^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ

History

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

See also ^{146}Nd(^{26}Mg,5nγ) dataset from 1999Cr01.

Includes ^{159}Tb(^{14}N,6nγ) from 1983Ar09 and 1981De36, and ^{154}Gd(^{16}O,3nγ) and ^{161}Dy(^{12}C,6nγ) from 1977JoZQ.

1999Cr01: ^{155}Gd(^{16}O,4nγ),E(^{16}O)=85 MeV. 92% enriched ^{155}Gd Au-backed target. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$(DCO) at 37°, 79°, 101° and 143° using 8π array of 20 HPGe detectors and 71-element BGO calorimeter at Chalk River MP tandem accelerator.

1983Ar09 (also 1981Ja11, 1981De36): ^{159}Tb(^{14}N,6nγ), E(^{14}N)=95 MeV; measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$, and quasicontinuum γ-ray spectra at high spins using Compton-suppressed spectrometer with average suppression factor of ≈10, Ge(Li) and NaI(Tl) detectors at the KVI cyclotron of Groningen. This work reports $\nu i_{13/2}$ band from 13/2$^+$ to 49/2$^+$ (α=+1/2) and nine in−band γ rays.

1981De36: ^{159}Tb(^{14}N,6nγ),E(^{14}N)=95 MeV; measured $\gamma\gamma$-energy correlation matrix, quasicontinuum γ-ray spectra at high spins. This work is by the same group as 1981Ja11 and 1983Ar09.

1977JoZQ (also 1976HjZY): ^{154}Gd(^{16}O,3nγ), E(^{16}O)=75-78 MeV; ^{161}Dy(^{12}C,6nγ),E(^{12}C)=95-115 MeV. Measured Eγ, Iγ, $\gamma\gamma$-coin at the NBI Super FN tandem accelerator for (^{16}O,3nγ) and Stockholm cyclotron for (^{12}C,6nγ). Following rotational bands were reported:

1. ν5/2[523] band: 5/2$^-$ to 33/2$^-$, α=+1/2 and tentative 9/2$^-$ to 19/2$^-$, α=−1/2 with the γ cascades (from top): 450.9→447.9→473.8→440.5→379.7→297.7→207.7, and 414.5→351.8→263.5.
2. $\nu i_{13/2}$ band: 9/2$^+$ to 41/2$^+$, α=+1/2 and 11/2$^+$ to 35/2$^+$, α=−1/2 with the γ cascades (from top): 660.8→674.0→627.4→553.6→459.2→343.4→206.0, and 686→647.4→578.8→486.7→368.0→213.5.
3. a ΔJ=2 side band from (35/2$^-$) to (23/2$^-$) with 660.9γ, 737.7γ, 844.0γ and 868.9γ to $\nu i_{13/2}$ band members. All the members of the ν5/2[523] and $\nu i_{13/2}$ bands were confirmed by 1999Cr01.

The level scheme and band structures are taken from 1999Cr01, with the ν5/2[523] and $\nu i_{13/2}$ bands first established by 1977JoZQ.

^{167}Hf Levels

Band structures were assigned in 1999Cr01, 1999Sm13 and 1977JoZQ.

E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡
0.0[@]	5/2$^-$	1561.2[&] 5	23/2$^-$	2869.0[a] 6	33/2$^-$	4333.7[g] 5	45/2$^+$
92.1[&] 4	7/2$^-$	1618.0[d] 6	25/2$^+$	2937.3[c] 5	35/2$^-$	4437.6[#] 5	45/2$^-$
144.9[e] 5	13/2$^+$	1704.5[e] 5	29/2$^+$	3005.0[e] 5	37/2$^+$	4525.6[b] 9	43/2$^-$
188.6[f] 5	11/2$^+$	1797.2[@] 4	25/2$^-$	3180.0[f] 6	35/2$^+$	4626.7[e] 6	45/2$^+$
207.2[@] 3	9/2$^-$	1832.1[f] 4	27/2$^+$	3206.9[#] 4	37/2$^-$	4672.4[f] 8	43/2$^+$
349.5[e] 4	17/2$^+$	1995.1[&] 5	27/2$^-$	3259.8 5	37/2$^+$	4822.0[a] 10	45/2$^-$
355.3[&] 4	11/2$^-$	2148.0[d] 6	29/2$^+$	3287.9[b] 7	35/2$^-$	4850.8[c] 6	47/2$^-$
401.7[f] 4	15/2$^+$	2244.9[#] 4	29/2$^-$	3416.5[d] 8	37/2$^+$	5082.6[g] 6	49/2$^+$
504.6[@] 3	13/2$^-$	2289.3[b] 6	27/2$^-$	3452.8[a] 7	37/2$^-$	5151.7[#] 6	49/2$^-$
692.5[e] 4	21/2$^+$	2331.5[e] 5	33/2$^+$	3502.3 5	39/2$^-$	5237.2[b] 11	47/2$^-$
706.4[&] 5	15/2$^-$	2339.1[a] 5	29/2$^-$	3665.9[g] 5	41/2$^+$	5429.2[e] 7	49/2$^+$
767.2[f] 4	19/2$^+$	2441.5[c] 5	31/2$^-$	3788.0[#] 4	41/2$^-$	5598.8[a] 11	49/2$^-$
883.8[@] 3	17/2$^-$	2479.6[f] 4	31/2$^+$	3872.0[e] 5	41/2$^+$	5623.7[c] 8	51/2$^-$
1120.7[&] 5	19/2$^-$	2695.4[#] 4	33/2$^-$	3874.7[b] 8	39/2$^-$	5920.9[g] 8	53/2$^+$
1151.3[e] 4	25/2$^+$	2757.7[d] 6	33/2$^+$	3921.8[f] 7	39/2$^+$	5927.6[#] 8	53/2$^-$
1253.6[f] 4	23/2$^+$	2769.3[b] 6	31/2$^-$	4103.5[a] 8	41/2$^-$	6249.6[e] 9	53/2$^+$
1324.0[@] 4	21/2$^-$	2810.1 6	33/2$^+$	4141.5[c] 5	43/2$^-$	6765.8[#] 9	57/2$^-$

