: E(^{16}O)=50 MeV.
1977Ta10: E(^{32}S)=130-140 MeV; thulium metal targets; measured Eγ, Iγ (Ge(Li), resolution≈2 keV at 1.3 MeV), ^{32}S-γ coin, γ-ray angular distributions (0° to 90°, 15° steps), level lifetimes).
1979BaYN: E(^{16}O)=60 MeV.
1999Ro03: E(^{58}Ni)=170, 190, 220 MeV; ^{169}Tm/annealed Gd foil/Cu targets; Ge detectors (at ±60° and ±120° for transient field measurements, at 0° to 65° for angular correlation study), Si surface barrier detector for charged particle detection; measured g-factors ($\gamma(\theta$,H,t), H=0.08 T), Eγ, Iγ, ^{58}Ni-$\gamma(\theta)$, relative Coulomb excitation cross sections; g-factors determined relative to values of 0.304 *18* and 0.383 *14*, respectively, for the 5/2$^+$ and 7/2$^+$ members of the g.s. band.
The level scheme is from 1977Ta10, except where noted.

^{169}Tm Levels

Band(ad) 1/2[411] band.

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
0.0	1/2$^+$		
8.39[‡] *5*	3/2$^+$	4.09 ns *5*	$T_{1/2}$: from Adopted Levels.
118.16 *4*	5/2$^+$	62 ps *3*	$T_{1/2}$: 62.4 ps *28* from microwave pulsed beam measurements (1960Bl10); see ^{169}Tm Adopted Levels for other $T_{1/2}$ data.
138.72 *23*	7/2$^+$	302 ps *2*	$T_{1/2}$: recoil-shadow measurements (1979BaYN); uncertainty includes only statistical component (total uncertainty is most certainly larger). See ^{169}Tm Adopted Levels for other $T_{1/2}$ data.
331.80 *24*	9/2$^+$	18.8 ps *5*	g-factor=+0.347 *20* (1999Ro03). $T_{1/2}$: recoil-distance measurements (1977Ta10).
367.0 *4*	11/2$^+$	41.6 ps *21*	g-factor=+0.414 *26* (1999Ro03). $T_{1/2}$: recoil-distance measurement (1977Ta10).
571.00[#] *23*	3/2$^+$	10 ps *7*	B(E2)↑=0.033 *4* B(E2)↑: from 1967Se09. Others: 1963Di09 (=0.028 *6*), 1963De25. J$^\pi$: E2 excitation from ratio of thick target yields At two ^{16}O beam energies for ce(K) of 562 and 570 transitions (1963Di09). $T_{1/2}$: deduced from B(E2)↑ and adopted γ-ray properties.
633.1[#] *5*	5/2$^+$	0.27 ps	B(E2)↑=0.0039 B(E2)↑: from 1963Di09. $T_{1/2}$: from B(E2)↑=0.0039 and adopted γ-ray properties.
636.5 *4*	13/2$^+$	5.4 ps *3*	g-factor=+0.365 *22* (1999Ro03). $T_{1/2}$: recoil-distance and Doppler-broadened line shape measurements (1977Ta10).
690.3 *9*	15/2$^+$	8.1 ps *3*	g-factor=+0.42 *4* (1999Ro03). $T_{1/2}$: recoil-distance and Doppler-broadened line shape measurements (1977Ta10).
717.9[#] *8*	(7/2$^+$)		
≈900?			B(E2)↑=0.008 *4* (1963Di09)
1027.4 *9*	17/2$^+$	1.91 ps *17*	g-factor=+0.37 *4* (1999Ro03). $T_{1/2}$: Doppler-broadened line shape measurements (1977Ta10).

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Coulomb excitation 1977Ta10,1999Ro03 (continued)

^{169}Tm Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	$T_{1/2}$	Comments
1103.0 *12*	19/2$^+$	1.94 ps *21*	g-factor=+0.44 *8* (1999Ro03). $T_{1/2}$: Doppler-broadened line shape measurements (1977Ta10).
1190 *20*	+		B(E2)↑=0.040 *9* B(E2)↑: Weighted average of 0.039 *13* (1963De25) and 0.041 *12* (1963Di09).
1497.0 *12*	21/2$^+$	0.87 ps *9*	$T_{1/2}$: Doppler-broadened line shape measurements (1977Ta10).
1597.0 *15*	(23/2$^+$)		

[†] From least-squares fit to Eγ, assigning 1 keV uncertainty to Eγ data for which the authors stated No uncertainty.
[‡] Adopted values.
[#] Band(A): 3/2[411] + K-2 γ vibration built on 1/2[411].

