^{178}Hf IT decay (31 y) 2003Sm05,1980Va04,1976De20

History

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

Parent: ^{178}Hf: E=2445.69 *11*; J$^{\pi}$=16^{+}; $T_{1/2}$=31 y *1*; %IT decay=100

^{178}Hf-E(ex) from 2003Au02; $T_{1/2}$ from 1973He19.

1968He10: Measured Eγ, Iγ, γγ coin. Detectors: Ge(Li), scin.

1976De20: Measured γ singles, ce spectra, γγ, Xγ and εγ coin, Detectors: Ge(Li) anti-Compton, scin, Si(Li). Provided γ intensities, determined conversion coefficients.

1980Va04: Measured Eγ, Iγ, ce, γγ coin. Detectors: Ge(Li) high purity, Ge(Li) anti-Compton, Si(Li). Deduced reduced transitions probabilities B(QL).

1993Tl01: Measured γγ(θ), detector: array of seven Ge(Li) detectors. Determined mixing ratios for several transitions in the K^{π}=8^{-} isomeric band.

2003Sm05: Measured Eγ, Iγ, γγ using an array of 20 Compton-suppressed HPGe detectors.

Others: 1973He19.

^{178}Hf Levels

E(level)†	J$^{\pi}$	$T_{1/2}$	Comments
0.0‡	0^{+}		
93.193‡ *7*	2^{+}		
306.627‡ *10*	4^{+}		
632.187‡ *15*	6^{+}		
1058.548‡ *17*	8^{+}		
1147.421# *20*	8^{-}	4.0 s *2*	$T_{1/2}$: From Adopted Levels.
1364.083# *21*	9^{-}		
1601.488# *22*	10^{-}		
1859.123# *23*	(11)$^{-}$		
2136.527# *25*	(12)$^{-}$		
2202.52@ *7*	11^{-}		E(level),J$^{\pi}$: from 2003Sm05.
2433.34# *3*	(13)$^{-}$		
2446.07& *7*	16^{+}	31 y *1*	$T_{1/2}$: from 1973He19. Long lived isomer identified in 1968He10. Limits on alternate decay modes: β^{-}<0.3%, ε<1%, α<5×10^{-6}%, SF<3×10^{-6}% (1980Va04,2007Ka27).

† From a least-squares fit to γ-ray energies.

‡ Band(A): K^{π}=0^{+} g.s. rotational band.

\# Band(B): K^{π}=8^{-} isomeric band.

@ Band(C): K^{π}=8^{-}_{2} band.

& Band(D): K^{π}=16^{+} isomeric band.

$\gamma(^{178}$Hf)

Iγ normalization: From decay scheme if I(γ+ce)(325.6γ)=100%.

