^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 110, 265 (2009)	15-Nov-2008

Others: 1976Be47, 1975Be03, 1974An11, 1973Bi13, 1973Li06, 1971Bi05.
^{177}Hf(α,2nγ): 1974An11, 1975Be03, 1976Be47.

1974An11: Eα=27 MeV; Ge(Li) detectors; measured $T_{1/2}$ for 309 level.

1975Me21: E(p)=7.5, 12, 16, 26 MeV; natural Ta target. At E(p)=26 MeV, measured Eγ, Iγ, Ice. Detectors:Ge(Li), bent crystal spectrometer, Si(Li).

1986Bo17: E(p)=26 MeV; bent crystal spectrometer. Measured Eγ.

^{179}W Levels

Adopted level scheme is from 1975Me21.

E(level)[†]	J^{π}[‡]	$T_{1/2}$	Comments
0.0[c]	7/2$^-$		
119.912[c] *5*	9/2$^-$		
221.83[a] *21*	1/2$^-$	6.40 min *7*	$T_{1/2}$: from Adopted Levels.
264.75[c] *15*	11/2$^-$		
304.68[a] *21*	3/2$^-$		
308.965[b] *9*	9/2$^+$	1.53 ns *10*	$T_{1/2}$: from ^{177}Hf(α,2nγ) (1974An11). authors measured centroid shift between background-corrected time distribution for delayed transition and time distribution for (prompt) background radiation at comparable energy.
318.27[a] *22*	5/2$^-$		
372.824[b] *10*	11/2$^+$		
430.18[@] *21*	5/2$^-$		
432.63[c] *3*	13/2$^-$		
468.62[b] *3*	13/2$^+$		
477.38[&] *16*	7/2$^+$		
508.7[a] *3*	7/2$^-$		
531.4[@] *3*	7/2$^-$		
533.3[a] *3*	9/2$^-$		
606.06[b] *3*	15/2$^+$		
623.1[c] *2*	15/2$^-$		
634.52[#] *23*	(1/2$^-$)		
654.37[&] *17*	(9/2$^+$)		
688.2[#] *3*	3/2$^-$		
748.19[b] *3*	17/2$^+$		
787.0[#] *3*	5/2$^-$		
809.01[&] *23*	(11/2$^+$)		
823.5[a] *3*	11/2$^-$		
833.54[c] *20*	17/2$^-$		
856.6[a] *4*	13/2$^-$		
910.39 *19*	(13/2$^+$)		J^{π}: tentatively assigned as 13/2$^+$ member of 7/2[633] band by 1975Me21, but this differs from adopted band assignments. E2 γ to (9/2$^+$); γ to (11/2$^+$).
913.8[#] *3*	(7/2$^-$)		
960.72[b] *15*	19/2$^+$		
1064.5[c] *3*	19/2$^-$		
1089.6[#] *3*	(9/2$^-$)		

Continued on next page (footnotes at end of table)

^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17 (continued)

^{179}W Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	Comments
1107.7 *3*	(15/2$^+$)	J$^{\pi}$: tentatively assigned as 15/2$^+$ member of 7/2[633] band by 1975Me21, but this differs from adopted assignment of a 1127-keV level As that band member. (E2) γ to (11/2$^+$); γ to (13/2$^+$).
1123.34[b] *20*	21/2$^+$	
1225.0[a] *4*	15/2$^-$	
1272.7[a] *5*	17/2$^-$	
1290.6[#] *4*	(11/2$^-$)	a tentative 376.6γ also deexcites this level according to fig. 4 of 1975Me21, but is absent In tables 1, 2 and 3 so it is omitted here.
1539.2[#] *4*	(13/2$^-$)	J$^{\pi}$ and band assignment May Be unreliable; multipolarities of deexciting transitions are unclear.
1754.7[a] *5*	21/2$^-$	

[†] Calculated by evaluator from a least-squares fit to Eγ, assigning ΔE=0.1 keV to the crystal spectrometer γ-ray energies for which 1975Me21 did not report uncertainties.

[‡] From 1975Me21. authors'J$^{\pi}$ and Nilsson orbital assignments are based on transition multipolarities, on rotational structure, and on approximate band-head energies expected from Nilsson model. Experimental level energies of strongly perturbed even-parity rotational bands can be reproduced with a calculation that includes the Coriolis interaction between all the $i_{13/2}$ (N=6) Nilsson orbitals (1975Me21).