$\gamma(^{169}Tm)$

E$_\gamma$[†]	I$_\gamma$[‡]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[#]	δ[#]	α[c]	Comments
(8.41)		8.39	3/2$^+$	0.0	1/2$^+$				E$_\gamma$: adopted value (rounded).
20.8		138.72	7/2$^+$	118.16	5/2$^+$				E$_\gamma$: from 1999Ro03. Iγ/I(130γ)=0.0168 *13* (1999Ro03).
109.77[@] *3*	100	118.16	5/2$^+$	8.39	3/2$^+$	M1+E2	−0.141 *25*	2.37	εB(E2)↑=1.1 *3* (1955He64). A$_2$=−0.456 *24*, A$_4$=0.00 *3* (1977Ta10). δ: unweighted average of −0.116 *4* from 1999Ro03 (^{58}Ni-$\gamma(\theta)$) and −0.146 *16* from 1965As03 (α-$\gamma(\theta)$; A$_2$=−0.339 *14*).
118.16[@] *4*	10.21 *5*	118.16	5/2$^+$	0.0	1/2$^+$	E2[b]		1.643	I$_\gamma$: from 1999Ro03. Others: 11.0 *20* (1967Se09), 11.0 *10* (1977Ta10). A$_2$=+0.44 *12*, A$_4$=−0.39 *15* (1977Ta10).
130.2[a] *3*	287 *4*	138.72	7/2$^+$	8.39	3/2$^+$	E2[b]		1.154 *19*	A$_2$=+0.351 *16*, A$_4$=−0.110 *20* (1977Ta10).
193.0[a] *3*	251 *4*	331.80	9/2$^+$	138.72	7/2$^+$	M1+E2	−0.126 *21*	0.480 *8*	A$_2$=+0.534 *17*, A$_4$=−0.016 *20* (1977Ta10). δ: unweighted average of −0.146 *3* (1999Ro03), −0.105 *11* (1977Ta10).
213.7[a] *3*	123.2 *21*	331.80	9/2$^+$	118.16	5/2$^+$	E2[b]		0.209	Iγ/I(193γ)=0.452 *5* (1999Ro03), 0.56 *5* (1967Se09). A$_2$=+0.455 *24*, A$_4$=−0.21 *3* (1977Ta10).
228.3[a] *3*	470 *5*	367.0	11/2$^+$	138.72	7/2$^+$	E2[b]		0.1683	A$_2$=+0.451 *13*, A$_4$=−0.198 *16* (1977Ta10).
269.5[a] *3*	146.2 *25*	636.5	13/2$^+$	367.0	11/2$^+$	M1+E2	−0.149 *21*	0.191	Iγ/I(305γ)=0.996 *12* (1999Ro03); other: 0.79 *8* (1967Se09). A$_2$=−0.532 *24*, A$_4$=−0.04 *3* (1977Ta10). δ: unweighted average of −0.174 *3* (1999Ro03), −0.123 *14* (1977Ta10).

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Coulomb excitation 1977Ta10,1999Ro03 (continued)

