# $^{177}$Hf IT decay (1.09 s)

| Type | Author | History Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | F. G. Kondev | NDS 159, 1 (2019) | 30-Aug-2019 |

Parent: $^{177}$Hf: E=1315.4502 *8*; $J^{\pi}=23/2^+$; $T_{1/2}=1.09$ s *5*; %IT decay=100.0

Data taken from: 1964Al04, 1966Bo01, 1967Be34, 1967Ha09, 1969Hu06, 1970Ka39, 1971Gl09, 1972Bo55, 1972Ch48, 1974Kr12, 1981Hn03, 1989Ma56, 1990Bu31, 2001Sc23, 2011De07, 2012De24, 2012Ko23, 2012Ko24, 2014La20, 2016Lu16.

## $^{177}$Hf Levels

| E(level)† | $J^{\pi}$‡ | $T_{1/2}$‡ | Comments |
|---|---|---|---|
| 0.0# | $7/2^-$ | stable | |
| 112.9499# *4* | $9/2^-$ | 0.541 ns *14* | |
| 249.6744# *4* | $11/2^-$ | 107 ps *10* | |
| 321.3162@ *4* | $9/2^+$ | 0.665 ns *16* | |
| 409.4085# *5* | $13/2^-$ | | |
| 426.6752@ *4* | $11/2^+$ | 40 ps *3* | |
| 555.1779@ *4* | $13/2^+$ | | |
| 591.3179# *7* | $15/2^-$ | | |
| 708.4622@ *5* | $15/2^+$ | | |
| 794.4394# *9* | $17/2^-$ | | |
| 882.8611@ *5* | $17/2^+$ | | |
| 1017.7911# *20* | $19/2^-$ | | |
| 1086.9662@ *6* | $19/2^+$ | | |
| 1260.2817# *14* | $21/2^-$ | | |
| 1301.4004@ *6* | $21/2^+$ | | |
| 1315.4502& *8* | $23/2^+$ | 1.09 s *5* | $T_{1/2}$: Weighted average of 1.08 s *6* (1971Gl09) and 1.12 s *10* (1966Bo01) measured from $\beta\gamma$(t) in $^{177}$Lu $\beta^-$ decay (160.4 d). Others: 1.1 s (1967Ra36). |

† From a least-squares fit to E$\gamma$.
‡ From Adopted Levels.
# Band(A): $K^{\pi}=7/2^-$, $\nu$7/2[514] band.
@ Band(B): $K^{\pi}=9/2^+$, $\nu$9/2[624] band.
& $K^{\pi}=23/2^+$, $\nu(7/2[514])\otimes\pi^2(7/2[404],9/2[514])$.

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf)

Iγ normalization: 100/I(γ+ce)(23/2$^+$)=100/609.8 *17*, weighted average of 610 *11* (Iπ=7/2$^-$), 610 *8* (I=9/2), 610 *5* (I=11/2), 609 *4* (I=13/2), 611.5 *34* (I=15/2), 609.1 *31* (I=17/2), 609 *7* (I=19/2) and 609 *9* (I=21/2).

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult. [‡] | δ [‡] | α [@] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| (14.050 *10*) | 1.161 *18* | 1315.4502 | 23/2$^+$ | 1301.4004 | 21/2$^+$ | [M1+E2] | | 217 | %Iγ=0.1904 *30*<br>α(L)=167.8 *24*; α(M)=38.2 *6*<br>α(N)=9.08 *13*; α(O)=1.389 *20*; α(P)=0.0917 *13*<br>$E_\gamma$: From level energy differences.<br>$I_\gamma$: Using I(γ+ce)(14.050γ)=253.2 *16* from transition intensity balance at the 1301-keV level and α=217. |
| 55.15 *2* | 15.42 *17* | 1315.4502 | 23/2$^+$ | 1260.2817 | 21/2$^-$ | [E1] | | 0.333 | %Iγ=2.529 *29*<br>α(N)=0.01357 *19*; α(O)=0.00183 *3*; α(P)=7.37×10$^{-5}$ *11*<br>$I_\gamma$: Using I(γ+ce)(55.15γ)=20.55 *22* from transition intensity balance at the 1260-keV level and α=0.333. Others: 13.5 *10* (2014La20), 14.9 *9* (2012De24) and 10.0 *15* (1967Ha09). |
| 69.2 *1* | 0.078 *9* | 1086.9662 | 19/2$^+$ | 1017.7911 | 19/2$^-$ | [E1] | | 0.919 | %Iγ=0.0128 *15*<br>α(K)=0.742 *11*; α(L)=0.1381 *21*; α(M)=0.0313 *5*<br>α(N)=0.00725 *11*; α(O)=0.001000 *15*; α(P)=4.33×10$^{-5}$ *7*<br>$I_\gamma$: Weighted average of 0.077 *9* (2012De24) and 0.088 *30* (1967Be34). Other: 0.08 (1967Ha09). |
| 71.6418 *6* | 6.91 *20* | 321.3162 | 9/2$^+$ | 249.6744 | 11/2$^-$ | E1+M2 | −0.018 *9* | 0.89 *6* | %Iγ=1.133 *33*<br>α(K)=0.71 *4*; α(L)=0.136 *14*; α(M)=0.031 *4*<br>α(N)=0.0072 *9*; α(O)=0.00101 *12*; α(P)=4.5×10$^{-5}$ *7*<br>$I_\gamma$: From intensity balance at the 321-keV level, Iγ(208.3662γ)=437 *6* and Iγ(71.6418γ)/Iγ(208.3662γ)=0.0158 *4*, weighted average of 0.0152 *11* (2016Lu16), 0.0163 *2* (2012Ko24), 0.01674 *21* (2001Sc23), 0.0171 *5* (1987Me17), 0.015 *1* (1974Ag01), 0.0146 *6* (1967Ha09) and 0.0140 *10* (1964Al04) (from $^{177}$Lu $\beta^-$ decay (6.6 d) – others: 0.01780 *7* (2011De07), 0.0030 *10* (1961We11) and 0.0091 (1955Ma12)), and 0.0137 *6* (2014La20), 0.0155 *11* (2012De24), 0.0128 *4* (2012Ko23), 0.0158 *6* (1981Hn03), 0.0145 *14* (1972Ch48), 0.0137 *8* (1967Be34), 0.0140 *8* (1967Ha09) and 0.015 *3* (1964Al04) (from $^{177}$Lu $\beta^-$ decay (160.4 d)). |
| 88.4 *1* | 0.34 *4* | 882.8611 | 17/2$^+$ | 794.4394 | 17/2$^-$ | [E1] | | 0.494 | %Iγ=0.056 *7*<br>α(K)=0.403 *6*; α(L)=0.0701 *10*; α(M)=0.01587 *23*<br>α(N)=0.00369 *6*; α(O)=0.000519 *8*; α(P)=2.41×10$^{-5}$ *4*<br>$I_\gamma$: Weighted average of 0.30 *7* (2014La20), 0.40 *7* (2012De24) and 0.32 *8* (1967Be34). |