[#] Band(A): 1/2[510] band.

[@] Band(B): 5/2[512] band.

[&] Band(C): 7/2[633] Coriolis mixed band.

[a] Band(D): 1/2[521] band.

[b] Band(E): 9/2[624] Coriolis mixed band.

[c] Band(F): 7/2[514] g.s. band.

γ(^{179}W)

Eγ[†]	Iγ[‡]	Ei(level)	J^{π}_i	E_f	J^{π}_f	Comments
[x]61.080						
[x]63.261	4					
63.859[&] 2	36	372.824	11/2+	308.965	9/2+	Eγ: 63.881 5 (1975Me21).
82.86 1	8.0	304.68	3/2−	221.83	1/2−	
95.79 1	21	468.62	13/2+	372.824	11/2+	
96.44 1	4.6	318.27	5/2−	221.83	1/2−	
[x]100.69	8					
101.24[b]	6.3[b]	531.4	7/2−	430.18	5/2−	
101.24[b]	6.3[b]	910.39	(13/2+)	809.01	(11/2+)	
[x]104.47	3.0					
[x]105.33	3.4					
[x]107.77	12					
108.25	4.4	372.824	11/2+	264.75	11/2−	
[x]112.61	1.5					
[x]114.08	2.0					
[x]114.90	1.4					
[x]116.07	4.8					
[x]116.97	4.8					
119.913[&] 2	100	119.912	9/2−	0.0	7/2−	Eγ: 119.95 3 (1975Me21).
[x]120.84	7.6					
[x]121.76	3.6					
[x]123.22	6.0					
[x]124.33	3.6					
[x]124.78	4.1					
125.49	3.4	748.19	17/2+	623.1	15/2−	
[x]126.00	3.1					
127.30	1.9	960.72	19/2+	833.54	17/2−	
[x]127.87	2.4					
[x]129.41	5.5					
[x]131.39	3.3					
[x]132.88	5.2					
[x]133.57	2.5					
[x]134.20	3.7					
[x]135.02	4.1					
[x]135.775[&] 5	3.3					Eγ: 135.79 (1975Me21).
[x]136.185[&] 3	10.3					Eγ: 136.33 (1975Me21).
137.439[&] 3	29	606.06	15/2+	468.62	13/2+	Eγ: 137.48 (1975Me21).
[x]139.08	2.9					
[x]140.37	3.3					
142.129[&] 4	9.6	748.19	17/2+	606.06	15/2+	Eγ: 142.27 (1975Me21).
[x]143.82	3.7					

$^{179}_{74}$W$_{105}$-3

γ(^{179}W) (continued)

Eγ[†]	Iγ[‡]	Ei(level)	$J^π_i$	Ef	$J^π_f$	Mult.[@]	δ	α[a]	Comments
144.71	11.2	264.75	11/2⁻	119.912	9/2⁻				
[x]146.94	2.2								
[x]147.20	1.6								
[x]149.44	1.3								
152.45	1.9	787.0	5/2⁻	634.52	(1/2⁻)				
154.58	2.6	809.01	(11/2⁺)	654.37	(9/2⁺)				Mult.: α(L)exp=0.4 *6* for 154.6γ+155.6γ (1975Me21).
[x]155.63	1.2								see comment on 154.6γ.
159.82	4.5	468.62	13/2⁺	308.965	9/2⁺				
[x]161.07	2.6								
162.78	1.9	1123.34	21/2⁺	960.72	19/2⁺				
[x]164.86	1.2								
[x]165.78	1.7								
167.48	1.7	432.63	13/2⁻	264.75	11/2⁻				
168.49	5.1	477.38	7/2⁺	308.965	9/2⁺				
[x]170.80	1.8								
173.73	3.7	606.06	15/2⁺	432.63	13/2⁻				
175.8	≈1.5	1089.6	(9/2⁻)	913.8	(7/2⁻)				
176.90	3.9	654.37	(9/2⁺)	477.38	7/2⁺				
[x]177.99	5.1								
[x]179.88	2.4								
[x]181.29	2.4								
189.053[&] *3*	134	308.965	9/2⁺	119.912	9/2⁻				Eγ: 189.03 *7* (1975Me21).
190.6 *5*		508.7	7/2⁻	318.27	5/2⁻				
197.21	10	1107.7	(15/2⁺)	910.39	(13/2⁺)				
200.79	11	1290.6	(11/2⁻)	1089.6	(9/2⁻)				
204.24[bc]	31[b]	468.62	13/2⁺	264.75	11/2⁻				
204.24[b]	31[b]	508.7	7/2⁻	304.68	3/2⁻				1975Me21 suggest possible alternative placements from 468 and 634 levels.
204.24[bc]	31[b]	634.52	(1/2⁻)	430.18	5/2⁻				
210.37	8.5	833.54	17/2⁻	623.1	15/2⁻				
212.34	11	960.72	19/2⁺	748.19	17/2⁺	M1(+E2)	≤1.2	0.47 *10*	Mult.,δ: from α(K)exp=0.47 *20* (1975Me21).
214.91 *8*	30	533.3	9/2⁻	318.27	5/2⁻	E2		0.243	Mult.: α(K)exp=0.077 *10* (1975Me21).
[x]218.84	1.8								
221.92	5	221.83	1/2⁻	0.0	7/2⁻	M3		10.10	Mult.: α(K)exp=6.6 *3*, α(M)exp=0.74 *6* (1975Me21).
[x]223.01	5.0								
224.89	5	913.8	(7/2⁻)	688.2	3/2⁻				
233.88 *9*	59	606.06	15/2⁺	372.824	11/2⁺	E2		0.184	Mult.: α(K)exp=0.07 *2*, α(L)exp=0.044 *5*, α(M)exp=0.009 *3* (1975Me21).
[x]238.01	16								
[x]241.63	12					E1		0.0389	Mult.: α(K)exp=0.020 *25* (1975Me21).
[x]247.66	17								Mult.: 1975Me21 suggest E2 based on decomposition of four-component ce line.

