

$^{178}\text{Hf}(\text{n},\text{n}'\gamma)$ 1979Bo42

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

Target: 92.4% enriched ^{178}Hf . Projectile: fast neutrons. Measured $E\gamma$, $I\gamma$ at $\theta=90^\circ$. Detector: Ge(Li).

 ^{178}Hf Levels

E(level) [†]	J^π [‡]	E(level) [†]	J^π [‡]	E(level) [†]	J^π [‡]	E(level) [†]	J^π [‡]
0.0 [#]	0 ⁺	1268.4 [@] 7	(3 ⁺)	1444.1 ^d 11	(0 ⁺)	1566.0 ^g 7	(2 ⁻)
93.0 [#] 4	(2 ⁺)	1276.4 ^{&} 5	(2 ⁺)	1450.4 ^{&} 11	(4 ⁺)	1635.7 ^c 8	(4 ⁺)
306.4 [#] 4	(4 ⁺)	1310.0 ^b 4	(1 ⁻)	1478 1		1639.8 ^e 7	(5 ⁺)
631.8 [#] 6	(6 ⁺)	1323.6 ^a 7	(3 ⁻)	1496.0 ^c 7	(2 ⁺)	1654.4 ^d 6	(4 ⁺)
1058.0 [#] 11	(8 ⁺)	1362.0 ^b 6	(2 ⁻)	1510.4 ^a 11	(5 ⁻)	1691.1 [@] 8	(6 ⁺)
1147?		1384.3 [@] 6	(4 ⁺)	1513 ^d 1	(2 ⁺)	1772.1 ^h 11	(0 ⁺)
1174.3 [@] 5	(2 ⁺)	1409.5 ^a 6	(4 ⁻)	1513.7 ^e 5	(4 ⁺)	1788.2 ^e 9	(6 ⁺)
1199.1 ^{&} 11	(0 ⁺)	1432.7 ^b 8	(3 ⁻)	1533.1 [@] 8	(5 ⁺)	1818.1 11	
1259.9 ^a 6	(2 ⁻)	1433.1 ^c 11	(0 ⁺)	1561.5 ^f 6	(2 ⁺)	1860.1 12	

[†] from a least-squares fit to γ -ray energies.

[‡] From γ -ray decay patterns and rotational band structure.

[#] $K^\pi=0^+$ g.s. rotational band.

[@] $K^\pi=2^+$ γ -vibrational band.

[&] $K^\pi=0^+$ band.

^a $K^\pi=2^-$ band.

^b $K^\pi=1^-$ band.

^c $K^\pi=0^+$ band.

^d $K^\pi=0^+$ band.

^e $K^\pi=4^+$ band.

^f $K^\pi=(2^+)$ band.

^g $K^\pi=2^-$ band.

^h $K^\pi=0^+$ band.

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

E_γ [†]	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Comments
89 ^{&}	<20	1147?		1058.0 (8 ⁺)		γ ray not observed.
93.0 5	2.60×10^3 70	93.0	(2 ⁺)	0.0 0 ⁺		
150 1	20 10	1409.5	(4 ⁻)	1259.9 (2 ⁻)		
204 1	20 10	1566.0	(2 ⁻)	1362.0 (2 ⁻)		
^x 209 1	23 7					
213.4 5	1.30×10^3 10	306.4	(4 ⁺)	93.0 (2 ⁺)		
245 1	26 [‡] 5	1513.7	(4 ⁺)	1268.4 (3 ⁺)		
256 1	22 5	1566.0	(2 ⁻)	1310.0 (1 ⁻)		I_γ : from $I_\gamma(\text{doublet})=27$ 5 and $I_\gamma(256\gamma, 1640 \text{ level})=5$ 2.
256 [@] 1	5 [@] 2	1639.8	(5 ⁺)	1384.3 (4 ⁺)		I_γ : from $I_\gamma=27$ 5, and $I_\gamma(256\gamma)/I_\gamma(1333\gamma)=0.20$ 1 in adopted gammas.
274 1	15 5	1788.2	(6 ⁺)	1513.7 (4 ⁺)		
^x 289 1	26 5					
325.5 5	150 20	631.8	(6 ⁺)	306.4 (4 ⁺)		

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$^{178}\text{Hf}(\text{n},\text{n}'\gamma)$ **1979Bo42** (continued) $\gamma(^{178}\text{Hf})$ (continued)