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## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult.[‡] | δ[‡] | α[@] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 105.3589 *4* | 100 | 426.6752 | 11/2$^+$ | 321.3162 | 9/2$^+$ | M1+E2 | −0.330 *13* | 3.39 | %Iγ=16.40 *5*<br>α(K)=2.67 *4*; α(L)=0.555 *11*; α(M)=0.129 *3*<br>α(N)=0.0304 *7*; α(O)=0.00443 *9*; α(P)=0.000226 *4*<br>$I_\gamma$: Used for normalization of relative γ-ray emission probabilities. |
| 112.9498 *4* | 168.5 *29* | 112.9499 | 9/2$^-$ | 0.0 | 7/2$^-$ | M1+E2 | −4.77 *19* | 2.23 | %Iγ=27.6 *5*<br>α(K)=0.805 *13*; α(L)=1.085 *16*; α(M)=0.270 *4*<br>α(N)=0.0627 *9*; α(O)=0.00798 *12*; α(P)=5.14×10$^{-5}$ *9*<br>$I_\gamma$: From intensity balance at the 113-keV level. Values measured in $^{177}$Lu $\beta^-$ decay (160.4 d) are 173.0 *25* (2014La20), 171.7 *23* (2012De24), 170 *5* (2012Ko23), 179 *4* (1981Hn03), 179 *8* (1972Ch48), 179 *13* (1967Ha09) and 251 *13* (1964Al04), but those can be affected from the $^{177}$Lu $\beta^-$ decay (6.6 d) decay feedings. |
| 117.1442 *12* | 1.53 *9* | 708.4622 | 15/2$^+$ | 591.3179 | 15/2$^-$ | [E1] | | 0.237 | %Iγ=0.251 *15*<br>α(K)=0.196 *3*; α(L)=0.0323 *5*; α(M)=0.00730 *11*<br>α(N)=0.001704 *24*; α(O)=0.000244 *4*; α(P)=1.213×10$^{-5}$ *17*<br>$I_\gamma$: Weighted average of 1.5 *2* (2014La20), 1.43 *13* (2012De24), 1.51 *20* (1981Hn03) and 1.8 *2* (1967Ha09). Other: 12 *2* (1964Al04). |
| 128.5027 *4* | 126.5 *11* | 555.1779 | 13/2$^+$ | 426.6752 | 11/2$^+$ | M1+E2 | −0.336 *10* | 1.90 | %Iγ=20.75 *19*<br>α(K)=1.519 *22*; α(L)=0.291 *5*; α(M)=0.0671 *11*<br>α(N)=0.0159 *3*; α(O)=0.00234 *4*; α(P)=0.0001277 *19*<br>$I_\gamma$: Weighted average of 126.1 *18* (2014La20), 127.3 *18* (2012De24), 125 *4* (2012Ko23), 126.6 *25* (1981Hn03), 127 *6* (1972Ch48), 127 *8* (1967Ha09) and 125 *6* (1964Al04). |
| 136.7245 *5* | 11.45 *9* | 249.6744 | 11/2$^-$ | 112.9499 | 9/2$^-$ | M1+E2 | −3.31 *15* | 1.130 *17* | %Iγ=1.878 *16*<br>α(K)=0.540 *10*; α(L)=0.450 *7*; α(M)=0.1113 *17*<br>α(N)=0.0259 *4*; α(O)=0.00334 *5*; α(P)=3.57×10$^{-5}$ *9*<br>$I_\gamma$: From intensity balance at the 249-keV level, Iγ(249.6742γ)=49.2 *6* and Iγ(136.7245γ)/Iγ(249.6742γ)=0.2327 *19*, weighted average of 0.243 *6* (2012Ko24), 0.234 *4* (2001Sc23), 0.229 *3* (1987Me17), 0.223 *16* (1964Al04) and 0.24 *8* (1961We11) (from $^{177}$Lu $\beta^-$ decay (6.6 d) − others: 0.184 *11* (2016Lu16), 0.274 *3* (2011De07), 0.274 *26* (1974Ag01), 0.306 *22* (1967Ha09)), and 0.234 *5* (2014La20), 0.236 *9* (2012Ko23), 0.228 *10* (1981Hn03), 0.222 *21* (1972Ch48) and 0.249 *17* (1967Ha09) (from $^{177}$Lu $\beta^-$ decay (160.4 d) − others: 0.315 *11* (2012De24)and 0.27 *5* (1964Al04)). Values measured in $^{177}$Lu $\beta^-$ decay (160.4 d) are 11.47 *23* (2014La20), 14.7 *5* (2012De24), 11.0 *4* (2012Ko23), 11.4 *5* (1981Hn03), 11.4 *11* (1972Ch48), 11.7 *8* (1967Ha09) and 17 *3* (1964Al04). |