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^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ (continued)

^{167}Hf Levels (continued)

† From a least-squares fit to Eγ data, using uncertainties for γ-ray energies assigned by the evaluators, based on other studies using 8π array at Chalk River, such as data for ^{157}Ho in 1992Ra17. Reduced χ^2=1.05.

‡ From 1999Cr01, based on transition multipolarities deduced from $\gamma(\theta)$ (1983Ar09) or DCO ratios from this reaction and/or the (^{26}Mg,5nγ) reaction (1999Cr01); consistent with deduced band structure and expected Nilsson states from total routhian plus cranked-shell-model calculations. Assignments for all the excited states are placed in parentheses by evaluators, as strong arguments for low-lying levels are lacking.

Band(A): ν5/2[523]$\otimes\nu i^2_{13/2}$,α=+1/2.

@ Band(B): ν5/2[523],α=+1/2.

& Band(b): ν5/2[523],α=−1/2.

a Band(C): ν3/2[521],α=+1/2. Not observed at frequencies below the first neutron alignment.

b Band(c): ν3/2[521],α=−1/2. Not observed at frequencies below the first neutron alignment.

c Band(D): ν5/2[523]$\otimes\nu i^2_{13/2}$,α=−1/2.

d Band(E): π=+, α=−1/2 band. Weak sideband decaying into 5/2[642] bands; observed in (^{16}O,4nγ) only.

e Band(F): ν5/2[642],α=+1/2.

f Band(f): ν5/2[642],α=−1/2.

g Band(G): ν5/2[642]$\otimes\nu i^2_{13/2}$,α=+1/2. Yrast for J≥41/2.

γ(^{167}Hf)

DCO ratios are from 1999Cr01. A_2 and A_4 coefficients are from $\gamma(\theta)$ data in 1983Ar09.

E$_\gamma$†	I$_\gamma$‡	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.#	Comments
92.3 *5*	0.9 *1*	92.1	7/2$^-$	0.0	5/2$^-$		
115.4 *5*	0.7 *1*	207.2	9/2$^-$	92.1	7/2$^-$		
148.3 *5*	0.2 *1*	355.3	11/2$^-$	207.2	9/2$^-$		
149.6 *5*	0.5 *1*	504.6	13/2$^-$	355.3	11/2$^-$		
204.6 *1*	88.2 *25*	349.5	17/2$^+$	144.9	13/2$^+$	Q	A_2=+0.34 *2*; A_4=−0.07 *3* E$_\gamma$: 205.0 *2* (1983Ar09).
207.1 *3*	6.3 *7*	207.2	9/2$^-$	0.0	5/2$^-$		
213.1 *3*	8.3 *3*	401.7	15/2$^+$	188.6	11/2$^+$		
256.8 *3*	6.1 *5*	401.7	15/2$^+$	144.9	13/2$^+$		
263.0 *5*	2.2 *2*	355.3	11/2$^-$	92.1	7/2$^-$		
297.4 *1*	19.7 *6*	504.6	13/2$^-$	207.2	9/2$^-$		
343.0 *1*	100.0 *30*	692.5	21/2$^+$	349.5	17/2$^+$	Q	A_2=+0.27 *2*; A_4=−0.04 *3* E$_\gamma$: 343.4 *2* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.72 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
351.0 *3*	4.1 *2*	706.4	15/2$^-$	355.3	11/2$^-$		
365.5 *1*	17.2 *6*	767.2	19/2$^+$	401.7	15/2$^+$		
379.2 *1*	24.7 *8*	883.8	17/2$^-$	504.6	13/2$^-$		
412.8 *3*	6.4 *2*	2244.9	29/2$^-$	1832.1	27/2$^+$		
414.2 *3*	4.1 *2*	1120.7	19/2$^-$	706.4	15/2$^-$		
417.6 *3*	6.2 *2*	767.2	19/2$^+$	349.5	17/2$^+$		
434.0 *3*	5.8 *2*	1995.1	27/2$^-$	1561.2	23/2$^-$		
440.2 *1*	27.7 *9*	1324.0	21/2$^-$	883.8	17/2$^-$		
440.5 *3*	3.6 *1*	1561.2	23/2$^-$	1120.7	19/2$^-$		
446.4 *1*	10.0 *3*	2441.5	31/2$^-$	1995.1	27/2$^-$		
447.6 *1*	23.9 *6*	2244.9	29/2$^-$	1797.2	25/2$^-$		
449.9 *5*	1.0 *1*	3259.8	37/2$^+$	2810.1	33/2$^+$		
450.5 *1*	22.2 *7*	2695.4	33/2$^-$	2244.9	29/2$^-$		
458.8 *1*	94.5 *29*	1151.3	25/2$^+$	692.5	21/2$^+$	(Q)	A_2=+0.26 *2*; A_4=−0.01 *3* E$_\gamma$: 459.2 *4* (1983Ar09).