$\gamma(^{169}Tm)$ (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [#]	δ [#]	α [c]	Comments
304.7[a] *3*	156 *3*	636.5	13/2$^+$	331.80	9/2$^+$	E2[b]		0.0682	A_2=+0.431 *27*, A_4=−0.17 *3* (1977Ta10).
323.3	146 *3*	690.3	15/2$^+$	367.0	11/2$^+$	E2[b]		0.0571	A_2=+0.45 *4*, A_4=−0.21 *5* (1977Ta10).
337.2	35 *3*	1027.4	17/2$^+$	690.3	15/2$^+$	M1+E2	−0.18 *3*	0.1043 *16*	Iγ/I(391γ)=0.587 *7* (1999Ro03). A_2=−0.58 *9*, A_4=−0.10 *11* (1977Ta10). δ: weighted average of −0.199 *20* (1999Ro03) and −0.127 *35* (1977Ta10) (as recommended in 1999Ro03).
390.9	67.0 *18*	1027.4	17/2$^+$	636.5	13/2$^+$	E2[b]		0.0331	A_2=+0.42 *5*, A_4=−0.50 *6* (1977Ta10).
394.0	3.5 *18*	1497.0	21/2$^+$	1103.0	19/2$^+$				E_γ: from 1999Ro03. I_γ: from 0.14<Iγ/I(470γ)<0.44 in 1999Ro03 if I(470γ)=12.1. Iγ=3.3 estimated from rotational-model expectations (peak masked by intense 390.9γ in 1977Ta10); 1999Ro03 report 1.7<Iγ<5.3.
412.7	21.7 *11*	1103.0	19/2$^+$	690.3	15/2$^+$	E2[b]		0.0285	A_2=+0.28 *11*, A_4=−0.09 *13* (1977Ta10).
452.8[a] *3*		571.00	3/2$^+$	118.16	5/2$^+$	M1+E2	1.5 *+9−4*	0.030 *5*	Mult.,δ: from α(K)exp=0.025 *4*, as deduced from ε(K)B(E2)↑=6.2×10^{-5} *9* (1963Di09) and ε(γ)B(E2)↑=2.45×10^{-3} *25* (1967Se09).
469.5	12.1 *17*	1497.0	21/2$^+$	1027.4	17/2$^+$	E2[b]		0.0202	A_2=+0.7 *3*, A_4=−0.3 *3* (1977Ta10).
494[&] *1*		633.1	5/2$^+$	138.72	7/2$^+$				ε(K)B(E2)↑=1.8×10^{-5} *10* (1963Di09).
494		1597.0	(23/2$^+$)	1103.0	19/2$^+$				E_γ: from 1999Ro03.
515[&] *1*		633.1	5/2$^+$	118.16	5/2$^+$				ε(K)B(E2)↑=3.6×10^{-5} *10* (1963Di09).
562.7[a] *5*		571.00	3/2$^+$	8.39	3/2$^+$	M1+E2	0.8 *+5−4*	0.022 *4*	Mult.,δ: from α(K)exp=0.018 *3*, as deduced from ε(K)B(E2)↑=2.4×10^{-4} *3* (1963Di09) and ε(γ)B(E2)↑=0.0132 *13* (1967Se09). Other: 0.010 (1960Na13).
571.0[a] *5*		571.00	3/2$^+$	0.0	1/2$^+$	M1+E2	0.8 *+5−4*	0.021 *4*	Mult.,δ: from α(K)exp=0.017 *3*, as deduced from ε(K)B(E2)↑=2.9×10^{-4} *3* (1963Di09) and ε(γ)B(E2)↑=0.0167 *22* (1967Se09).
579[&] *1*		717.9	(7/2$^+$)	138.72	7/2$^+$				
600[&] *1*		717.9	(7/2$^+$)	118.16	5/2$^+$				

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Coulomb excitation 1977Ta10,1999Ro03 (continued)

$\gamma(^{169}Tm)$ (continued)

E_γ [†]	E_i(level)	J_i^π	E_f	J_f^π	Comments
625[&] *1*	633.1	$5/2^+$	8.39	$3/2^+$	ε(K)B(E2)↑=3.8×10^{-5} *9* (1963Di09).
633[&] *1*	633.1	$5/2^+$	0.0	$1/2^+$	ε(K)B(E2)↑=1.0×10^{-5} *7* (1963Di09).
≈900[d]	≈900?		0.0	$1/2^+$	E_γ: from 1963Di09.
1190 *20*	1190	$^+$	0.0	$1/2^+$	E_γ: from 1963De25. Other value:≈1170 (1963Di09).

[†] From 1977Ta10, except as noted.
[‡] Arbitrary units for E(^{32}S)=140 MeV (1977Ta10), except as noted.
[#] From $\gamma(\theta)$ angular distributions, except where noted; $\Delta\pi$=No from RUL. Q assignments were based on large positive A_2, and intraband D+Q assignments on negative A_2 and placement relative to cascading Q γ's between Coulomb-excited states. 1999Ro03 do not quote A_2 from their ^{58}Ni-$\gamma(\theta)$ data, but clearly establish that 118γ, 131γ, 214γ, 229γ, 305γ and 323γ are stretched Q, and the 110γ, 193γ, 269γ and 337γ are D+Q.
[@] Cryst (1958Ch36).
[&] Mag spect (E(ce) measured) (1963Di09).
[a] Ge(Li) (1967Se09).
[b] Stretched Q from $\gamma(\theta)$, not M2 from RUL.
[c] 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.
[d] Placement of transition in the level scheme is uncertain.

