^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Khalifeh Abusaleem	NDS 116, 163 (2014)	31-Dec-2012

2013Le21: E=25 MeV beam with an intensity of 1-2 μA. Target=100 μg/cm^{2}thick ^{230}Th with isotopic purity of 99% on 22 μg/cm^2 thick carbon backing. Experiment using the Tandem accelerator of Munich facility. Measured triton spectra, $\sigma(\theta)$, integrated cross sections, cross section ratios using the Q3D magnetic spectrograph and a focal-plane detector. FWHM=4-7 keV. Deduced levels, J, π, L-values, bands. DWBA and coupled-channel (using CHUCK3 code) analysis of $\sigma(\theta)$ data.

2004Wi06: E=25 MeV. Triton spectra measured with Q3D magnetic spectrograph. FWHM=5-7 keV. Measured $\sigma(\theta)$ at ten angles. DWBA analysis.

1996Ba67: E=22 MeV from Munich tandem accelerator bombarded two ^{230}Th targets with 50 μg/cm^2 and 300 μg/cm^2 densities and 99.9% and 8.5% purity, respectively. Tritons were detected using 1.7 m long position sensitive detector in the focal plane of a Q3D spectrometer. Angular distributions were measured at 5° and 30°.

Other: 1972Ma15: E=17 MeV. Photographic emulsion for Tritons and NaI for p. Uncertainty on cross section is around 25%.

^{228}Th Levels

L(p,t) is deduced from the angular distribution of the scattered particles (2013Le21).

Cross section data

E(level) keV	2004Wi06 dσ/dΩ 7.5° μb/sr	1972Ma15 dσ/dΩ 20°(CM) μb/sr	2013Le13 dσ/dΩ 10° μb/sr
0	246.6	210 at 60°	
57		97	
185		28	
831.9	89.4	42 at 60°	
874		12	
938.7	25.0	11	
977		21	
1120	1.1		
1160		10	
1511	3.6		
1628	18.6		
1691	1.7		
2045	1.7		
2080	8.9		
2131	50.7		
2159	3.0		
2290	26.3		
2513.5			2.00
2531.5			6.60
2536.8			3.20
2542.4			1.85
2554.5			6.00
2566.3			2.20
2595.4			5.40
2606.1			23.5
2615.1			0.15
2634.8			1.60
2644.0			9.20
2657.1			5.20
2660.1			6.00
2667.1			3.30
2676.0			67.2
2688.4			2.10

2695.6	1.10
2705.5	1.35
2718.4	2.10
2742.3	5.50
2763.7	8.60
2781.4	1.75
2798.6	1.55
2805.6	2.00
2821.0	2.90
2839.3	1.30
2853.7	2.75
2868.1	3.20
2877.5	1.80
2883.7	1.60
2918.8	1.85
2927.4	3.25
2936.8	1.40
2945.3	1.35
2955.1	1.25
2993.1	1.00
2999.5	1.50
3014.3	0.80
3035.6	0.95
3046.4	2.10
3059.2	2.15
3075.2	2.20
3085.2	1.25
3097.0	3.10
3104.7	3.40
3112.7	1.70
3119.9	2.30
3128.2	1.25
3158.8	1.50
3165.7	2.00
3186.0	2.00
3195.2	2.60
3209.6	1.40
3214.8	2.20
3225.0	0.50
3232.9	1.20
3239.9	3.40

E(level)[†]	J^{π}[†]	L	σ(expt.)/σ(calc.)$_{CHUCK3}$[&]	Comments
0.0 *2*	0^+	0	6.20	R(7.5°/16°)=5.83. R(26°/16°)=5.61. σ(integral)=165.56 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=100.0.
57.8[#] *2*	2^+	2	8.30	R(7.5°/16°)=1.59. R(26°/16°)=0.68. σ(integral)=37.07 μb.
186.8[#] *2*	4^+	4	1.90	R(7.5°/16°)=0.74. R(26°/16°)=0.38. σ(integral)=9.07 μb.
328.0[a] *2*	1^-	1	0.50	R(7.5°/16°)=0.45. R(26°/16°)=0.66. σ(integral)=0.82 μb.
378.2 *2*	6^+	6	1.60	R(7.5°/16°)=0.58. R(26°/16°)=0.71. σ(integral)=4.48 μb.
396.9[a] *2*	3^-	3	0.56	R(7.5°/16°)=0.54. R(26°/16°)=0.33. σ(integral)=2.89 μb.
519.2[a] *3*	(5^-)	(5)	0.90	R(7.5°/16°)=1.23. R(26°/16°)=1.33. σ(integral)=0.43 μb.
622.5 *4*	(8^+)	(8)		R(7.5°/16°)=0.20. R(26°/16°)=0.94. σ(integral)=0.26 μb.
695.6[a] *3*	(7^-)	(7)		R(7.5°/16°)=0.15. R(26°/16°)=0.41. σ(integral)=0.37 μb.
831.9[e] *2*	0^+	0	360	R(7.5°/16°)=12.06. R(26°/16°)=7.5. σ(integral)=39.1 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=28.9.
874.4[e] *2*	2^+	2	160	R(7.5°/16°)=1.22. R(26°/16°)=0.58. σ(integral)=9.57 μb.
911.6 *5*				
920.6[a] *5*				
938.7 *2*	0^+	0	8.20	R(7.5°/16°)=18.38. R(26°/16°)=7.21. σ(integral)=6.83 μb.