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^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ (continued)

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

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	Comments
							I(γ+ce)/I(γ+ce)(205γ)=0.55 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
473.3 *1*	23.9 *7*	1797.2	25/2$^-$	1324.0	21/2$^-$		
479.1 *5*	2.7 *1*	2769.3	31/2$^-$	2289.3	27/2$^-$		
486.3 *1*	21.4 *7*	1253.6	23/2$^+$	767.2	19/2$^+$		
495.9 *1*	14.6 *5*	2937.3	35/2$^-$	2441.5	31/2$^-$		
511.5 *1*	19.3 *6*	3206.9	37/2$^-$	2695.4	33/2$^-$		
518.6 *3*	3.4 *2*	3287.9	35/2$^-$	2769.3	31/2$^-$		
529.9 *3*	6.2 *2*	2869.0	33/2$^-$	2339.1	29/2$^-$		
530.0 *5*	1.3 *1*	2148.0	29/2$^+$	1618.0	25/2$^+$	(Q)	DCO=1.23 *25* Mult.: E2 in 1999Cr01.
541.9 *3*	7.1 *2*	2339.1	29/2$^-$	1797.2	25/2$^-$		
543.5 *3*	5.1 *2*	1797.2	25/2$^-$	1253.6	23/2$^+$		
553.1 *1*	77.0 *23*	1704.5	29/2$^+$	1151.3	25/2$^+$	Q	A_2=+0.26 *3*; A_4=−0.06 *4* E_γ: 553.6 *4* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.39 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
561.3 *3*	5.5 *2*	1253.6	23/2$^+$	692.5	21/2$^+$		
565.0 *1*	13.2 *4*	3502.3	39/2$^-$	2937.3	35/2$^-$		
578.6 *1*	17.1 *6*	1832.1	27/2$^+$	1253.6	23/2$^+$		
581.1 *1*	13.8 *4*	3788.0	41/2$^-$	3206.9	37/2$^-$		
583.8 *3*	4.8 *2*	3452.8	37/2$^-$	2869.0	33/2$^-$		
586.8 *3*	3.1 *1*	3874.7	39/2$^-$	3287.9	35/2$^-$		
605.4 *3*	4.7 *2*	2937.3	35/2$^-$	2331.5	33/2$^+$		
609.7 *5*	2.5 *1*	2757.7	33/2$^+$	2148.0	29/2$^+$		DCO=0.87 *17* Mult.: E2 in 1999Cr01.
612.1 *5*	2.5 *1*	3872.0	41/2$^+$	3259.8	37/2$^+$		
627.0 *1*	54.4 *17*	2331.5	33/2$^+$	1704.5	29/2$^+$	(Q)	A_2=+0.24 *3*; A_4=−0.03 *4* E_γ: 627.4 *3* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.29 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
639.2 *1*	10.0 *3*	4141.5	43/2$^-$	3502.3	39/2$^-$		
647.4 *1*	11.8 *4*	2479.6	31/2$^+$	1832.1	27/2$^+$		
649.6 *3*	9.4 *3*	4437.6	45/2$^-$	3788.0	41/2$^-$		
650.7 *5*	2.7 *1*	4103.5	41/2$^-$	3452.8	37/2$^-$		
650.9 *5*	2.3 *1*	4525.6	43/2$^-$	3874.7	39/2$^-$		
658.8 *5*	2.2 *2*	3416.5	37/2$^+$	2757.7	33/2$^+$		Mult.: E2 in 1999Cr01.
660.9 *1*	19.2 *6*	3665.9	41/2$^+$	3005.0	37/2$^+$	(Q)	A_2=+0.13 *8*; A_4=−0.01 *12* E_γ: 660.8 *7* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.09 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
667.8 *1*	10.7 *4*	4333.7	45/2$^+$	3665.9	41/2$^+$	(Q)	A_2=+0.33 *2*; A_4=+0.02 *30* E_γ: 667.9 *7* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.06 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
673.5 *1*	34.0 *10*	3005.0	37/2$^+$	2331.5	33/2$^+$	(Q)	A_2=+0.24 *4*; A_4=−0.04 *6* E_γ: 673.6 *5* (1983Ar09). I(γ+ce)/I(γ+ce)(205γ)=0.21 in (^{14}N,6nγ) at 95 MeV (1983Ar09).
679.8 *5*	2.9 *1*	1832.1	27/2$^+$	1151.3	25/2$^+$		E_γ: level-energy difference=680.8.
700.4 *3*	6.1 *2*	3180.0	35/2$^+$	2479.6	31/2$^+$		
709.3 *3*	5.6 *2*	4850.8	47/2$^-$	4141.5	43/2$^-$		
711.6 *5*	1.4 *1*	5237.2	47/2$^-$	4525.6	43/2$^-$		
714.1 *3*	4.9 *2*	5151.7	49/2$^-$	4437.6	45/2$^-$		
718.5 *5*	2.1 *1*	4822.0	45/2$^-$	4103.5	41/2$^-$		