$^{179}_{74}W_{105}$-4

γ(^{179}W) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [@]	α [a]	I(ce(K)) [#]	Comments
248.31	20	1539.2	(13/2⁻)	1290.6	(11/2⁻)				E1 multipolarity indicated in 1975Me21 is not consistent with placement in level scheme (M1(+E2) required there).
253.05 *11*	52	372.824	11/2⁺	119.912	9/2⁻	E1	0.0347		Mult.: α(L)exp<0.019 from decomposition of complex ce line which includes ce(K) for E1 309γ.
255.84	15	910.39	(13/2⁺)	654.37	(9/2⁺)	E2	0.1385		Mult.: α(K)exp=0.09 *3*, α(L)exp=0.04 *1* (1975Me21).
264.77 *11*	72	264.75	11/2⁻	0.0	7/2⁻	E2	0.1244		Mult.: α(K)exp=0.079 *8*, α(L)exp=0.035 *3*, α(M)exp=0.0085 *14* (1975Me21).
[x]272.30	8								
[x]275.57	11								
279.77	29	748.19	17/2⁺	468.62	13/2⁺	E2	0.1050		Mult.: α(L)exp=0.028 *3* (1975Me21).
[x]285.5	5								
[x]288.5	7								
290.0	8	823.5	11/2⁻	533.3	9/2⁻				
298.74	8	1107.7	(15/2⁺)	809.01	(11/2⁺)	(E2)	0.0861		Mult.: α(M)exp≈0.048 from decomposition of ce triplet (1975Me21).
302.6	6	1089.6	(9/2⁻)	787.0	5/2⁻				
308.951 [&] *11*	100	308.965	9/2⁺	0.0	7/2⁻	E1	0.0213		E_γ: 309.05 (1975Me21). Mult.: α(K)exp=0.018 *2* (1975Me21) from decomposition of complex ce line; α(K)exp<0.027 if other ce components are ignored, ruling out M1 and E2.
312.725 [&] *11*	47	432.63	13/2⁻	119.912	9/2⁻	E2	0.0751		E_γ: 312.73 (1975Me21). Mult.: α(K)exp=0.051 *4* (1975Me21). α(L)exp=0.017 *2* for 312.7γ+315.0γ doublet.
314.97	17	823.5	11/2⁻	508.7	7/2⁻	E2	0.0736		Mult.: α(L)exp=0.017 *2* (1975Me21) for 312.7+315.0 doublet. Given that mult(312.7)=E2, α(L)exp(315.0)=0.015 *6*, consistent with mult=E2, but an M1 admixture cannot Be ruled out.
[x]318.2 *2*								0.83 *1*	
323.31	14	856.6	13/2⁻	533.3	9/2⁻	[E2]	0.0681		Mult.: see comment on 324.8γ.
[x]324.78	13					(E2)	0.0673		Mult.: α(K)exp=0.047 *7* (consistent with mult=E2) for 323.3γ+324.8γ doublet (1975Me21); from decomposition of ce triplet dominated by 265 ce(L). This implies mult=E2 for both transitions or a combination of E1 and M1+E2 transitions. the former is adopted since the level scheme requires ΔJ=2 for the 323.3 transition.
329.69	3	634.52	(1/2⁻)	304.68	3/2⁻	M1	0.1699		Mult.: α(K)exp=0.14 *3* (1975Me21).
[x]335.60	11					E1	0.01751		Mult.: α(K)exp=0.015 *9* (1975Me21).
354.87	16	960.72	19/2⁺	606.06	15/2⁺	E2	0.0522		Mult.: α(K)exp=0.038 *6* (1975Me21).
358.46	36	623.1	15/2⁻	264.75	11/2⁻	E2	0.0507		Mult.: α(K)exp=0.033 *3* (1975Me21).
374.99	12	1123.34	21/2⁺	748.19	17/2⁺	(E2)	0.0447		Mult.: 0.046≤α(K)exp≤0.075 (1975Me21), consistent with E2+M1. However, level scheme requires ΔJ=2.
[x]375.0 *2*								0.55 *1*	E_γ: matches that of the Iγ=12, 374.99γ reported In 1975Me21.
382.32	4.2	688.2	3/2⁻	304.68	3/2⁻	M1	0.1144		Mult.: α(K)exp=0.095 *24* (1975Me21).