E_γ [†]	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Comments
331 [#] <i>I</i>	<10 [#]	1478		1147?		
331 [#] <i>I</i>	<10 [#]	1654.4	(4 ⁺)	1323.6	(3 ⁻)	
339 <i>I</i>	19 5	1513.7	(4 ⁺)	1174.3	(2 ⁺)	
^x 348 <i>I</i>	12 4					
378 ^{&} <i>I</i>	8 3	1654.4	(4 ⁺)	1276.4	(2 ⁺)	Additional information 1.
^x 395 <i>I</i>	5 3					
426.2 <i>IO</i>	35 7	1058.0	(8 ⁺)	631.8	(6 ⁺)	
^x 493 <i>I</i>	8 4					
498 <i>I</i>	35 7	1860.1		1362.0	(2 ⁻)	
^x 646 <i>I</i>	7 4					I_γ : complex line.
^x 663 <i>I</i>	7 4					
^x 682 <i>I</i>	5 3					
753 <i>I</i>	5 5	1384.3	(4 ⁺)	631.8	(6 ⁺)	
868 <i>I</i>	≤8	1174.3	(2 ⁺)	306.4	(4 ⁺)	
882 <i>I</i>	9 [‡] 4	1513.7	(4 ⁺)	631.8	(6 ⁺)	
901 <i>I</i>	≤5	1533.1	(5 ⁺)	631.8	(6 ⁺)	
^x 921 <i>I</i>	17 4					
962.2 <i>IO</i>	28 5	1268.4	(3 ⁺)	306.4	(4 ⁺)	
970 <i>I</i>	20 5	1276.4	(2 ⁺)	306.4	(4 ⁺)	
1008 <i>I</i>	10 5	1639.8	(5 ⁺)	631.8	(6 ⁺)	
1018 <i>I</i>	10 5	1323.6	(3 ⁻)	306.4	(4 ⁺)	
1059 <i>I</i>	≤8	1691.1	(6 ⁺)	631.8	(6 ⁺)	
1078.0 5	60 20	1384.3	(4 ⁺)	306.4	(4 ⁺)	
1081.0 5	120 20	1174.3	(2 ⁺)	93.0	(2 ⁺)	
^x 1093 <i>I</i>	8 4					
1103.0 5	60 10	1409.5	(4 ⁻)	306.4	(4 ⁺)	
1106 <i>I</i>	45 10	1199.1	(0 ⁺)	93.0	(2 ⁺)	
1126 <i>I</i>	9 5	1432.7	(3 ⁻)	306.4	(4 ⁺)	
1144 <i>I</i>	20 4	1450.4	(4 ⁺)	306.4	(4 ⁺)	
1157 <i>I</i>	4 3	1788.2	(6 ⁺)	631.8	(6 ⁺)	
1167.0 5	140 20	1259.9	(2 ⁻)	93.0	(2 ⁺)	
1175 [@] <i>I</i>	85 [@] 30	1174.3	(2 ⁺)	0.0	0 ⁺	E_γ : Unresolved doublet in 1979Bo42 , deexcites levels at 1174 and 1268 keV. I_γ : Estimate based on $I_\gamma(\text{doublet})=200$ 30 and the ratio $I_\gamma(\text{level } 1174)/I_\gamma(\text{level } 1268)=0.76$ (1979Bo42).
1175 [@] <i>I</i>	115 [@] 30	1268.4	(3 ⁺)	93.0	(2 ⁺)	E_γ : Unresolved doublet in 1979Bo42 , deexcites levels at 1174 and 1268 keV. I_γ : Estimate based on $I_\gamma(\text{doublet})=200$ 30 and the ratio $I_\gamma(\text{level } 1174)/I_\gamma(\text{level } 1268)=0.76$ (1979Bo42).
1183.4 5	58 10	1276.4	(2 ⁺)	93.0	(2 ⁺)	
^x 1198 <i>I</i>	25 15					
1204 <i>I</i>	20 10	1510.4	(5 ⁻)	306.4	(4 ⁺)	
^x 1207.0 [@] 5	45 [@] 15					I_γ : from measured $I_\gamma=85$ 10, and $I_\gamma=40$ 11 which deexcites the 1513.7 level.
1207.0 [@] 5	40 [@] 11	1513.7	(4 ⁺)	306.4	(4 ⁺)	I_γ : from $I_\gamma(339\gamma)=19$ 5, and $I_\gamma(1207\gamma)/I_\gamma(339\gamma)=2.1$ <i>I</i> in adopted gammas. Measured $I_\gamma(1207\gamma)=85$ 10 indicates possible doublet.
1217 <i>I</i>	22 4	1310.0	(1 ⁻)	93.0	(2 ⁺)	
1227 <i>I</i>	60	1533.1	(5 ⁺)	306.4	(4 ⁺)	I_γ : $I_\gamma(1227\gamma + 1230\gamma)=170$ 20.
1230 <i>I</i>	110	1323.6	(3 ⁻)	93.0	(2 ⁺)	I_γ : $I_\gamma(1227\gamma + 1230\gamma)=170$ 20.
^x 1247 <i>I</i>	13 4					
1256 <i>I</i>	28 5	1561.5	(2 ⁺)	306.4	(4 ⁺)	
1269.0 5	100	1362.0	(2 ⁻)	93.0	(2 ⁺)	
1276.5 10	8 3	1276.4	(2 ⁺)	0.0	0 ⁺	
1291 <i>I</i>	20 4	1384.3	(4 ⁺)	93.0	(2 ⁺)	