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^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ (continued)

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

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	Comments
727.9 *5*	1.4 *1*	2289.3	27/2$^-$	1561.2	23/2$^-$		
737.0 *1*	10.1 *3*	2441.5	31/2$^-$	1704.5	29/2$^+$		
741.8 *3*	3.7 *2*	3921.8	39/2$^+$	3180.0	35/2$^+$		
748.9 *3*	5.4 *2*	5082.6	49/2$^+$	4333.7	45/2$^+$		I(γ+ce)/I(γ+ce)(205γ)=0.03 in (^{14}N,6nγ) at 95 MeV (1983Ar09); includes contaminant. Other Eγ=750.2 *7* (1983Ar09), contaminated γ ray.
750.6 *5*	1.4 *1*	4672.4	43/2$^+$	3921.8	39/2$^+$		
754.7 *3*	4.1 *2*	4626.7	45/2$^+$	3872.0	41/2$^+$		
772.9 *5*	2.6 *1*	5623.7	51/2$^-$	4850.8	47/2$^-$		
775.0 *5*	2.2 *1*	2769.3	31/2$^-$	1995.1	27/2$^-$		
775.7 *5*	2.2 *1*	2479.6	31/2$^+$	1704.5	29/2$^+$		
775.9 *5*	2.1 *1*	5927.6	53/2$^-$	5151.7	49/2$^-$		
776.8 *5*	0.8 *1*	5598.8	49/2$^-$	4822.0	45/2$^-$		
802.6 *5*	2.1 *1*	5429.2	49/2$^+$	4626.7	45/2$^+$		
820.4 *5*	1.2 *1*	6249.6	53/2$^+$	5429.2	49/2$^+$		
838.2 *5*	1.2 *1*	6765.8	57/2$^-$	5927.6	53/2$^-$		
838.3 *5*	2.1 *1*	5920.9	53/2$^+$	5082.6	49/2$^+$		
843.9 *1*	11.5 *4*	1995.1	27/2$^-$	1151.3	25/2$^+$		
866.9 *3*	5.0 *2*	3872.0	41/2$^+$	3005.0	37/2$^+$		
868.9 *3*	4.9 *2*	1561.2	23/2$^-$	692.5	21/2$^+$		
925.6 *5*	1.7 *2*	1618.0	25/2$^+$	692.5	21/2$^+$		Mult.: E2 in 1999Cr01.
928.2 *3*	4.6 *2*	3259.8	37/2$^+$	2331.5	33/2$^+$		
961.1 *5*	1.1 *1*	4626.7	45/2$^+$	3665.9	41/2$^+$		
996.6 *5*	2.0 *1*	2148.0	29/2$^+$	1151.3	25/2$^+$	(Q)	DCO=0.95 *19* Mult.: E2 in 1999Cr01.
1053.2 *5*	1.6 *1*	2757.7	33/2$^+$	1704.5	29/2$^+$		DCO=1.59 *27* DCO is larger than expected for ΔJ=2, quadrupole. Mult.: E2 in 1999Cr01.
1095		5429.2	49/2$^+$	4333.7	45/2$^+$		Eγ: from level scheme; absent in Table II of 1999Cr01.
1105.9 *5*	2.3 *1*	2810.1	33/2$^+$	1704.5	29/2$^+$		DCO=0.68 *11* DCO implies ΔJ=0 or 1, but γ placement requires ΔJ=2, quadrupole. Mult.: E2 in 1999Cr01.
1137.3 *5*	1.3 *1*	2289.3	27/2$^-$	1151.3	25/2$^+$		