From ENSDF

γ(^{179}W) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult. [@]	δ	α [a]	I(ce(K)) [#]	Comments
[x]396.58	4.0					E2(+M1)		0.07 *4*		Mult.: α(K)exp=0.05 *3* (1975Me21).
401.51[b]	29[b]	833.54	17/2⁻	432.63	13/2⁻					Mult.: α(K)exp=0.024 *3*, α(L)exp=0.0055 *10* (1975Me21) for doubly-placed γ; possibly E2.
401.51[b]	29[b]	1225.0	15/2⁻	823.5	11/2⁻					Mult.: α(K)exp=0.024 *3*, α(L)exp=0.0055 *10* (1975Me21) for doubly-placed γ; possibly E2.
412.92	6.5	634.52	(1/2⁻)	221.83	1/2⁻					
416.10	14	1272.7	17/2⁻	856.6	13/2⁻	E2		0.0337		Mult.: α(L)exp=0.005 *2* (1975Me21).
[x]425.1 *2*									0.3 *1*	
430.08	25	430.18	5/2⁻	0.0	7/2⁻	M1(+E2)	≤0.29	0.0817 *24*		Mult.: α(K)exp=0.072 *4*, α(L)exp=0.005 *2*, α(M)exp=0.0016 *12* (1975Me21). δ: from α(K)exp.
[x]434.7 *4*									0.18 *8*	
441.38	13	1064.5	19/2⁻	623.1	15/2⁻	E2		0.0288		Mult.: α(K)exp=0.031 *72*, α(L)exp=0.0054 *23* (1975Me21).
[x]446.8 *6*									0.18 *7*	
449.83[c]	14	1539.2	(13/2⁻)	1089.6	(9/2⁻)					I_γ: may contain contribution from ^{180}W (8^+ to 6^+ transition). Mult.: α(K)exp=0.021 *5*, mult=E2 for transition which May include an E2 contaminant.
[x]456.00	2.4									
[x]462.56	3.3									
466.33	5.3	688.2	3/2⁻	221.83	1/2⁻	M1		0.0677		Mult.: α(K)exp=0.051 *8* (1975Me21).
477.22	33	477.38	7/2⁺	0.0	7/2⁻	E1		0.00786 *11*		Mult.: α(K)exp=0.0055 *12*, α(L)exp=0.0011 *2* (1975Me21); uncertainty given In 1975Me21 for α(L)exp (0.002) is presumed to Be a typographical error.
481.96	17	1754.7	21/2⁻	1272.7	17/2⁻	E2		0.0230		Mult.: α(K)exp=0.016 *2*, α(L)exp=0.0034 *5* (1975Me21).
[x]507.9 *2*									0.07 *4*	
[x]517.83	3.1					E2		0.0192		Mult.: α(K)exp=0.016 *10* (1975Me21).
[x]521.4 *5*									0.04 *4*	
531.5 *3*		531.4	7/2⁻	0.0	7/2⁻				0.012 *10*	
[x]543.12	1.7					M1		0.0455		Mult.: α(K)exp=0.032 *5* (1975Me21).
[x]551.4 *2*									0.050 *8*	Mult.: α(L)exp=0.009 *5* (1975Me21).
[x]557.0 *2*									0.049 *9*	
[x]563.35	12					E2		0.01570		Mult.: α(K)exp=0.009 *3* (1975Me21).
[x]570.54	7					E2		0.01523		Mult.: α(K)exp=0.016 *7* (1975Me21).
[x]578.3 *6*									0.07 *4*	
[x]584.40	5.7					M1		0.0377		Mult.: α(K)exp=0.026 *7* (1975Me21).
601.66	15	910.39	(13/2⁺)	308.965	9/2⁺	E2		0.01344		Mult.: α(L)exp=0.0023 *8* (1975Me21). a 601.5γ is placed elsewhere in (^{13}C,4nγ).
609.12	19	913.8	(7/2⁻)	304.68	3/2⁻	E2		0.01306		Mult.: α(L)exp=0.0020 *5* (1975Me21).
[x]630.68	4.7					E1				Mult.: α(K)exp=0.0013 *19* (1975Me21).
[x]637.38	2.2									