E_γ[†]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	δ	α[&]	Comments
(12.7 *2*)	7.2×10^{-6}	2446.07	16$^+$	2433.34	(13)$^-$	E3		1.47×10^7 *15*	B(E3)(W.u.)<4.5×10^{-10} Eγ: from adjusted level energy differences. Iγ: Estimated by evaluators based on intensity balance at the isomeric level, using theoretical total conversion coefficients, and assuming a pure E3 multipolarity for the 12.7 keV transition. Mult.: α(M)/α(L)(exp)=0.44 *+31−23*, 0.3≤α(L2)/α(L3)(exp)≤0.7 (1976De20). Note that the range of the measured conversion coefficients allows a significant M4 admixture.
88.873 *11*	67.9 *9*	1147.421	8$^-$	1058.548	8$^+$	E1		0.487	B(E1)(W.u.)=5.1×10^{-14} *3* Mult.: Experiment: α(tot)=0.52 *3*, α(L1+L2)=0.058 *13*, α(M)=0.019 *6* (1980Va04); α(K)=0.59 *9*, α(L)=0.089 *21*, α(M)=0.030 *7* (1976De20). Theory: α(tot)(E1)=0.487, α(tot)(M2)=57.4, α(K)(E1)=0.4, α(K)(M2)=39.8, α(L)(E1)=0.069, α(L)(M2)=13.4, α(L1+L2)(E1)=0.054, α(L1+L2)(M2)=11.0, α(M)(E1)=0.016, α(M)(M2)=3.3. The evaluators deduce an average value for the mixing ratio of δ=0.042 *9*, indicating an upper limit of ≈0.3% for any M2 admixture.
93.193 *7*	18.7 *3*	93.193	2$^+$	0.0	0$^+$	E2		4.66	Mult.: Experiment: α(K)=0.93 *23*, α(L)=2.68 *16*, α(M)=0.85 *6* (1976De20). Theory: α(K)=1.08, α(L)=2.72, α(M)=0.68.
213.434 *6*	85.8 *11*	306.627	4$^+$	93.193	2$^+$	E2		0.232	Mult.: Experiment: α(K)=0.148 *7*, α(L)=0.071 *4*, α(M)=0.0195 *10* (1976De20). Theory: α(K)(E2)=0.140, α(K)(M3)=6.63, α(L)(E2)=0.070, α(L)(M3)=2.79, α(M)(E2)=0.0172, α(M)(M3)=0.708.
216.668 *7*	69.0 *9*	1364.083	9$^-$	1147.421	8$^-$	M1+E2	1.63[#] *+22−18*	0.284 *12*	Mult.: α(K)(exp)=0.207 *11*, α(L)(exp)=0.069 *4*, α(M)(exp)=0.022 *1* (1976De20). Theory: α(K)(M1)=0.376, α(K)(E2)=0.134, α(L)(M1)=0.058, α(L)(E2)=0.066, α(M)(M1)=0.013, α(M)(E2)=0.016.
230.8 *1*	0.006 *1*	2433.34	(13)$^-$	2202.52	11$^-$				Eγ,Iγ: from 2003Sm05.
237.430 *10*	9.73 *15*	1601.488	10$^-$	1364.083	9$^-$	M1+E2	1.57[#] *+31−24*	0.218 *14*	Mult.: α(K)(exp)=0.165 *14*, α(L)(exp)=0.060 *7* (1976De20)l theory: α(K)(M1)=0.293,

γ(^{178}Hf) (continued)