[†] From 1999Cr01, except as noted. Uncertainties are not given by authors. Note that 1999Cr01 report best values for Eγ derived from their (^{16}O,4nγ) and/or (^{26}Mg,5nγ) studies. Based on other studies using 8π array at Chalk River such as data for ^{157}Ho in 1992Ra17, evaluators assign 0.1 keV for strong γ rays (I$\gamma\geq$10), 0.3 keV for medium intensity (Iγ=3-9.9) and 0.5 keV for weak γ rays (I$\gamma\leq$3).

[‡] From 1999Cr01. Data are for (^{16}O,4nγ) at E=85 MeV. I(γ+ce) data for (^{14}N,6nγ), E(^{14}N)=95 MeV (1983Ar09) are given in comments. These were deduced by the authors by correcting Iγ for internal conversion and angular distribution effects.

[#] From $\gamma(\theta)$ data (1983Ar09). The DCO ratio data from 1999Cr01, measured in (^{16}O,4nγ) and/or (^{26}Mg,5nγ), are given in the (^{26}Mg,5nγ) dataset, except for transitions observed only in (^{16}O,4nγ).

^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ

Level Scheme

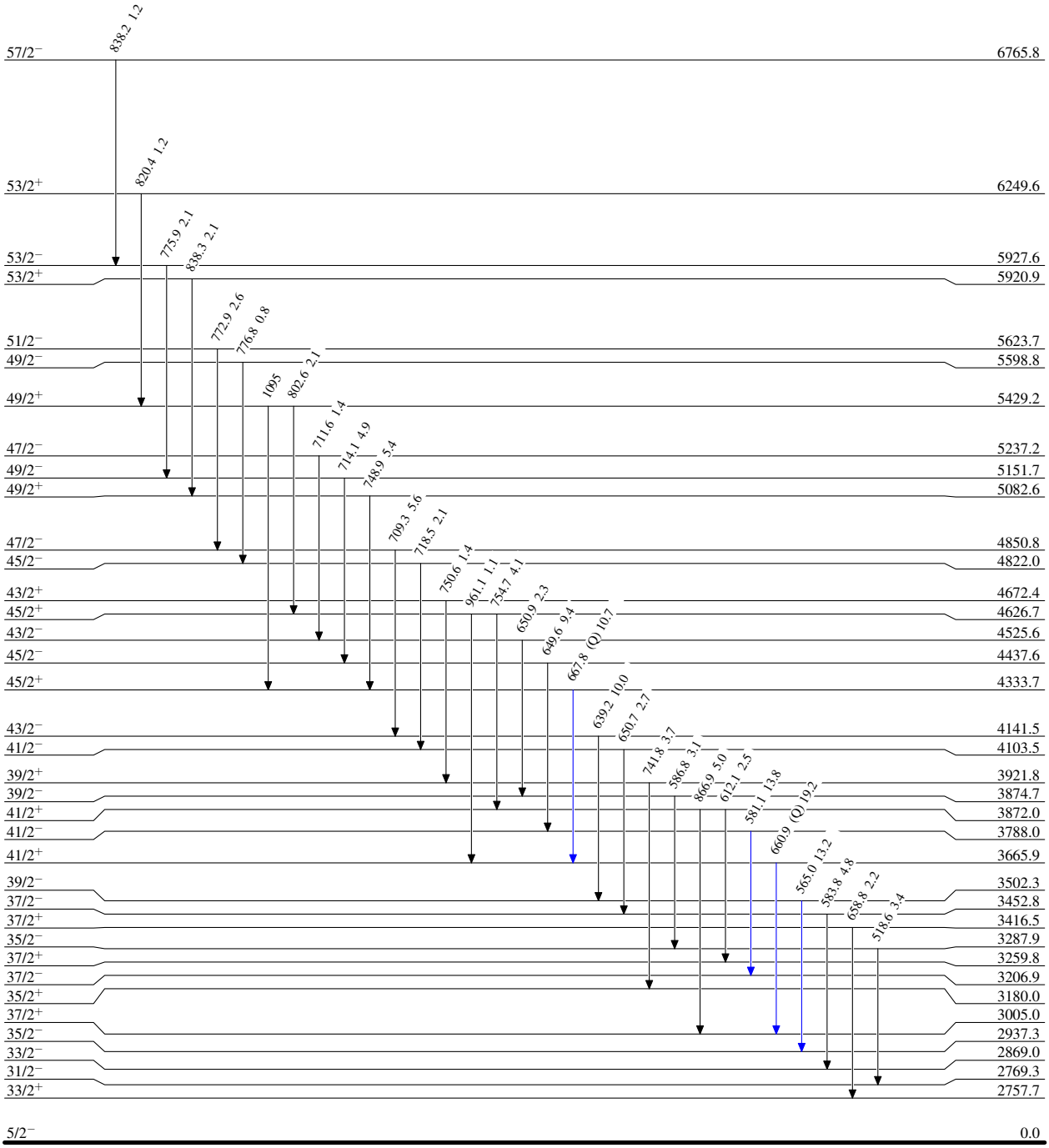
Intensities: Relative I_γ

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$



$^{167}_{72}Hf_{95}$

^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ

Level Scheme (continued)