$^{179}_{74}W_{105}$-6

^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17 (continued)

γ(^{179}W) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [@]	I(ce(K)) [#]	Comments
[x]652.8 *5*							0.033 *11*	
654.21	3.1	654.37	(9/2$^+$)	0.0	7/2$^-$			
[x]658.53	6.8					E1		Mult.: α(K)exp=0.0035 *7* (1975Me21).
[x]662.39	4.4							
[x]671.46	5.5							
[x]681.8 *2*							0.047 *8*	
[x]696.8 *3*							0.032 *8*	
[x]745.1 *2*							0.078 *24*	
[x]754.9 *3*							0.047 *19*	
[x]772.6 *3*							0.020 *8*	
[x]776.8 *2*							0.055 *8*	
[x]788.9 *2*							0.030 *7*	
[x]799.6 *4*							0.026 *7*	
[x]801.99	8.2					E1		Mult.: α(K)exp=0.0028 *6* (1975Me21).
[x]817.9 *2*							0.030 *5*	
[x]825.2 *3*							0.022 *7*	
[x]833.89	17							
[x]842.88	17					E1		Mult.: α(K)exp=0.0009 *9* (1975Me21).
[x]860.2 *3*							0.05 *3*	
[x]864.6 *3*							0.06 *4*	
[x]878.61	3.4							Mult.: α(K)exp=0.016 *13* (1975Me21).
[x]882.82	11					(E2)		Mult.: α(K)exp=0.007 *5* (1975Me21).
[x]896.1 *8*							0.045 *12*	
[x]932.7 *4*							0.014 *5*	
[x]955.2 *3*							0.049 *9*	
[x]958.6 *3*							0.053 *11*	
[x]1014.30	20					E1		Mult.: α(K)exp=0.0015 *5* (1975Me21).
[x]1023.64	4.0							
[x]1040.06	11							

[†] From 1975Me21, unless otherwise specified.

[‡] From 1975Me21 for E(p)=26 MeV.

[#] Normalized ce intensity (relative to I(119.9γ)=100) for transitions for which no γ was observed (1975Me21).

[@] From Iγ and Ice. Normalization between the electron and photon intensities was achieved using several E2 transitions from neighboring even-A isotopes assuming theoretical conversion coefficients (1975Me21).

[&] From 1986Bo17.

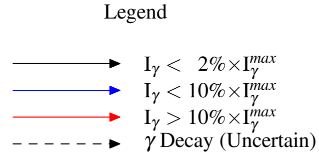
[a] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

[b] Multiply placed with undivided intensity.

[c] Placement of transition in the level scheme is uncertain.

[x] γ ray not placed in level scheme.