E_γ[†]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	δ	α[&]	Comments
									α(K)(E2)=0.104, α(L)(M1)=0.045, α(L)(E2)=0.046.
257.645 *10*	17.7 *3*	1859.123	(11)$^-$	1601.488	10$^-$	M1+E2	4.3[#] *+26−12*	0.134 *7*	Mult.: α(K)(exp)=0.095 *6*, α(L)(exp)=0.037 *6*, α(M)(exp)=0.009 *3* (1976De20). Theory: α(K)(M1)=0.234, α(K)(E2)=0.083, α(L)(M1)=0.036, α(L)(E2)=0.033, α(M)(M1)=0.0081, α(M)(E2)=0.0080.
277.402 *18*	1.58 *10*	2136.527	(12)$^-$	1859.123	(11)$^-$	(M1+E2)	>1.13[#]	0.13 *3*	Mult.: α(K)(exp)≤0.13 (1976De20); theory: α(K)(M1)=0.192, α(K)(E2)=0.068.
296.812 *10*	10.64 *18*	2433.34	(13)$^-$	2136.527	(12)$^-$	M1+E2	−3.8[#] *+12−28*	0.089 *8*	Mult.: α(K)(exp)=0.058 *8*, α(L)(exp)=0.024 *7* (1976De20). Theory: α(K)(M1)=0.160, α(K)(E2)=0.056, α(L)(M1)=0.0244, α(L)(E2)=0.0194.
309.40 *21*	0.015 *1*	2446.07	16$^+$	2136.527	(12)$^-$	M4(+E5)	0.12 *10*	8.44 *13*	B(M4)(W.u.)=3.7×10^{-8} *5*; B(E5)(W.u.)=8.E−6 *+13−8* Additional information 2. Mult.: α(L)/α(K)(exp)=0.55 *8*, α(K)(exp)>2.5 (1980Va04); theory: α(L)/α(K)=0.50, α(K)=5.06. These values are consistent with an δ(M4/E5)=0.12 *10* mixing ratio.
325.560 *11*	100.0 *11*	632.187	6$^+$	306.627	4$^+$	E2		0.0622	Mult.: α(K)(exp)=0.0443 *20*, α(L)(exp)=0.0124 *8*, α(M)(exp)=0.0050 *8* (1976De20). Theory: α(K)(E2)=0.0441, α(K)(M3)=1.381, α(L)(E2)=0.0138, α(L)(M3)=0.412, α(M)(E2)=0.0033, α(M)(M3)=0.101.
343.3 *1*	0.0018 *3*	2202.52	11$^-$	1859.123	(11)$^-$				E_γ,I_γ: from 2003Sm05.
426.360 *8*	102.6 *13*	1058.548	8$^+$	632.187	6$^+$	E2		0.0292	Mult.: α(K)(exp)=0.0217 *10*, α(L)(exp)=0.0056 *7*, α(M)(exp)=0.0015 *4* (1976De20). Theory: α(K)(E2)=0.0221, α(L)(E2)=0.0055, α(M)(E2)=0.0013.
454.048 *12*	17.60 *25*	1601.488	10$^-$	1147.421	8$^-$	E2		0.0248	Mult.: α(K)(exp)=0.026 *5* (1976De20); theory: α(K)(E2)=0.0189, α(K)(M3)=0.423.
495.013 *15*	74.5 *14*	1859.123	(11)$^-$	1364.083	9$^-$	E2		0.0198	Mult.: α(K)(exp)=0.0174 *14*, α(L)(exp)=0.0032 *7*, α(M)(exp)=0.0014 *5* (1976De20). Theory: α(K)(E2)=0.0154, α(K)(M3)=0.314, α(L)(E2)=0.0034, α(L)(M3)=0.074, α(M)(E2)=0.00081, α(M)(M3)=0.0176.
515.1[a]	<0.0008	1147.421	8$^-$	632.187	6$^+$	M2		0.1365	B(M2)(W.u.)=3.E−14 *3* E_γ,I_γ,Mult.: from 2003Sm05.
535.038 *18*	9.8 *3*	2136.527	(12)$^-$	1601.488	10$^-$	E2		0.01635	Mult.: α(K)(exp)=0.018 *4* (1976De20). Theory: α(K)(E2)=0.0128, α(K)(M3)=0.241.
574.219 *21*	94.2 *19*	2433.34	(13)$^-$	1859.123	(11)$^-$	E2		0.01378	Mult.: α(K)(exp)=0.0122 *10*, α(L)(exp)=0.0023 *4*, α(M)(exp)=8.4×10^{-4} *23* (1976De20). Theory: α(K)(E2)=0.0109, α(K)(M3)=0.191, α(L)(E2)=0.00223, α(L)(M3)=0.0418, α(M)(E2)=5.2×10^{-4}, α(M)(M3)=0.0099.
587.0 *1*	0.0062 *5*	2446.07	16$^+$	1859.123	(11)$^-$	E5		0.284	B(E5)(W.u.)=1.9×10^{-7} *3* E_γ,I_γ,Mult.: from 2003Sm05.
601.1 *1*	0.0026 *3*	2202.52	11$^-$	1601.488	10$^-$				E_γ,I_γ: from 2003Sm05.

$\gamma(^{178}$Hf) (continued)

† Weighted averages of data from 2003Sm05, 1980Va04, and 1968He10, unless noted otherwise.
‡ Weighted averages of data from 2003Sm05, 1980Va04, 1976De20, and 1968He10, unless noted otherwise.
# From $\gamma\gamma(\theta)$ (1993Tl01).
@ For absolute intensity per 100 decays, multiply by 0.941 *12*.
& 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.
[a] Placement of transition in the level scheme is uncertain.