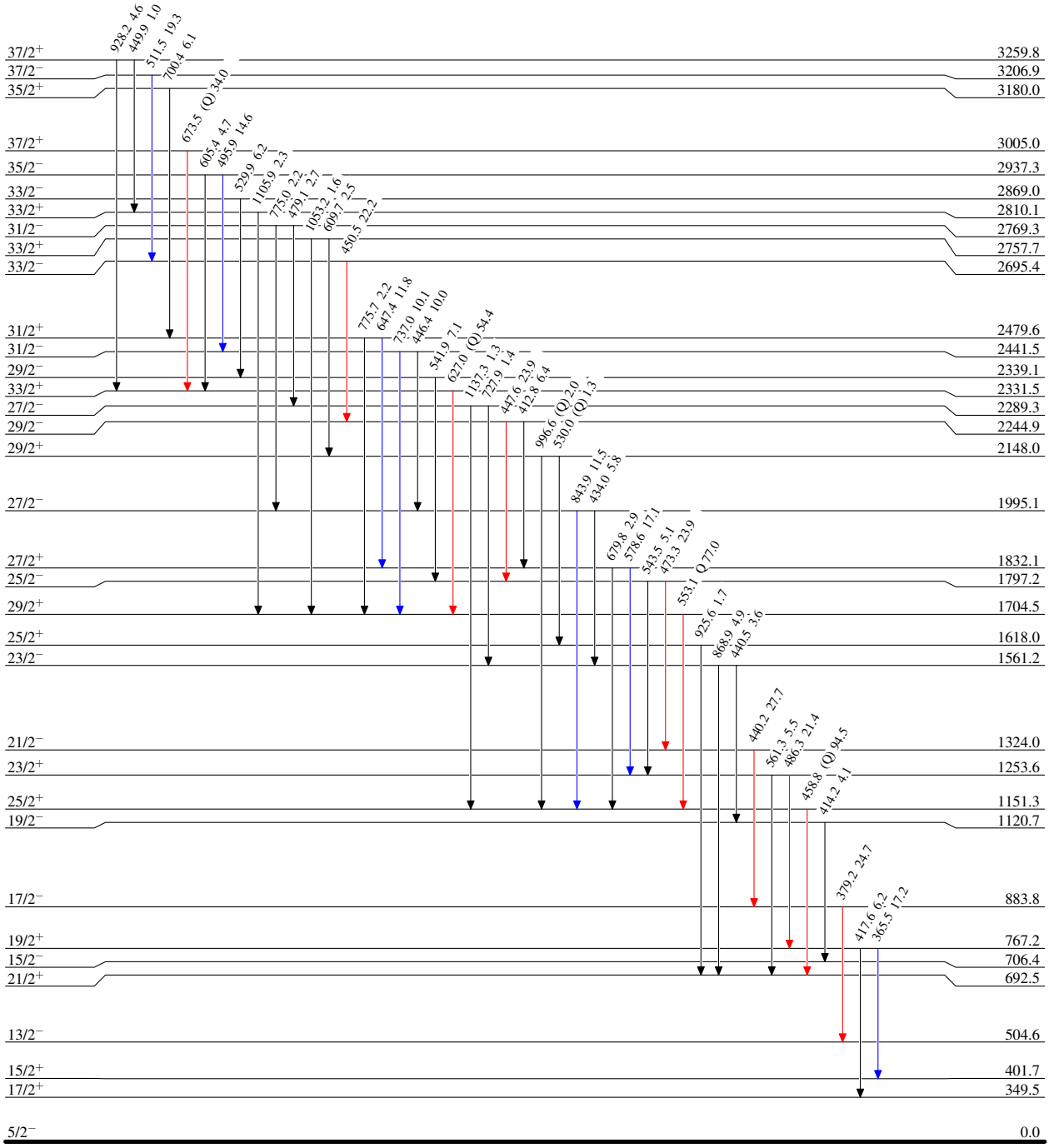
Intensities: Relative I_γ

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$

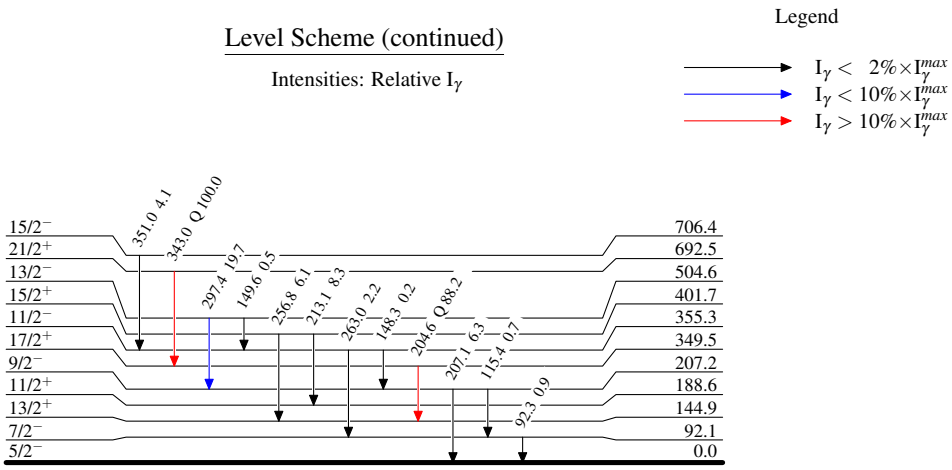


