

¹⁷⁷Hf(³He,d),¹⁷⁷Hf(α,t) 2006Bu19

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

2006Bu19: This work reports two experiments which consist in the transfer of a proton to an ¹⁷⁷Hf core: a) ¹⁷⁷Hf(³He,d), E(³He)=32 MeV; b) ¹⁷⁷Hf(α,t), E(α)=30 MeV. Enriched target. The light reaction products were analyzed using an Enge split-pole magnetic spectrograph and detected with photographic emulsion plates. The energy resolution was FWHM=15-20 keV for the (α,t) reaction, and FWHM=20-25 keV, for (³He,d).

¹⁷⁸Ta Levels

Band assignments have been obtained by **2006Bu19** from comparison of experimental cross sections to predicted values from DWBA calculations.

T_{1/2}(K),S(K) The quoted cross sections belong to the combination of the 220+x and 225+x levels.

E(level) [#]	J ^π	dσ/dΩ (³ He,d) [†]	dσ/dΩ (α,t) [‡]	Comments
0.0+x ^{@c}	7 ⁻	8 2	16 2	It is experimentally unknown whether the 7 ⁻ is the ground state for ¹⁷⁸ Ta (see extensive discussion of this issue in 2006Bu19 ; see also Adopted Levels dataset).
24+x ^{& 3}			4 1	
101+x ^{d 1}	1 ⁻	35 6	23 2	
128+x ^{& 3}			4 1	
151+x ^{d 2}	2 ⁻	26 4	16 2	
180+x ^{& 2}			9 2	
220+x ^{e 2}	8 ⁺	21 3	18 2	Bandhead of the K ^π =8 ⁺ band. Member of unresolved multiplet in 2006Bu19 , overlapping with the 225+x keV state.
225+x ^{d 2}	3 ⁻	21 3	18 2	Third member of the K ^π =1 ⁻ band. Member of unresolved multiplet in 2006Bu19 . See comment for the 220+x level.
250+x ^{& 3}			4 1	
289.1+x ^{@f}	6 ⁻	88 7	45 3	E(level): Adopted as energy calibration reference in 2006Bu19 from 1998Ko09 (see ¹⁷⁶ Yb(⁷ Li,5nγ) dataset).
382+x 3		4 3	4 1	
420+x ^{g 3}	4 ⁺	74 ^a 8	33 ^b 4	Bandhead of the K ^π =4 ⁺ band. Member of unresolved multiplet in 2006Bu19 . See comments for levels at 422+x and 434+x keV.
422+x ^{e 3}	9 ⁺	74 ^a 8	33 ^b 4	Member of the K ^π =8 ⁺ band. Member of unresolved multiplet in 2006Bu19 . See comments for levels at 420+x and 434+x keV.
434+x ^{g 4}	(5 ⁺)	74 ^a 8	24 4	
485+x ^{g 2}	(6 ⁺)	12 3	20 2	
525+x 2		41 5	10 2	
564+x ^{g 2}	(7 ⁺)	21 3	12 2	
584+x 2			4 1	
631+x 5		5 2		
671+x ^{g 2}	(8 ⁺)	38 5	11 2	
712+x 4		8 2	4 1	
770+x 3		38 5	7 2	
812+x 4		11 3	4 1	
881+x 3		19 5	6 2	
901+x 4		15 5	2 1	
925+x 5		13 3		
1005+x 3		17 6	5 1	
1032+x 3		27 6	7 2	
1054+x 4		16 5	2 1	

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$^{177}\text{Hf}(^3\text{He,d}), ^{177}\text{Hf}(\alpha,t)$ **2006Bu19 (continued)** ^{178}Ta Levels (continued)

E(level)#	J^π	$d\sigma/d\Omega (^3\text{He,d})^\dagger$	$d\sigma/d\Omega (\alpha,t)^\ddagger$	Comments
1098+x 4		11 3	3 1	
1132+x 4		18 5	3 1	
1173+x 4		79 8	11 2	
1203+x 4			5 2	
1223+x ^h 3	(3 ⁺)	119 5	12 2	
1281+x ^h 4	(4 ⁺)	96 10	20 3	
1311+x 5			5 1	
1328+x 5		66 10	7 2	
1390+x ^h 4	(5 ⁺)	97 10	15 2	
1430+x 4		29 8	5 1	
1460+x 4		78 8	18 3	
1494+x 4		45 5	8 2	
1519+x 3			11 2	
1531+x? 4		145 10		Additional information 1. Unresolved multiplet in (³ He,d) (2006Bu19). $d\sigma/d\Omega (^3\text{He,d})$: Peak shows multiplet structure, not resolved in 2006Bu19.
1540+x 3			22 3	Additional information 2.
1602+x 5		41 10	4 2	
1621+x 4		38 10	7 2	
1705+x 6		20 4	5 2	

[†] At 30°, in ($\mu\text{b}/\text{sr}$).

[‡] At 60°, in ($\mu\text{b}/\text{sr}$).

Values rounded to nearest keV. Unweighted averages from the two reactions used in this work. The data were calibrated relative to the 289.1-keV level energy from 1998Ko09 in $^{176}\text{Yb}(^7\text{Li},5n\gamma)$. The uncertainties are statistical only. The calibration uncertainty is ≤ 1 keV up to ≈ 1 MeV, but increases to as much as ≈ 10 keV at ≈ 2.5 MeV excitation energy.

@ Band assignments previously proposed in 1998Ko09 (see $^{176}\text{Yb}(^7\text{Li},5n\gamma)$ dataset), and confirmed in the present work.

& These levels are suggested by 2006Bu19 as possible members of a band based on the $K^\pi=1^+$ state.

^a The value for the (³He,d) cross section belongs to an unresolved multiplet comprising the 420+x, 422+x, and 434+x keV states.

^b The value for the (α,t) cross section belongs to an unresolved multiplet comprising the 420+x and 422+x states.

^c Band(A): $\pi 7/2^+ [404] + \nu 7/2^- [514]$, $K^\pi=7^-$ based on the 0.0+x 2.36 h isomeric state.

^d Band(B): $\pi 5/2^+ [402] - \nu 7/2^- [514]$, $K^\pi=1^-$ based on the 101+x keV level.

^e Band(C): $\pi 9/2^- [514] + \nu 7/2^- [514]$, $K^\pi=8^+$ based on the 220+x keV level.

^f Band(D): $\pi 5/2^+ [402] + \nu 7/2^- [514]$, $K^\pi=6^-$ based on the 289+x level.

^g Band(E): $\pi 1/2^- [541] + \nu 7/2^- [514]$, $K^\pi=4^+$ based on the 420+x level.

^h Band(F): $\pi 1/2^- [530] - \nu 7/2^- [514]$, $K^\pi=3^+$ based on the 1223+x level. Tentative band proposal in 2006Bu19.