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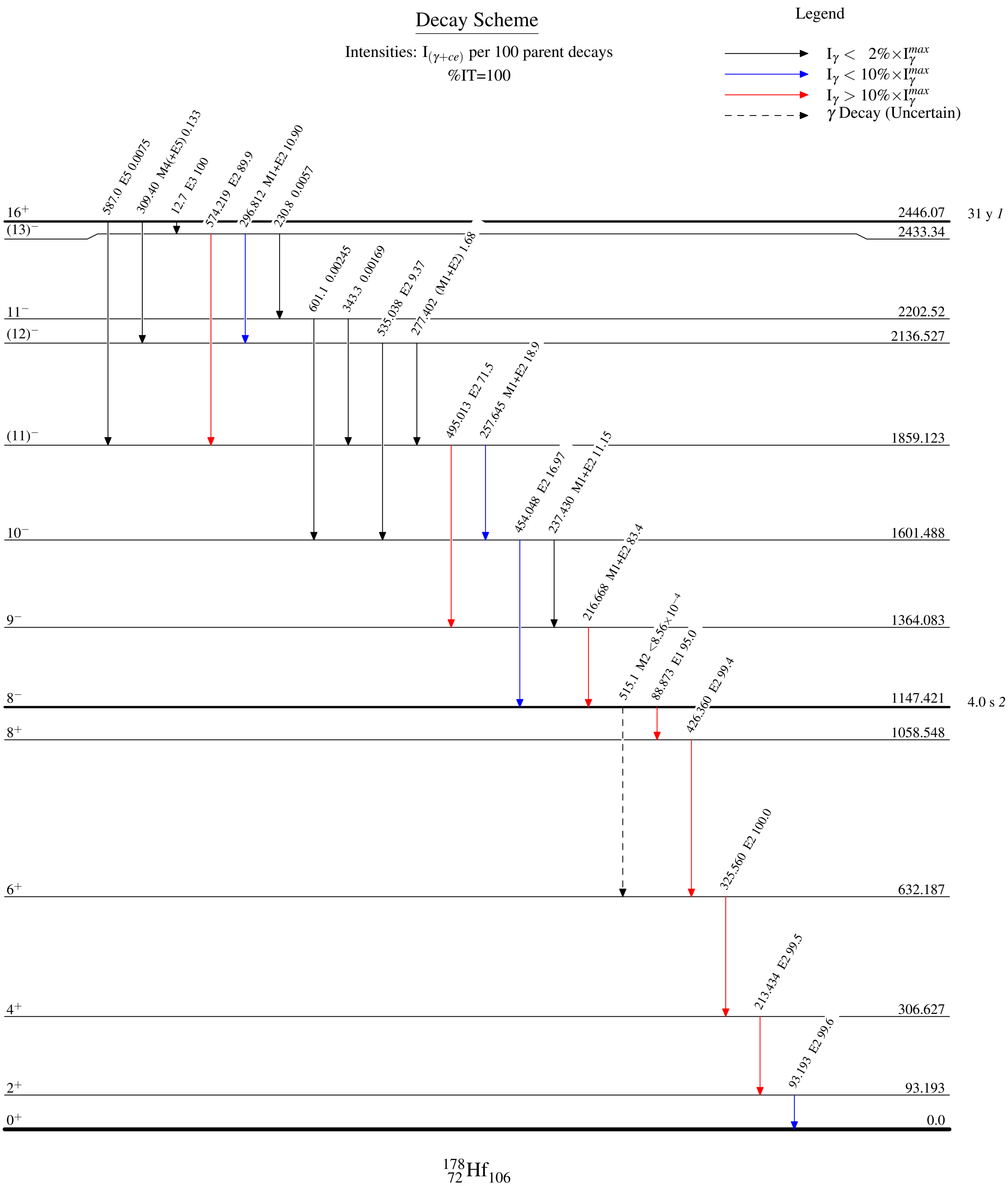
Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays
%IT=100