$^{167}_{72}Hf_{95}$

^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ

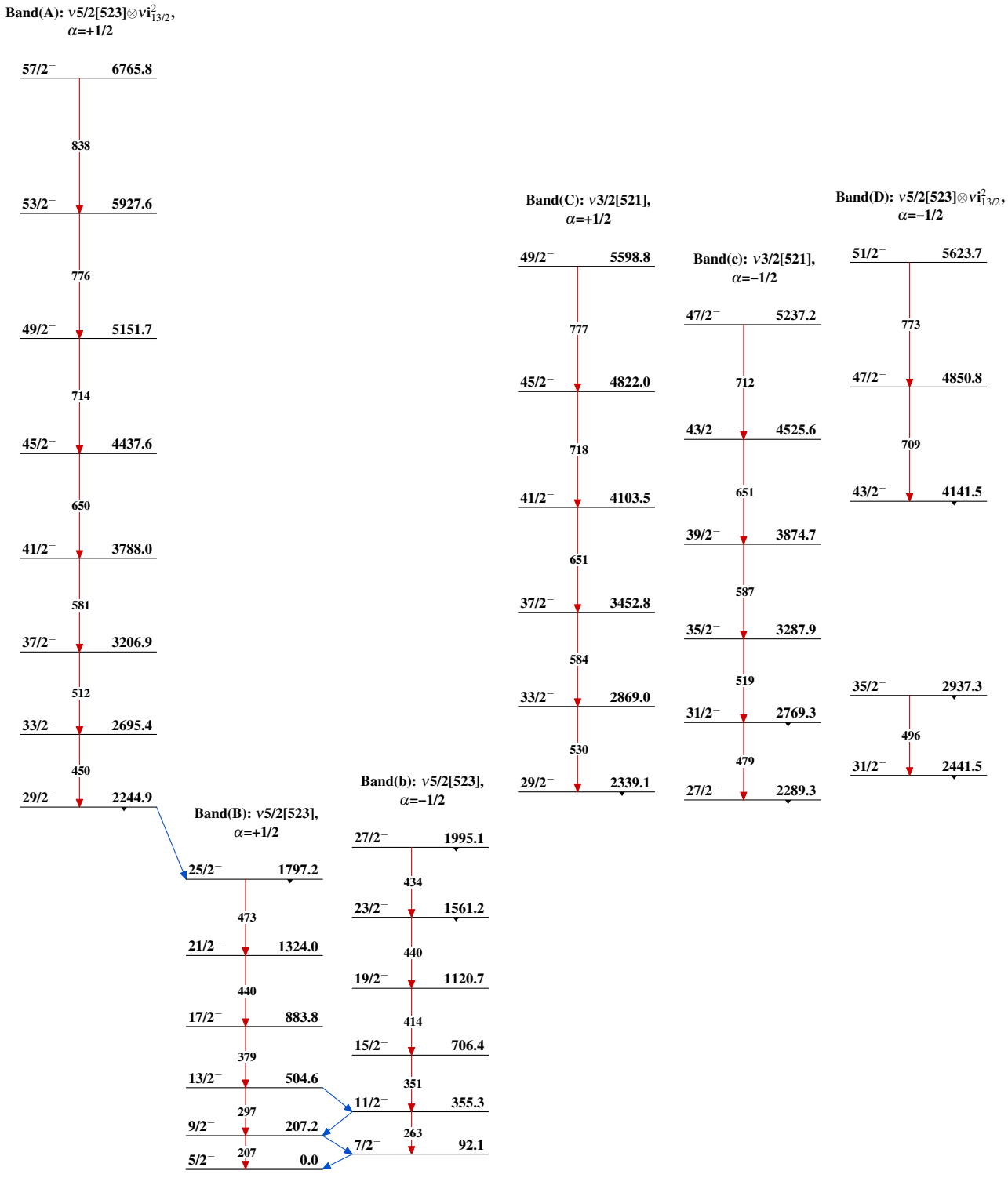
Level Scheme (continued)