$^{177}_{72}Hf_{105}$-3

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult. [‡] | δ [‡] | α [@] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 145.7693 *7* | 7.61 *12* | 555.1779 | 13/2$^+$ | 409.4085 | 13/2$^-$ | [E1] | | 0.1339 | %Iγ=1.248 *20*<br>α(K)=0.1109 *16*; α(L)=0.01781 *25*; α(M)=0.00402 *6*<br>α(N)=0.000940 *14*; α(O)=0.0001361 *19*; α(P)=7.10×10$^{-6}$ *10*<br>$I_\gamma$: Weighted average of 7.65 *13* (2014La20), 7.4 *4* (1981Hn03), 7.5 *8* (1972Ch48), 7.7 *5* (1967Be34), 6.6 *9* (1967Ha09). Others: 9.1 *3* (2012De24) and 11 *2* (1964Al04). |
| 153.2842 *4* | 130.5 *13* | 708.4622 | 15/2$^+$ | 555.1779 | 13/2$^+$ | M1+E2 | −0.352 *17* | 1.135 *17* | %Iγ=21.40 *22*<br>α(K)=0.918 *15*; α(L)=0.168 *3*; α(M)=0.0386 *7*<br>α(N)=0.00913 *15*; α(O)=0.001357 *21*; α(P)=7.70×10$^{-5}$ *13*<br>$I_\gamma$: Weighted average of 130.9 *14* (2012De24) and 127 *4* (2012Ko23). Others: 136.2 *20* (2014La20), 136 *3* (1981Hn03), 150 *7* (1972Ch48) 133 *8* (1967Ha09) and 134 *7* (1964Al04). |
| 159.7341 *7* | 4.21 *7* | 409.4085 | 13/2$^-$ | 249.6744 | 11/2$^-$ | M1+E2 | −2.4 *10* | 0.69 *9* | %Iγ=0.690 *12*<br>α(K)=0.39 *11*; α(L)=0.223 *20*; α(M)=0.055 *6*<br>α(N)=0.0127 *13*; α(O)=0.00167 *13*; α(P)=2.8×10$^{-5}$ *11*<br>$I_\gamma$: Weighted average of 4.2 *2* (1981Hn03), 4.21 *9* (2014La20), 4.5 *5* (2012De24), 4.06 *14* (2012Ko23), 5.4 *5* (1967Ha09) and 5.0 *6* (1972Ch48). Other: 5 *1* (1964Al04). |
| 174.3988 *4* | 98.4 *8* | 882.8611 | 17/2$^+$ | 708.4622 | 15/2$^+$ | M1+E2 | −0.313 *16* | 0.793 *12* | %Iγ=16.14 *14*<br>α(K)=0.649 *10*; α(L)=0.1116 *17*; α(M)=0.0255 *4*<br>α(N)=0.00604 *9*; α(O)=0.000908 *13*; α(P)=5.45×10$^{-5}$ *9*<br>$I_\gamma$: Weighted average of 102.5 *20* (1981Hn03), 100.8 *14* (2014La20), 94.7 *14* (2012De24), 93 *3* (2012Ko23), 96 *8* (1967Ha09), 105 *5* (1972Ch48). Other: 110 *6* (1964Al04). |
| 177.0007 *4* | 28.6 *3* | 426.6752 | 11/2$^+$ | 249.6744 | 11/2$^-$ | [E1] | | 0.0808 | %Iγ=4.69 *5*<br>α(K)=0.0672 *10*; α(L)=0.01057 *15*; α(M)=0.00238 *4*<br>α(N)=0.000558 *8*; α(O)=8.15×10$^{-5}$ *12*; α(P)=4.42×10$^{-6}$ *7*<br>$I_\gamma$: Weighted average of 28.6 *4* (2014La20), 29.0 *5* (2012De24), 28.0 *9* (1981Hn03), 28.9 *18* (1972Ch48), 27.8 *12* (1967Be34), 26 *3* (1967Ha09). Other: 34 *3* (1964Al04). |
| 181.9093 *13* | 0.77 *3* | 591.3179 | 15/2$^-$ | 409.4085 | 13/2$^-$ | [M1+E2] | | 0.734 | %Iγ=0.126 *5*<br>α(K)=0.612 *9*; α(L)=0.0947 *14*; α(M)=0.0214 *3*<br>α(N)=0.00508 *8*; α(O)=0.000779 *11*; α(P)=5.18×10$^{-5}$ *8*<br>$I_\gamma$: From Iγ(181.9γ)/Iγ(341.6423γ)=0.0556 *24* in adopted gammas and Iγ(341.6423γ)=13.88 *22*. |
| 203.0 *1* | 0.98 *5* | 794.4394 | 17/2$^-$ | 591.3179 | 15/2$^-$ | [M1+E2] | | 0.541 | %Iγ=0.161 *8*<br>α(K)=0.451 *7*; α(L)=0.0697 *11*; α(M)=0.01572 *23*<br>α(N)=0.00374 *6*; α(O)=0.000573 *9*; α(P)=3.81×10$^{-5}$ *6*<br>$I_\gamma$: From Iγ(203.0γ)/Iγ(385.0304γ)=0.0390 *21* in adopted gammas and Iγ(385.0304γ)=25.0 *3*. |