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$^{178}\text{Hf}(\text{n},\text{n}'\gamma)$ **1979Bo42 (continued)** $\gamma(^{178}\text{Hf})$ (continued)

$E_\gamma^\dagger$	I_γ	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Comments
1310.0 5	120 20	1310.0	(1 ⁻)	0.0	0 ⁺	
^x 1325 1	13 4					
1329 1	30 8	1635.7	(4 ⁺)	306.4	(4 ⁺)	
1333 1	25 8	1639.8	(5 ⁺)	306.4	(4 ⁺)	
1340 [#] 1	≤88 [#]	1432.7	(3 ⁻)	93.0	(2 ⁺)	Unresolved doublet, multiply placed.
1340.8 [#]	≤88 [#]	1433.1	(0 ⁺)	93.0	(2 ⁺)	Unresolved doublet, multiply placed.
1348 1	17 6	1654.4	(4 ⁺)	306.4	(4 ⁺)	
1351 1	19 4	1444.1	(0 ⁺)	93.0	(2 ⁺)	
^x 1359 1	5					
1385 1	7 3	1691.1	(6 ⁺)	306.4	(4 ⁺)	
^x 1398 1	10 5					
1403 1	32 7	1496.0	(2 ⁺)	93.0	(2 ⁺)	
1421.0 5	29 [‡] 5	1513.7	(4 ⁺)	93.0	(2 ⁺)	1979Bo42 also place this γ ray from the 1513 ($J^\pi=2^+$) level. However, $I_\gamma(1421\gamma)/I_\gamma(339\gamma)=1.5\ 5$ agrees with 1.08 6 for the 1513.7 ($J^\pi=4^+$) level from adopted gammas, consistent with 1421 γ deexciting this level only.
1468 1	9 3	1561.5	(2 ⁺)	93.0	(2 ⁺)	
1473 1	13 3	1566.0	(2 ⁻)	93.0	(2 ⁺)	
^x 1492 1	9 4					
1496 1	15 4	1496.0	(2 ⁺)	0.0	0 ⁺	
1513 1	15 [‡] 4	1513	(2 ⁺)	0.0	0 ⁺	
1543 1	8 3	1635.7	(4 ⁺)	93.0	(2 ⁺)	
1561 [@] 1	11 [@] 3	1561.5	(2 ⁺)	0.0	0 ⁺	
1561 ^{@&} 1	≤6 [@]	1654.4	(4 ⁺)	93.0	(2 ⁺)	I_γ : from $I_\gamma=11\ 3$, $I_\gamma(1254\gamma + 1468\gamma)=37\ 6$, and $I_\gamma(1254\gamma + 1468\gamma)/I_\gamma(1561\gamma)=4.6\ 3$ in adopted gammas.
^x 1648 1	6 3					
1679 1	8 3	1772.1	(0 ⁺)	93.0	(2 ⁺)	
1725 1	12 4	1818.1		93.0	(2 ⁺)	
^x 1892 1	7 3					

[†] Uncertainties are 0.5 keV for intense γ rays, and up to 1.0 keV for weak γ rays. Values shown here were assigned by evaluator.

[‡] Deexciting level was assigned by evaluator based on γ -ray branching ratios in adopted gammas.

[#] Multiply placed with undivided intensity.

[@] Multiply placed with intensity suitably divided.

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

^x γ ray not placed in level scheme.