Intensities: Relative I_γ



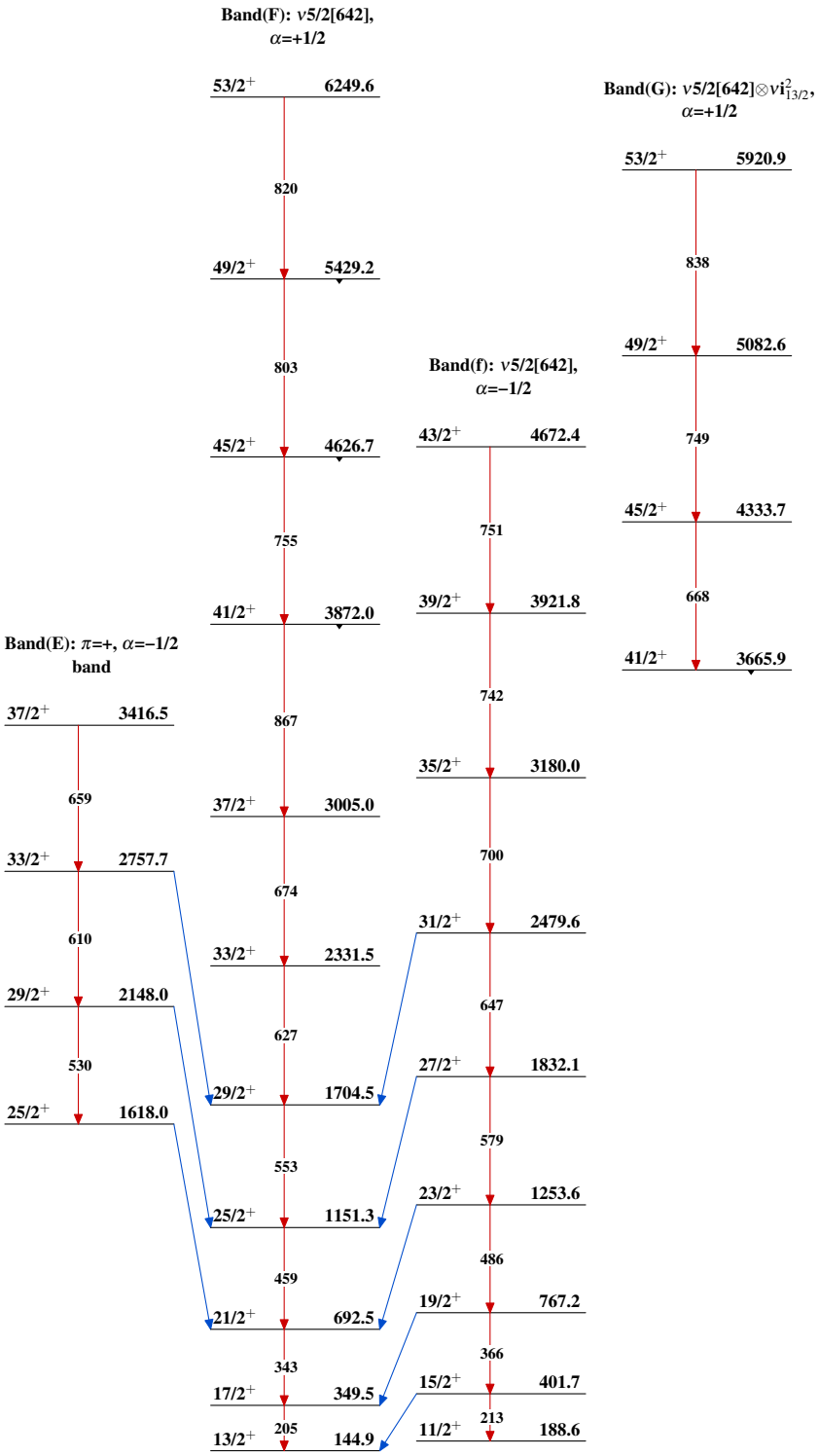
$^{167}_{72}Hf_{95}$

^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ



$^{167}_{72}Hf_{95}$

^{155}Gd(^{16}O,4nγ) 1999Cr01,1983Ar09,1977JoZQ (continued)



$^{167}_{72}Hf_{95}$