$^{177}_{72}Hf_{105}$-4

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$[†] | $I_\gamma$[#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult.[‡] | δ[‡] | α[@] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 204.1050 *4* | 106.6 *19* | 1086.9662 | 19/2$^+$ | 882.8611 | 17/2$^+$ | M1+E2 | −0.335 *23* | 0.506 *8* | %Iγ=17.48 *32*<br>α(K)=0.415 *7*; α(L)=0.0702 *10*; α(M)=0.01601 *24*<br>α(N)=0.00379 *6*; α(O)=0.000572 *8*; α(P)=3.48×10$^{-5}$ *6*<br>$I_\gamma$: Weighted average of 111.7 *25* (1981Hn03), 109.2 *16* (2014La20), 102.5 *14* (2012De24), 105 *3* (2012Ko23), 114 *8* (1967Ha09) and 119 *6* (1972Ch48). Other: 130 *13* (1964Al04). |
| 208.3662 *4* | 437 *6* | 321.3162 | 9/2$^+$ | 112.9499 | 9/2$^-$ | E1+M2 | +0.076 *19* | 0.068 *9* | %Iγ=71.7 *10*<br>α(K)=0.055 *7*; α(L)=0.0094 *15*; α(M)=0.0022 *4*<br>α(N)=0.00051 *9*; α(O)=7.5×10$^{-5}$ *13*; α(P)=4.3×10$^{-6}$ *8*<br>$I_\gamma$: From intensity balance at the 321-keV level, Iγ(71.6418γ)/Iγ(208.3662γ)=0.0158 *4*, weighted average of 0.0152 *11* (2016Lu16), 0.0163 *2* (2012Ko24), 0.01674 *21* (2001Sc23), 0.0171 *5* (1987Me17), 0.015 *1* (1974Ag01), 0.0146 *6* (1967Ha09) and 0.0140 *10* (1964Al04) (from $^{177}$Lu $\beta^-$ decay (6.6 d) − others: 0.01780 *7* (2011De07), 0.0030 *10* (1961We11) and 0.0091 (1955Ma12)), and 0.0137 *6* (2014La20), 0.0155 *11* (2012De24), 0.0128 *4* (2012Ko23), 0.0158 *6* (1981Hn03), 0.0145 *14* (1972Ch48), 0.0137 *8* (1967Be34), 0.0140 *8* (1967Ha09) and 0.015 *3* (1964Al04) (from $^{177}$Lu $\beta^-$ decay (160.4 d)), and Iγ(321.3159γ)/Iγ(208.3662γ)=0.0210 *3*, weighted average of 0.0189 *19* (2012Ko24), 0.02002 *19* (2001Sc23), 0.0217 *2* (1987Me17), 0.0198 *18* (1974Ag01), 0.0220 *12* (1967Ha09), 0.0199 *14* (1964Al04), 0.0228 *10* (1961We11) (from $^{177}$Lu $\beta^-$ decay (6.6 d) − others: 0.0152 *11* (2016Lu16), 0.02470 *7* (2011De07) and 0.0146 (1955Ma12)), and 0.0214 *8* (2014La20), 0.0228 *4* (2012De24), 0.0199 *9* (2012Ko23), 0.0203 *18* (1981Hn03), 0.0227 *18* (1972Ch48), 0.0191 *10* (1967Be34), 0.0186 *21* (1967Ha09) (from $^{177}$Lu $\beta^-$ decay (160.4 d) − other: 0.0197 (1964Al04)). |
| 214.4341 *5* | 50.7 *5* | 1301.4004 | 21/2$^+$ | 1086.9662 | 19/2$^+$ | M1+E2 | −0.30 *3* | 0.445 *8* | %Iγ=8.31 *9*<br>α(K)=0.367 *7*; α(L)=0.0605 *9*; α(M)=0.01377 *20*<br>α(N)=0.00327 *5*; α(O)=0.000494 *7*; α(P)=3.08×10$^{-5}$ *6*<br>$I_\gamma$: Weighted average of 53.7 *15* (1981Hn03), 51.8 *7* (2014La20), 47.6 *9* (2012De24), 55 *3* (1972Ch48), 50.7 *14* (2012Ko23), 48 *4* (1967Ha09). Other: 79 *8* (1964Al04). |
| 223.3 *3* | 0.102 *6* | 1017.7911 | 19/2$^-$ | 794.4394 | 17/2$^-$ | [E2+M1] | | 0.415 | %Iγ=0.0167 *10*<br>α(K)=0.347 *5*; α(L)=0.0534 *8*; α(M)=0.01206 *18*<br>α(N)=0.00287 *5*; α(O)=0.000440 *7*; α(P)=2.93×10$^{-5}$ *5*<br>$I_\gamma$: From Iγ(223.3γ)/Iγ(426.4726γ)=0.0270 *17* in adopted gammas and Iγ(385.0304γ)=3.56 *10*. |