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^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67 (continued)

^{228}Th Levels (continued)

E(level)[†]	Jπ[†]	L	σ(expt.)/σ(calc.)$_{CHUCK3}$[&]	Comments
				$(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=7.8.
943.8[#b] *4*	1⁻	1	1.00	R(7.5°/16°)=0.12. R(26°/16°)=0.67. σ(integral)=0.37 μb.
968.8[‡] *2*	2⁺	2	132	R(7.5°/16°)=0.67. R(26°/16°)=0.47. σ(integral)=20.0 μb.
979.4[‡] *2*	2⁺	2	55.6	R(7.5°/16°)=0.78. R(26°/16°)=0.59. σ(integral)=9.25 μb.
1016.4[‡b] *2*	3⁻	3	1.10	R(7.5°/16°)=0.80. R(26°/16°)=0.47. σ(integral)=5.37 μb.
1022.5[@]				
1074.8 *3*	4⁺	4	0.26	R(7.5°/16°)=0.74. R(26°/16°)=1.32. σ(integral)=1.62 μb.
1091.0 *3*	4⁺	4	0.10	R(7.5°/16°)=0.74. R(26°/16°)=0.44. σ(integral)=0.42 μb.
1105.5[e] *3*	6⁺	6	21.0	R(7.5°/16°)=0.61. R(26°/16°)=0.56. σ(integral)=0.77 μb.
1120.1 *3*	0⁺	0	0.04	R(7.5°/16°)=2.63. R(26°/16°)=3.71. σ(integral)=1.24 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=0.3.
1142.8[b] *3*	5⁻	5	26.0	R(7.5°/16°)=0.80. R(26°/16°)=0.98. σ(integral)=1.10 μb.
1153.3[‡f] *3*	2⁺	2	140	E(level): Probably 1160 keV reported in 1972Ma15. R(7.5°/16°)=0.65. R(26°/16°)=0.49. σ(integral)=23.89 μb.
1168.0[c] *4*	3⁻	3	1.00	R(7.5°/16°)=0.36. R(26°/16°)=0.58. σ(integral)=0.68 μb.
1175.2[‡] *4*	2⁺	2	13.0	R(7.5°/16°)=1.05. R(26°/16°)=0.91. σ(integral)=2.09 μb.
1201.0[f] *9*	3⁺		0.56	R(7.5°/16°)=0.31. R(26°/16°)=1.10. σ(integral)=0.40 μb.
1225.7 *6*	4⁺	4	1.75	R(7.5°/16°)=1.00 R(26°/16°)=0.64. σ(integral)=0.25 μb.
1261.6[‡f] *3*	4⁺	4	67.0	R(7.5°/16°)=1.33. R(26°/16°)=1.12. σ(integral)=3.64 μb.
1270.2 *6*	6⁺	6	0.15	R(7.5°/16°)=0.40. R(26°/16°)=0.97. σ(integral)=0.31 μb.
1290.4[‡] *3*	4⁺	4	67.0	R(7.5°/16°)=1.14. R(26°/16°)=0.88. σ(integral)=3.59 μb.
1296.0[c] *5*	(5⁻)	(5)	1.00	R(7.5°/16°)=1.33. R(26°/16°)=1.23. σ(integral)=0.50 μb.
1319.2 *4*	(2⁺)	(2)	1.50	R(7.5°/16°)=0.74. R(26°/16°)=1.08. σ(integral)=0.24 μb.
1343.9[d] *5*	3⁻	3	0.08	R(7.5°/16°)=0.77. R(26°/16°)=0.33. σ(integral)=0.31 μb.
1415.8 *6*	(3⁻)	(3)	2.80	R(7.5°/16°)=1.15. R(26°/16°)=1.20. σ(integral)=0.05 μb.
1420?[@] *2*				
1423.8 *5*	(2⁺)	(2)	0.03	R(7.5°/16°)=2.20. R(26°/16°)=1.33. σ(integral)=0.16 μb.
1432.1 *5*	4⁺	4	6.80	R(7.5°/16°)=1.61. R(26°/16°)=1.17. σ(integral)=0.21 μb.
1453.5[‡] *5*	(3⁻)	(3)	1.80	R(7.5°/16°)=0.61. R(26°/16°)=0.63. σ(integral)=1.34 μb.
1467?[@] *2*				
1470.0 *5*	(6⁺)	(6)	0.01	R(7.5°/16°)=0.94. R(26°/16°)=1.81. σ(integral)=0.19 μb.
1497.4[d] *4*	(5⁻)	(5)	0.56	R(7.5°/16°)=1.07. R(26°/16°)=0.91. σ(integral)=0.37 μb.
1511.2 *3*	0⁺	0	1.10	R(7.5°/16°)=7.96. R(26°/16°)=6.96. σ(integral)=2.13 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=1.0.
1531.7[‡] *3*	0⁺&3⁺	0	2.60	E(level),L: this group is likely a doublet, mixed with a weak component. σ(θ) calculations for the composite peak fit 0⁺ and 3⁺. R(7.5°/16°)=2.21. R(26°/16°)=0.83. σ(integral)=0.47 μb. σ(expt.)/σ(calc.)=0.02 for 3⁺ component.
1544.4[‡] *3*	2⁺	2	1.53	R(7.5°/16°)=1.27. R(26°/16°)=0.65. σ(integral)=1.61 μb.
1586.9 *4*	2⁺	2	1.00	R(7.5°/16°)=0.98. R(26°/16°)=0.71. σ(integral)=0.31 μb.
1613.0 *5*	4⁺	4	12.0	R(7.5°/16°)=1.06. R(26°/16°)=1.26. σ(integral)=0.54 μb.
1618.3 *5*	4⁺	4	0.16	R(7.5°/16°)=0.88. R(26°/16°)=0.76. σ(integral)=1.22 μb.
1627.9 *3*	0⁺	0	10.0	R(7.5°/16°)=7.44. R(26°/16°)=5.21. σ(integral)=9.66 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=4.9.
1638.4 *4*	2⁺	2	23.5	R(7.5°/16°)=0.59. R(26°/16°)=0.37. σ(integral)=1.45 μb.
1643.8[‡g] *3*	4⁺	4	160	R(7.5°/16°)=1.58. R(26°/16°)=1.08. σ(integral)=8.54 μb.
1651.4 *3*	(3⁻)	(3)	1.20	R(7.5°/16°)=0.08. R(26°/16°)=0.79. σ(integral)=0.86 μb.
1667.3[‡] *5*	2⁺	2	46.0	R(7.5°/16°)=0.71. R(26°/16°)=0.61. σ(integral)=3.17 μb.
1672.3 *5*	2⁺	2	3.80	R(7.5°/16°)=0.91. R(26°/16°)=0.53. σ(integral)=1.85 μb.
1678.4[‡] *5*	2⁺	2	19.5	R(7.5°/16°)=0.88. R(26°/16°)=0.75. σ(integral)=1.48 μb.
1691.3 *4*	0⁺	0	0.75	R(7.5°/16°)=2.66. R(26°/16°)=2.06. σ(integral)=1.26 μb.