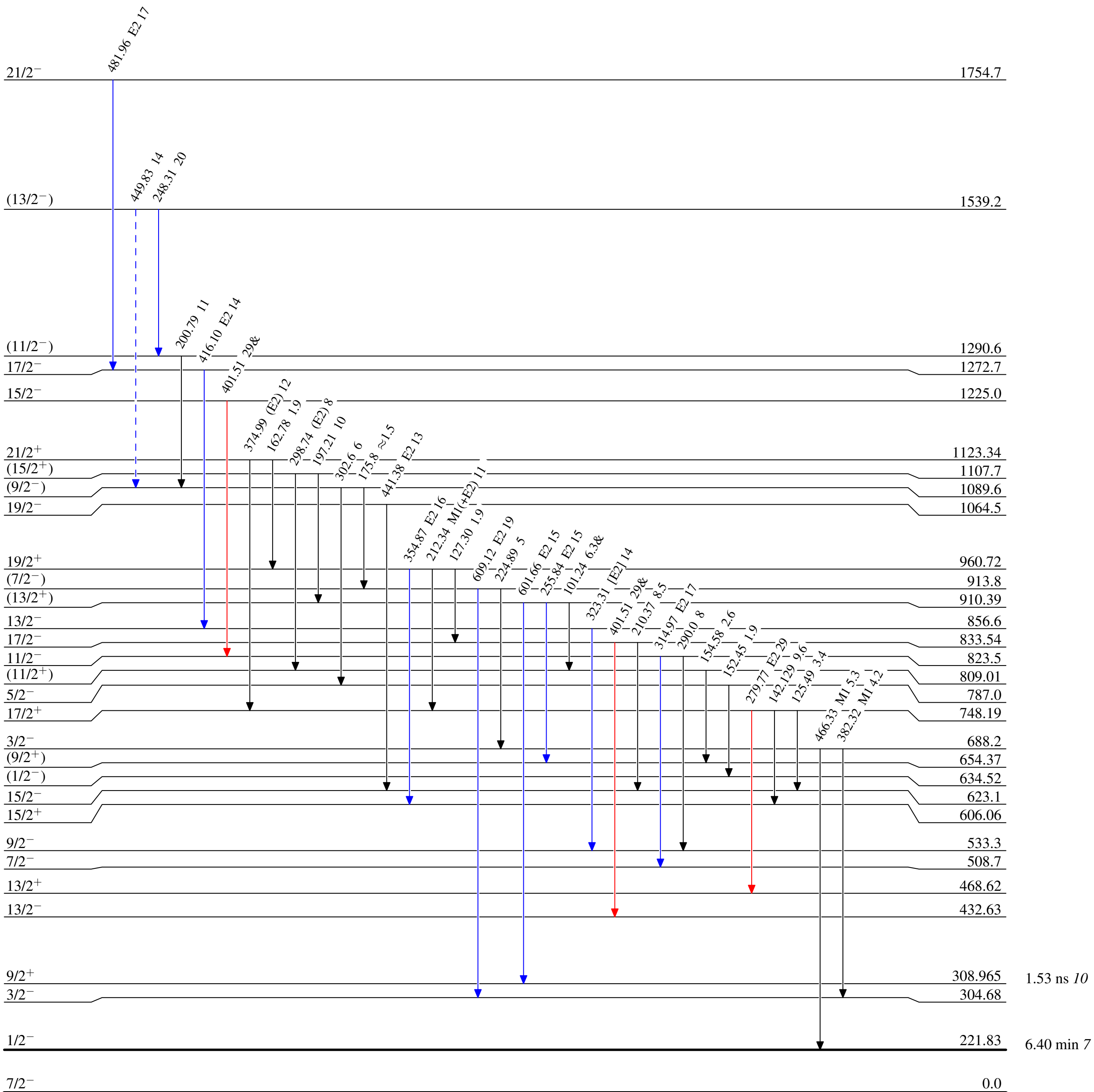
^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17