$^{177}_{72}Hf_{105}$-5

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$[†] | $I_\gamma$[#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult.[‡] | α[@] | Comments |
|---|---|---|---|---|---|---|---|---|
| 228.4838 *6* | 283 *6* | 1315.4502 | 23/2$^+$ | 1086.9662 | 19/2$^+$ | E2 | 0.185 | %Iγ=46.4 *10*<br>α(K)=0.1156 *17*; α(L)=0.0533 *8*; α(M)=0.01300 *19*<br>α(N)=0.00303 *5*; α(O)=0.000402 *6*; α(P)=7.81×10$^{-6}$ *11*<br>$I_\gamma$: Weighted average of 301 *6* (1981Hn03), 296 *5* (2014La20), 273 *3* (2012De24), 310 *13* (1972Ch48), 271 *8* (2012Ko23) and 287 *26* (1967Ha09) and the external uncertainty. Other: 340 *17* (1964Al04). Note, that Iγ(228.4838)=282 *4* from transition intensity balance at the 1086.9-keV level, which is in excellent agreement with the recommend value. |
| 233.8615 *5* | 36.7 *11* | 555.1779 | 13/2$^+$ | 321.3162 | 9/2$^+$ | E2 | 0.1719 | %Iγ=6.02 *18*<br>α(K)=0.1084 *16*; α(L)=0.0486 *7*; α(M)=0.01183 *17*<br>α(N)=0.00276 *4*; α(O)=0.000367 *6*; α(P)=7.36×10$^{-6}$ *11*<br>$I_\gamma$: From 2012Ko23. Others: 44.5 *7* (2014La20), 42.6 *5* (2012De24), 45.3 *15* (1981Hn03), 47.1 *23* (1972Ch48), 45 *4* (1967Ha09) and 43 *4* (1964Al04). |
| 242.1 *3* | 0.456 *23* | 1260.2817 | 21/2$^-$ | 1017.7911 | 19/2$^-$ | [E2+M1] | 0.333 | %Iγ=0.075 *4*<br>α(K)=0.278 *4*; α(L)=0.0427 *6*; α(M)=0.00964 *14*<br>α(N)=0.00229 *4*; α(O)=0.000352 *5*; α(P)=2.34×10$^{-5}$ *4*<br>$I_\gamma$: Weighted average of 0.458 *24* (2014La20) and 0.43 *9* (2012De24). Other: 0.30 *10* (1981Hn03). |
| 249.6742 *6* | 49.2 *6* | 249.6744 | 11/2$^-$ | 0.0 | 7/2$^-$ | E2 | 0.1395 | %Iγ=8.07 *10*<br>α(K)=0.0905 *13*; α(L)=0.0375 *6*; α(M)=0.00911 *13*<br>α(N)=0.00213 *3*; α(O)=0.000284 *4*; α(P)=6.23×10$^{-6}$ *9*<br>$I_\gamma$: From intensity balance at the 249-keV level and Iγ(136.7245γ)/Iγ(249.6742γ)=0.2327 *19*, weighted average of 0.243 *6* (2012Ko24), 0.234 *4* (2001Sc23), 0.229 *3* (1987Me17), 0.223 *16* (1964Al04) and 0.24 *8* (1961We11) (from $^{177}$Lu $\beta^-$ decay (6.6 d) – others: 0.184 *11* (2016Lu16), 0.274 *3* (2011De07), 0.274 *26* (1974Ag01), 0.306 *22* (1967Ha09)), and 0.234 *5* (2014La20), 0.236 *9* (2012Ko23), 0.228 *10* (1981Hn03), 0.222 *21* (1972Ch48) and 0.249 *17* (1967Ha09) (from $^{177}$Lu $\beta^-$ decay (160.4 d) – others: 0.315 *11* (2012De24)and 0.27 *5* (1964Al04)). |
| 281.7868 *5* | 110.2 *10* | 708.4622 | 15/2$^+$ | 426.6752 | 11/2$^+$ | E2 | 0.0958 | %Iγ=18.07 *17*<br>α(K)=0.0650 *10*; α(L)=0.0236 *4*; α(M)=0.00569 *8*<br>α(N)=0.001329 *19*; α(O)=0.000180 *3*; α(P)=4.59×10$^{-6}$ *7*<br>$I_\gamma$: Weighted average of 112.6 *23* (2014La20), 108.2 *14* (2012De24), 106 *3* (2012Ko23), 115.2 *25* (1981Hn03), 117 *5* (1972Ch48) and 108 *9* (1967Ha09). Other: 121 *6* (1964Al04). |
| 283.609 *3* | 3.25 *19* | 1301.4004 | 21/2$^+$ | 1017.7911 | 19/2$^-$ | [E1] | 0.0245 | %Iγ=0.533 *31*<br>α(K)=0.0205 *3*; α(L)=0.00310 *5*; α(M)=0.000697 *10*<br>α(N)=0.0001642 *23*; α(O)=2.44×10$^{-5}$ *4*; α(P)=1.425×10$^{-6}$ *20*<br>$I_\gamma$: Weighted average of 2.9 *4* (1981Hn03), 3.23 *26* (2014La20), 4.3 *6* (1972Ch48), 4.7 *12* (1967Ha09), and 2.9 *5* (1967Be34). Other: 5.12 *23* (2012De24). |