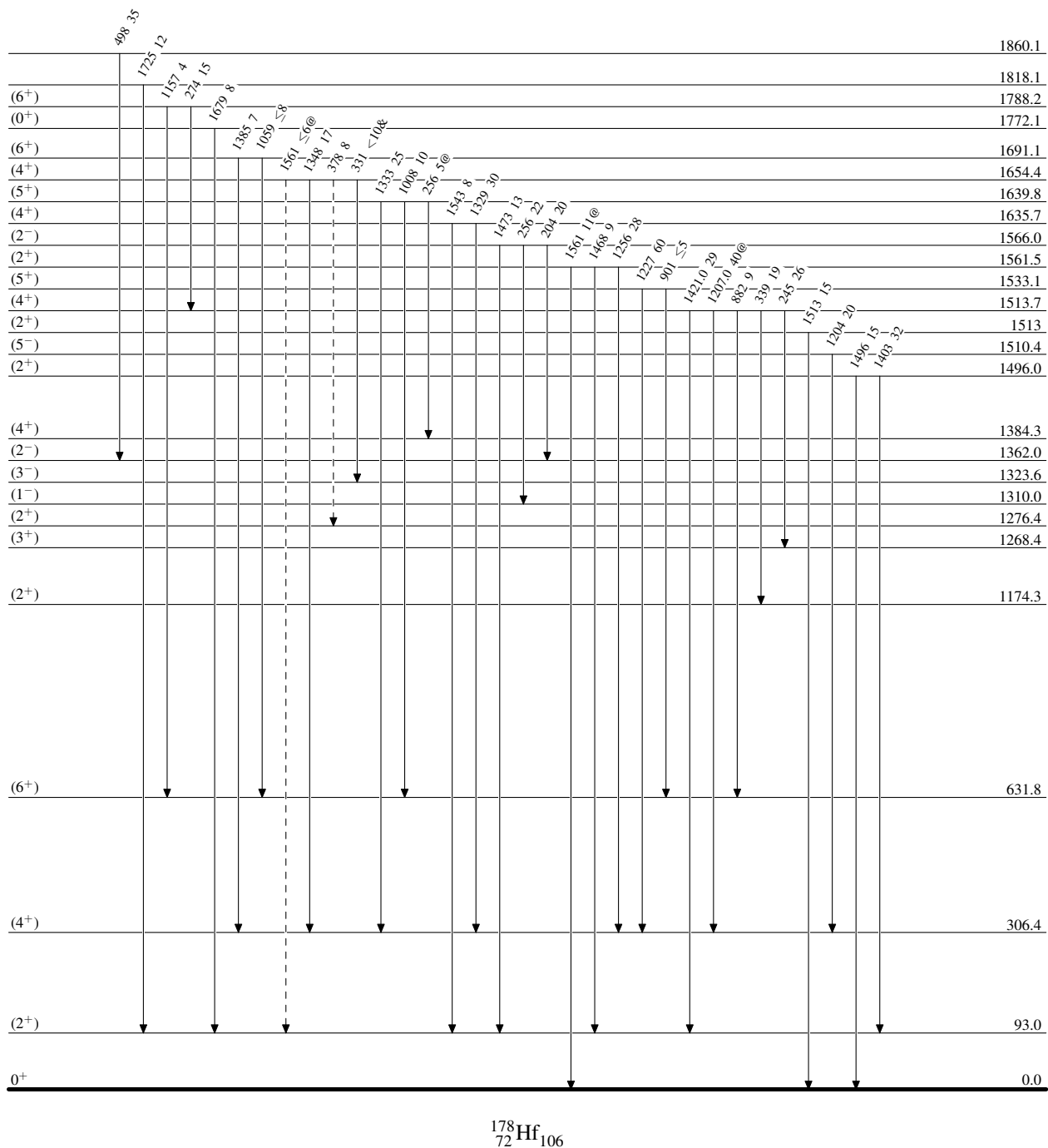
$^{178}\text{Hf}(n,n'\gamma)$ 1979Bo42

Level Scheme

Intensities: Relative I_γ
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided

Legend

- $\longrightarrow$ $I_\gamma < 2\% \times I_\gamma^{\max}$
 $\longrightarrow$ $I_\gamma < 10\% \times I_\gamma^{\max}$
 $\longrightarrow$ $I_\gamma > 10\% \times I_\gamma^{\max}$
 $-\cdots-\cdots$ γ Decay (Uncertain)

 $^{178}_{72}\text{Hf}_{106}$

$^{178}\text{Hf}(n,n'\gamma)$ 1979Bo42

Level Scheme (continued)

Legend

Intensities: Relative I_γ
 & Multiply placed: undivided intensity given
 @ Multiply placed: intensity suitably divided

—→ $I_\gamma < 2\% \times I_\gamma^{\max}$
 —→ $I_\gamma < 10\% \times I_\gamma^{\max}$
 —→ $I_\gamma > 10\% \times I_\gamma^{\max}$
 - - - - -→ γ Decay (Uncertain)