Level Scheme

Intensities: Relative Iγ from (p,3nγ), E(p)=26 MeV

& Multiply placed: undivided intensity given

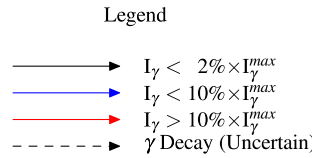


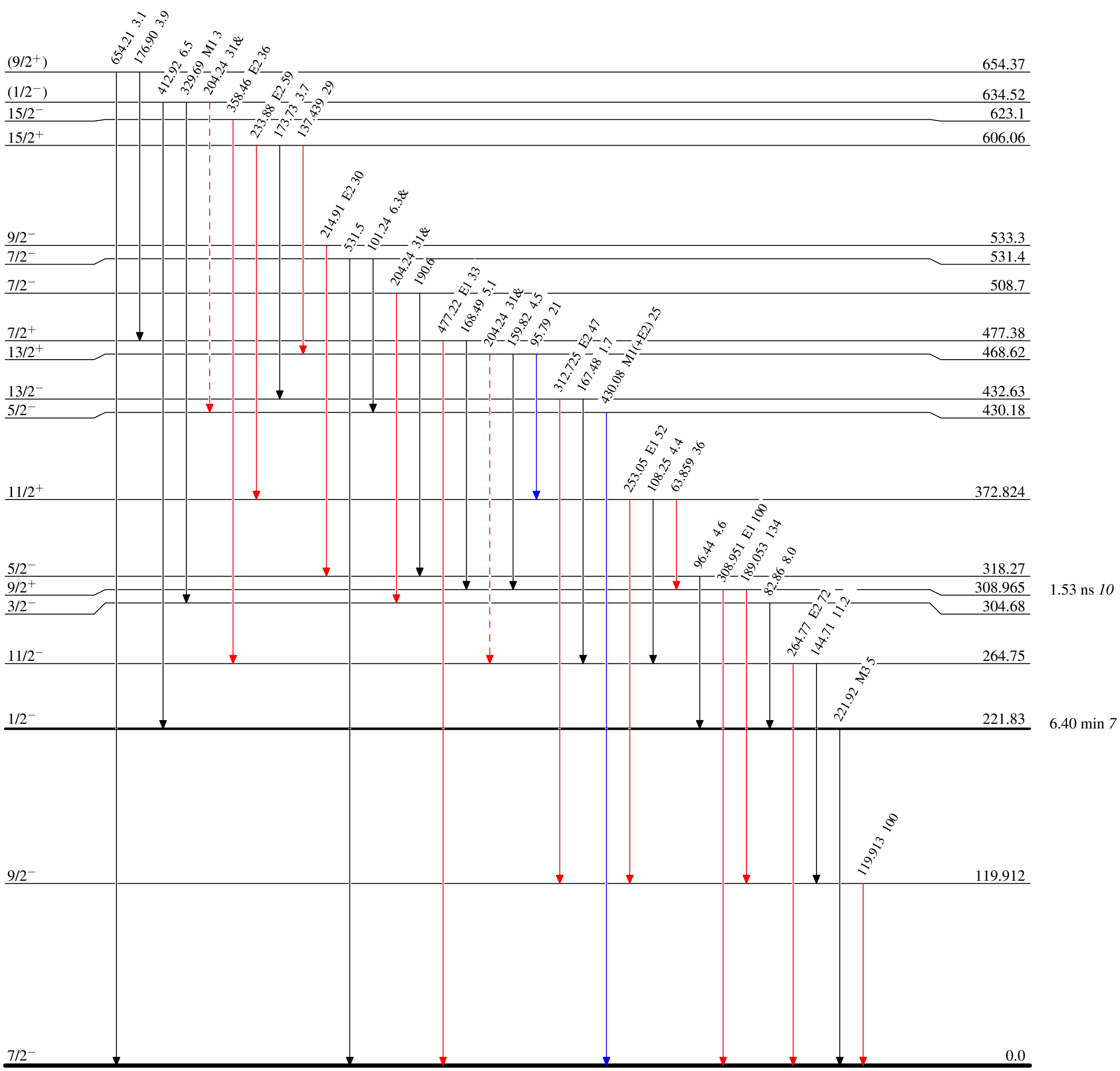
$^{179}_{74}W_{105}$

^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17

Level Scheme (continued)