$^{177}_{72}Hf_{105}$-6

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult.[‡] | δ[‡] | α[@] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 291.5429 *12* | 8.14 *23* | 882.8611 | 17/2$^+$ | 591.3179 | 15/2$^-$ | E1+M2 | +0.08 *8* | 0.028 *15* | %Iγ=1.33 *4*<br>α(K)=0.023 *12*; α(L)=0.0037 *25*; α(M)=0.0008 *6*<br>α(N)=0.00020 *14*; α(O)=3.0×10$^{-5}$ *21*; α(P)=1.8×10$^{-6}$ *13*<br>$I_\gamma$: Weighted average of 8.2 *6* (1981Hn03), 8.1 *3* (2014La20), 8.3 *6* (2012Ko23), 7.7 *9* (1967Ha09) and 8.4 *8* (1967Be34). Others: 6.3 *3* (2012De24), 14.9 *13* (1972Ch48) and 20 *4* (1964Al04). |
| 292.5266 *14* | 6.4 *4* | 1086.9662 | 19/2$^+$ | 794.4394 | 17/2$^-$ | E1+M2 | +0.08 *8* | 0.028 *15* | %Iγ=1.05 *7*<br>α(K)=0.023 *12*; α(L)=0.0037 *24*; α(M)=0.0008 *6*<br>α(N)=0.00020 *14*; α(O)=3.0×10$^{-5}$ *21*; α(P)=1.8×10$^{-6}$ *13*<br>$I_\gamma$: Weighted average of 6.7 *4* (1981Hn03), 6.75 *10* (2014La20), 6.7 *7* (1967Be34) and 5.4 *3* (2012De24). Others: 7.8 *9* (1967Ha09), 14.9 *13* (1972Ch48) and 20 *4* (1964Al04). |
| 296.4584 *5* | 39.5 *10* | 409.4085 | 13/2$^-$ | 112.9499 | 9/2$^-$ | E2 | | 0.0821 | %Iγ=6.48 *17*<br>α(K)=0.0567 *8*; α(L)=0.0195 *3*; α(M)=0.00469 *7*<br>α(N)=0.001097 *16*; α(O)=0.0001490 *21*; α(P)=4.04×10$^{-6}$ *6*<br>$I_\gamma$: Weighted average of 40.8 *12* (1981Hn03), 39.8 *8* (2014La20), 35.8 *10* (2012De24), 36.5 *11* (2012Ko23), 38 *4* (1967Ha09), 45 *3* (1972Ch48). Other: 65 *7* (1964Al04). |
| 299.0534 *7* | 12.88 *44* | 708.4622 | 15/2$^+$ | 409.4085 | 13/2$^-$ | E1+M2 | +0.11 *5* | 0.030 *10* | %Iγ=2.11 *7*<br>α(K)=0.025 *8*; α(L)=0.0041 *16*; α(M)=0.0009 *4*<br>α(N)=0.00022 *9*; α(O)=3.3×10$^{-5}$ *14*; α(P)=2.0×10$^{-6}$ *9*<br>$I_\gamma$: Weighted average of 13.11 *29* (2014La20), 11.0 *5* (2012De24), 12.2 *5* (2012Ko23), 14.8 *5* (1981Hn03), 14.3 *10* (1972Ch48), 12.6 *7* (1967Be34), 12 *2* (1967Ha09) and 10 *2* (1964Al04). |
| 305.5033 *5* | 14.19 *18* | 555.1779 | 13/2$^+$ | 249.6744 | 11/2$^-$ | E1+M2 | +0.16 *7* | 0.038 *18* | %Iγ=2.327 *30*<br>α(K)=0.031 *14*; α(L)=0.005 *3*; α(M)=0.0012 *7*<br>α(N)=0.00029 *16*; α(O)=4.4×10$^{-5}$ *24*; α(P)=2.6×10$^{-6}$ *15*<br>$I_\gamma$: Weighted average of 14.11 *29* (2014La20), 14.6 *4* (2012De24), 13.1 *5* (2012Ko23), 14.9 *5* (1981Hn03), 14.5 *12* (1972Ch48), 14.2 *6* (1967Be34), 14 *1* (1967Ha09) and 13 *3* (1964Al04). |
| 313.7250 *5* | 10.35 *11* | 426.6752 | 11/2$^+$ | 112.9499 | 9/2$^-$ | E1+M2 | +0.06 *5* | 0.021 *6* | %Iγ=1.697 *19*<br>α(K)=0.018 *5*; α(L)=0.0028 *9*; α(M)=0.00063 *20*<br>α(N)=0.00015 *5*; α(O)=2.2×10$^{-5}$ *8*; α(P)=1.3×10$^{-6}$ *5*<br>$I_\gamma$: Weighted average of 9.9 *3* (2014La20), 10.42 *14* (2012De24), 10.9 *4* (2012Ko23), 10.0 *4* (1981Hn03), 11.5 *8* (1972Ch48), 10.5 *5* (1967Be34) and 9.4 *7* (1967Ha09). Other: 12 *2* (1964Al04). |
| 321.3159 *6* | 9.18 *18* | 321.3162 | 9/2$^+$ | 0.0 | 7/2$^-$ | E1+M2 | +0.175 *10* | 0.0354 *21* | %Iγ=1.506 *30* |