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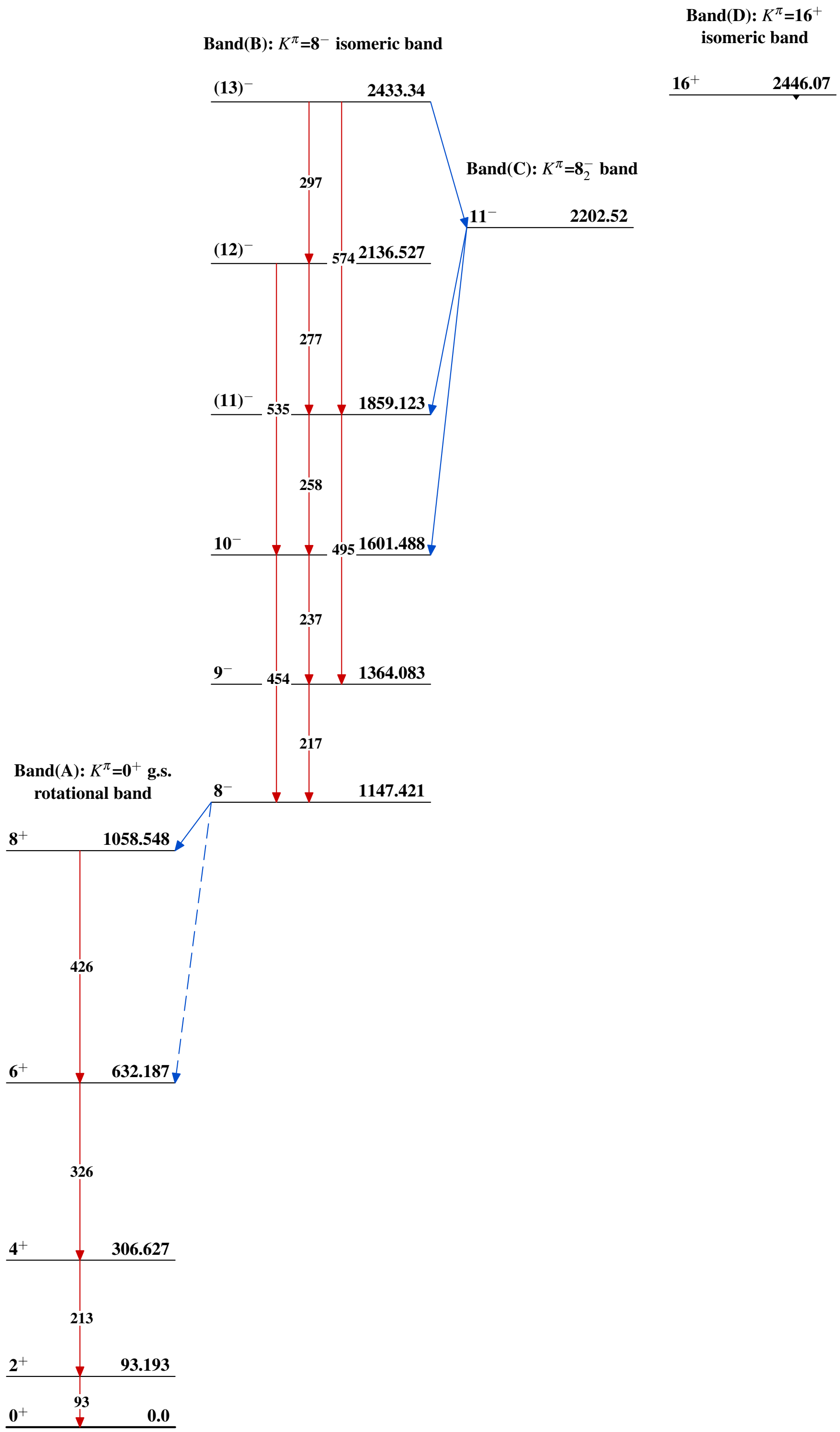

$^{178}_{72}Hf_{106}$