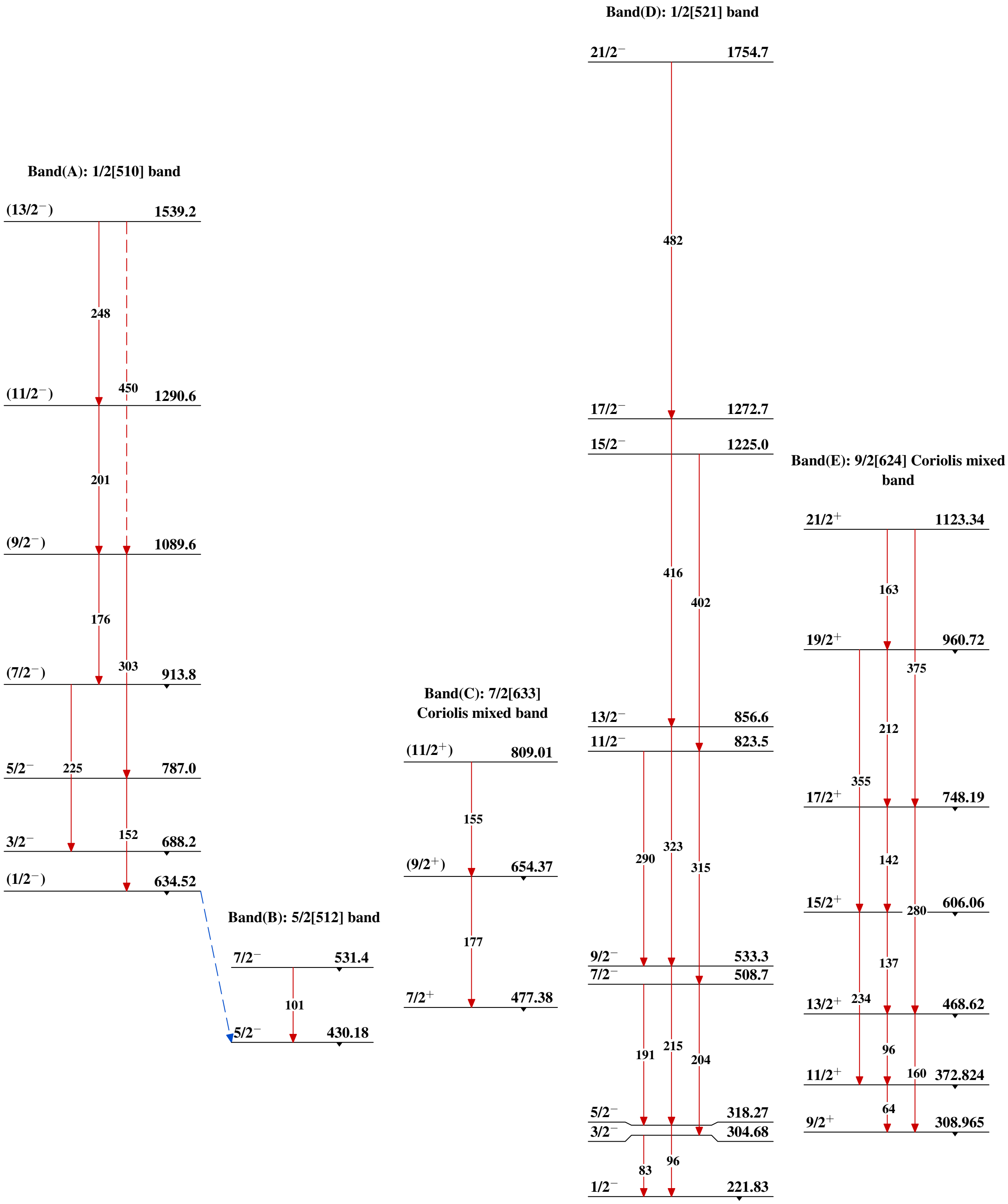
Intensities: Relative Iγ from (p,3nγ), E(p)=26 MeV
& Multiply placed: undivided intensity given





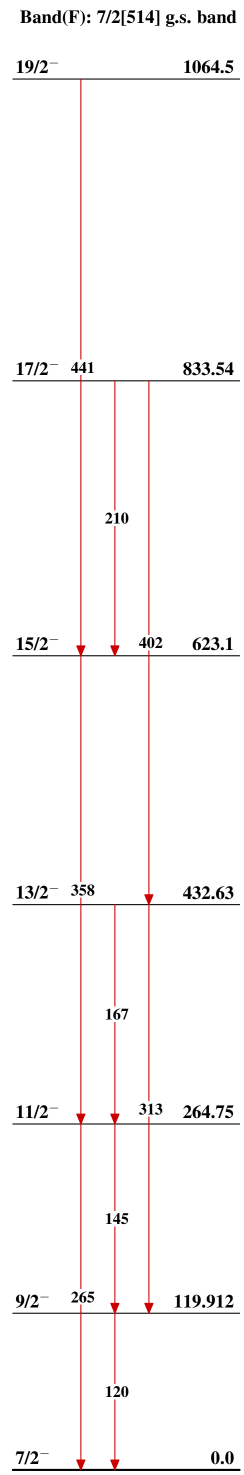
$^{179}_{74}W_{105}$

^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17



$^{179}_{74}W_{105}$

^{181}Ta(p,3nγ), ^{177}Hf(α,2nγ) 1975Me21,1986Bo17 (continued)



$^{179}_{74}W_{105}$