$^{177}_{72}Hf_{105}$-7

## $^{177}$Hf IT decay (1.09 s) (continued)

### γ($^{177}$Hf) (continued)

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult. [‡] | α [@] | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | α(K)=0.0289 *16*; α(L)=0.0050 *4*; α(M)=0.00116 *8*<br>α(N)=0.000274 *18*; α(O)=4.1×10$^{-5}$ *3*; α(P)=2.52×10$^{-6}$ *17*<br>$I_\gamma$: From intensity balance at the 321-keV level and Iγ(208.3662γ)=437 *6* and Iγ(321.3159γ)/Iγ(208.3662γ)=0.0210 *3*, weighted average of 0.0189 *19* (2012Ko24), 0.02002 *19* (2001Sc23), 0.0217 *2* (1987Me17), 0.0198 *18* (1974Ag01), 0.0220 *12* (1967Ha09), 0.0199 *14* (1964Al04), 0.0228 *10* (1961We11) (from $^{177}$Lu $\beta^-$ decay (6.6 d) − others: 0.0152 *11* (2016Lu16), 0.02470 *7* (2011De07) and 0.0146 (1955Ma12)), and 0.0214 *8* (2014La20), 0.0228 *4* (2012De24), 0.0199 *9* (2012Ko23), 0.0203 *18* (1981Hn03), 0.0227 *18* (1972Ch48), 0.0191 *10* (1967Be34), 0.0186 *21* (1967Ha09) (from $^{177}$Lu $\beta^-$ decay (160.4 d) − other: 0.0197 (1964Al04)). |
| 327.6829 *5* | 145.4 *16* | 882.8611 | 17/2$^+$ | 555.1779 | 13/2$^+$ | E2 | 0.0610 | %Iγ=23.85 *27*<br>α(K)=0.0434 *6*; α(L)=0.01352 *19*; α(M)=0.00324 *5*<br>α(N)=0.000758 *11*; α(O)=0.0001040 *15*; α(P)=3.15×10$^{-6}$ *5*<br>$I_\gamma$: Weighted average of 145.8 *28* (2014La20), 148 *4* (2012De24), 137 *4* (2012Ko23), 149 *3* (1981Hn03), 146 *6* (1972Ch48), 136 *8* (1967Ha09) and 149 *15* (1964Al04). |
| 341.6432 *10* | 13.88 *22* | 591.3179 | 15/2$^-$ | 249.6744 | 11/2$^-$ | E2 | 0.0540 | %Iγ=2.28 *4*<br>α(K)=0.0389 *6*; α(L)=0.01165 *17*; α(M)=0.00279 *4*<br>α(N)=0.000652 *10*; α(O)=8.98×10$^{-5}$ *13*; α(P)=2.84×10$^{-6}$ *4*<br>$I_\gamma$: Weighted average of 13.8 *4* (2014La20), 14.4 *4* (2012De24), 13.4 *5* (2012Ko23), 13.7 *6* (1981Hn03), 14.9 *13* (1972Ch48), 13 *1* (1967Ha09) and 14 *4* (1964Al04). |
| 378.5036 *5* | 231.9 *22* | 1086.9662 | 19/2$^+$ | 708.4622 | 15/2$^+$ | E2 | 0.0404 | %Iγ=38.0 *4*<br>α(K)=0.0298 *5*; α(L)=0.00817 *12*; α(M)=0.00194 *3*<br>α(N)=0.000455 *7*; α(O)=6.34×10$^{-5}$ *9*; α(P)=2.21×10$^{-6}$ *3*<br>$I_\gamma$: Weighted average of 246 *6* (1981Hn03), 241 *5* (2014La20), 227 *3* (2012De24) and 232 *11* (1972Ch48), 224 *7* (2012Ko23), 222 *17* (1967Ha09) and 223 *22* (1964Al04). |
| 385.0304 *9* | 25.0 *3* | 794.4394 | 17/2$^-$ | 409.4085 | 13/2$^-$ | E2 | 0.0386 | %Iγ=4.10 *5*<br>α(K)=0.0285 *4*; α(L)=0.00771 *11*; α(M)=0.00183 *3*<br>α(N)=0.000429 *6*; α(O)=5.98×10$^{-5}$ *9*; α(P)=2.12×10$^{-6}$ *3*<br>$I_\gamma$: Weighted average of 25.4 *4* (2014La20), 24.9 *10* (2012De24), 23.1 *7* (2012Ko23), 26.0 *8* (1981Hn03), 24.5 *16* (1972Ch48), and 24 *2* (1967Ha09). Other: 37 *7* (1964Al04). |
| 418.5388 *5* | 171.3 *13* | 1301.4004 | 21/2$^+$ | 882.8611 | 17/2$^+$ | E2 | 0.0307 | %Iγ=28.09 *23*<br>α(K)=0.0231 *4*; α(L)=0.00584 *9*; α(M)=0.001382 *20*<br>α(N)=0.000324 *5*; α(O)=4.56×10$^{-5}$ *7*; α(P)=1.738×10$^{-6}$ *25*<br>$I_\gamma$: Weighted average of 176 *4* (1981Hn03), 171.7 *23* (2014La20), 172.1 *18* (2012De24), 167 *8* (1972Ch48), 160 *5* (2012Ko23), 161 *12* (1967Ha09) and 185 *19* (1964Al04). |
| 426.4726 *24* | 3.76 *28* | 1017.7911 | 19/2$^-$ | 591.3179 | 15/2$^-$ | E2 | 0.0292 | %Iγ=0.62 *5*<br>α(K)=0.0221 *3*; α(L)=0.00550 *8*; α(M)=0.001299 *19*<br>α(N)=0.000305 *5*; α(O)=4.29×10$^{-5}$ *6*; α(P)=1.662×10$^{-6}$ *24* |





$^{177}_{72}Hf_{105}$-8

## $^{177}$Hf IT decay (1.09 s) (continued)

### $\gamma(^{177}Hf)$ (continued)

| $E_\gamma$ [†] | $I_\gamma$ [#] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult. [‡] | $\alpha$ [@] | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | $I_\gamma$: Weighted average (external uncertainty) of 3.52 *20* (1981Hn03), 3.64 *16* (2014La20), 5.7 *3* (2012De24), 3.56 *18* (2012Ko23), 3.4 *4* (1967Ha09) and 3.4 *4* (1972Ch48). |
| 465.8416 *10* | 19.49 *21* | 1260.2817 | 21/2$^-$ | 794.4394 | 17/2$^-$ | E2 | 0.0232 | %I$\gamma$=3.20 *4*<br>$\alpha$(K)=0.01778 *25*; $\alpha$(L)=0.00415 *6*; $\alpha$(M)=0.000977 *14*<br>$\alpha$(N)=0.000230 *4*; $\alpha$(O)=3.26×10$^{-5}$ *5*; $\alpha$(P)=1.351×10$^{-6}$ *19*<br>$I_\gamma$: Weighted average of 19.2 *15* (1981Hn03), 19.8 *3* (2014La20), 19.2 *3* (2012De24), 19.4 *13* (1972Ch48) and 19 *2* (1967Ha09). Others: 17.4 *5* (2012Ko23) and 23 *7* (1964Al04). |

[†] From 1989Ma56, unless otherwise stated.
[‡] From adopted gammas.
[#] For absolute intensity per 100 decays, multiply by 0.1640 *5*.
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on $\gamma$-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.