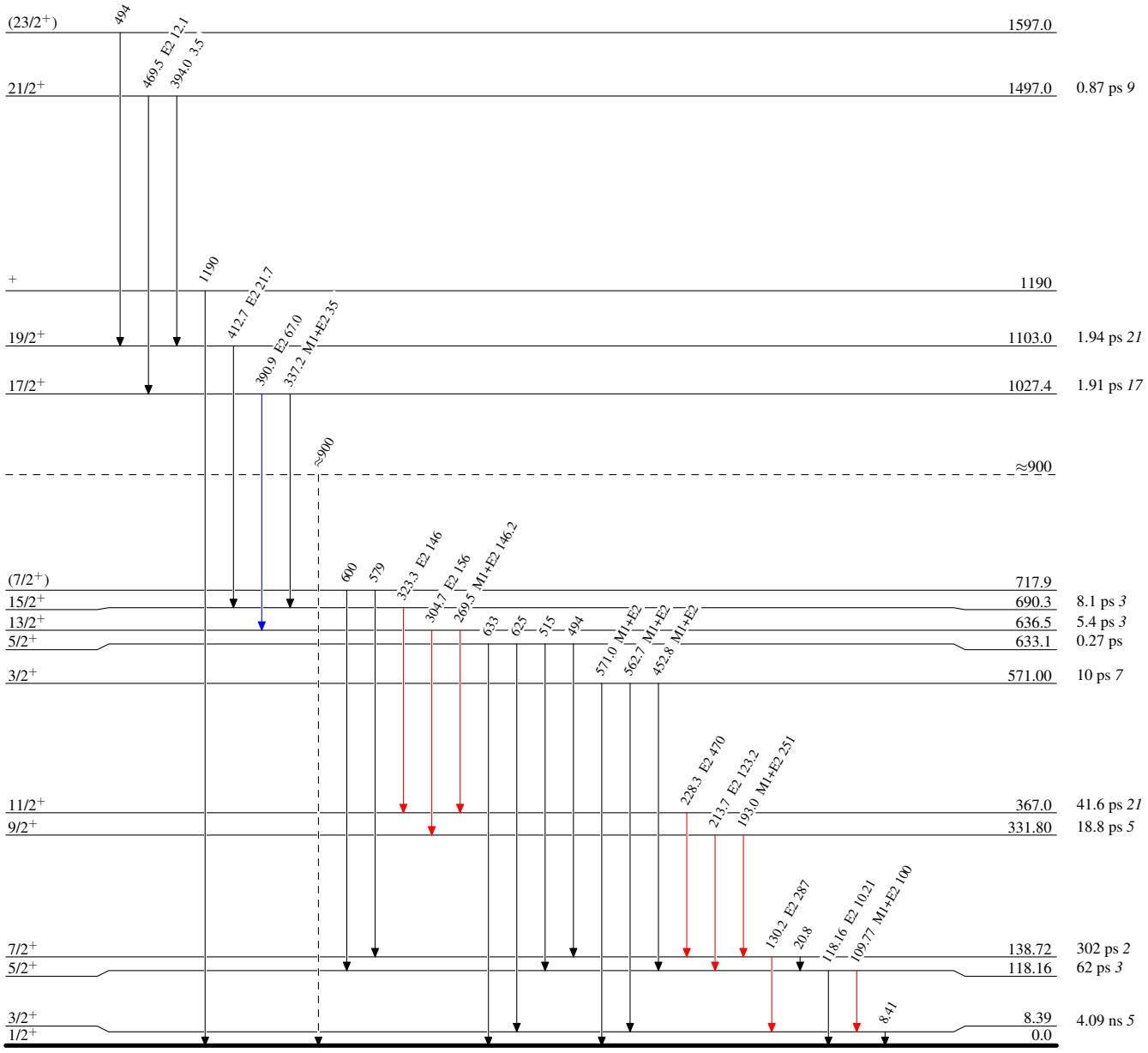
Coulomb excitation 1977Ta10,1999Ro03

Level Scheme

Intensities: Relative Iγ for E(^{32}S)=140 MeV

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)



$^{169}_{69}Tm_{100}$

Coulomb excitation 1977Ta10,1999Ro03

Band(A): 3/2[411] + K-2 γ vibration built on 1/2[411]

$(7/2^+)$ 717.9

$5/2^+$ 633.1

$3/2^+$ 571.00

$^{169}_{69}Tm_{100}$