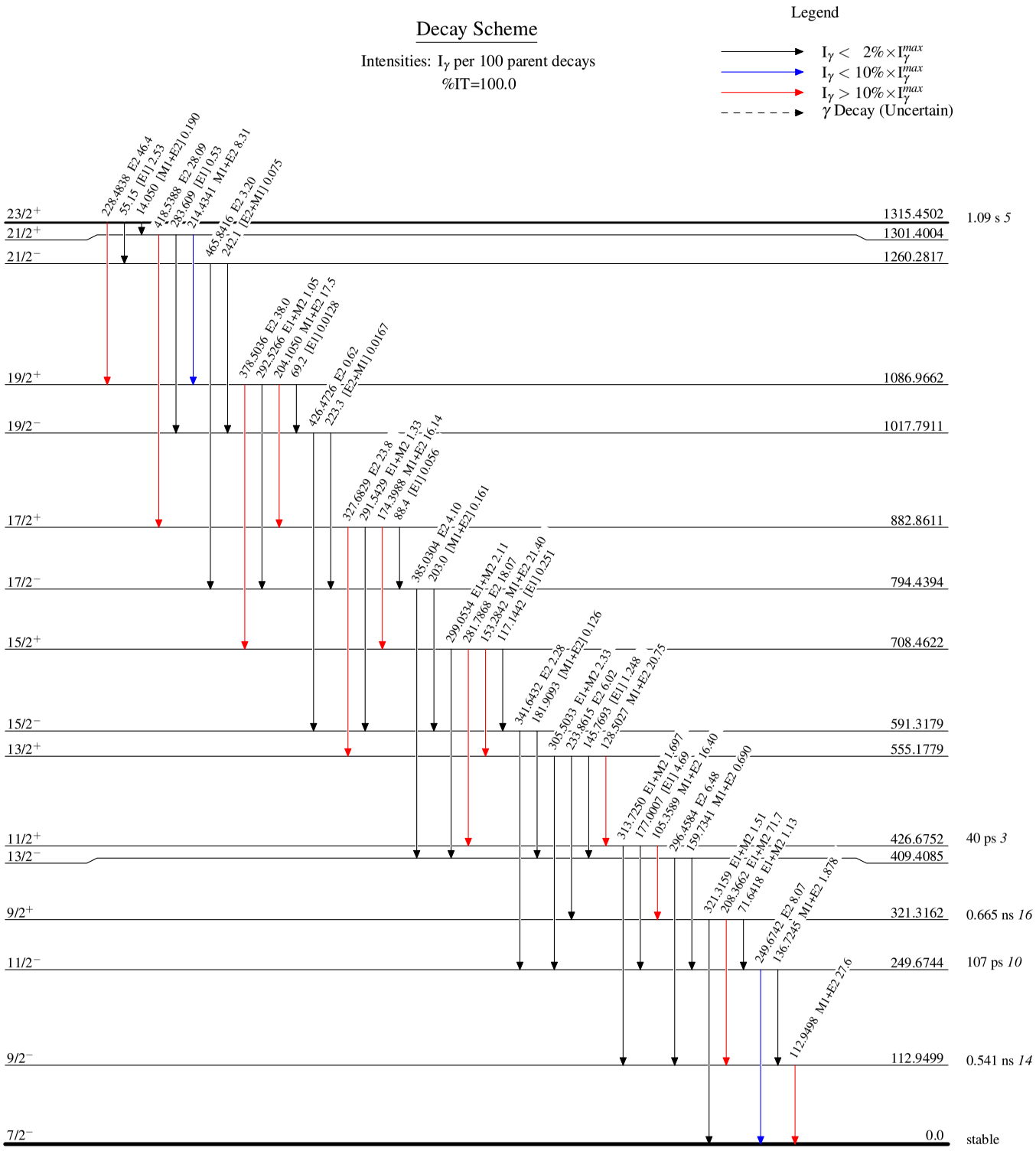


$^{177}_{72}Hf_{105}$-9

## $^{177}$Hf IT decay (1.09 s)

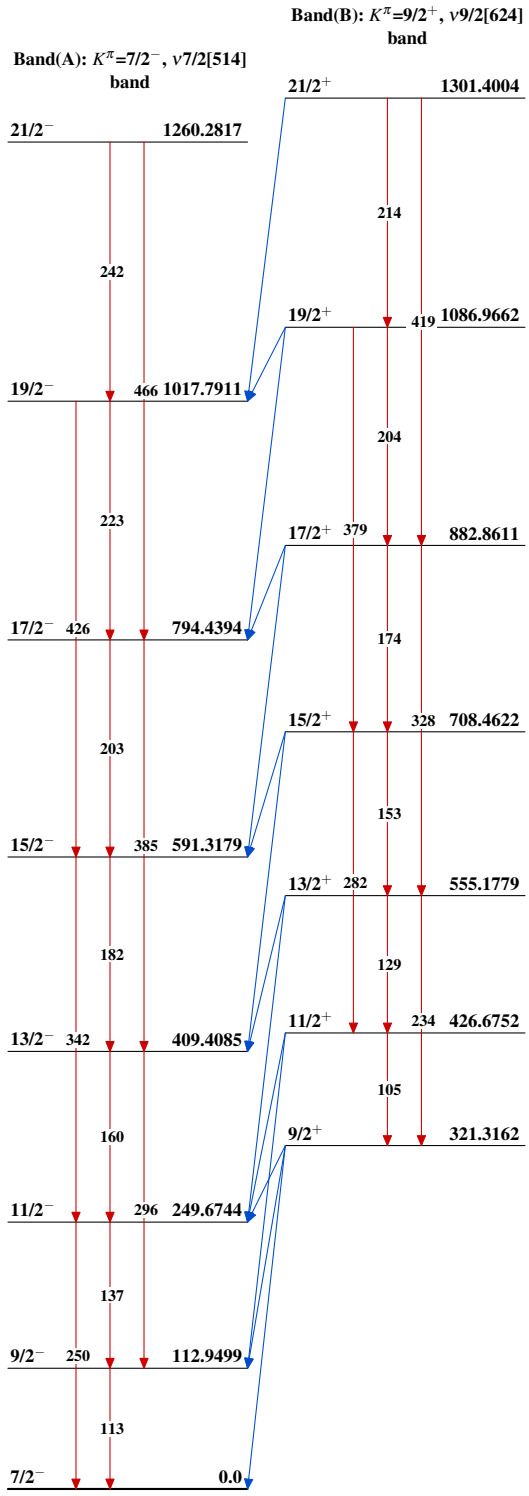
### Decay Scheme

Intensities: $I_\gamma$ per 100 parent decays
%IT=100.0




$^{177}_{72}Hf_{105}$

## $^{177}$Hf IT decay (1.09 s)




$^{177}_{72}Hf_{105}$