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^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67 (continued)

^{228}Th Levels (continued)

E(level)[†]	Jπ[†]	L	σ(expt.)/σ(calc.)$_{CHUCK3}$[&]	Comments
				$(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=0.4.
1710.7 *6*	0^+	0	0.02	R(7.5°/16°)=1.38. R(26°/16°)=1.86. σ(integral)=0.54 μb.
1724.6[‡] *4*	2^+	2	5.50	R(7.5°/16°)=1.06. R(26°/16°)=0.66. σ(integral)=2.73 μb.
1733.8[‡] *4*	4^+	4	3.50	R(7.5°/16°)=1.13. R(26°/16°)=0.86. σ(integral)=2.28 μb.
1742.8 *4*	4^+	4	0.16	R(7.5°/16°)=0.81. R(26°/16°)=0.56. σ(integral)=1.36 μb.
1750.7[‡] *3*	0^+	0	0.70	R(7.5°/16°)=1.27. R(26°/16°)=1.84. σ(integral)=1.75 μb.
1758.1[‡] *3*	2^+	2	26.0	R(7.5°/16°)=0.85. R(26°/16°)=0.75. σ(integral)=4.35 μb.
1796.8[‡] *3*	4^+	4	89.0	R(7.5°/16°)=1.40. R(26°/16°)=0.83. σ(integral)=6.47 μb.
1803.0[‡] *4*	2^+	2	90.0	R(7.5°/16°)=0.65. R(26°/16°)=0.49. σ(integral)=15.34 μb.
1812.7[g] *4*	(6^+)	(6)	0.04	R(7.5°/16°)=1.35. R(26°/16°)=1.63. σ(integral)=0.62 μb.
1826.2[‡] *4*	(4^+)	(4)	7.50	R(7.5°/16°)=1.16. R(26°/16°)=0.83. σ(integral)=1.91 μb.
1840.3 *8*				R(7.5°/16°)=1.41. R(26°/16°)=0.33. σ(integral)=0.21 μb.
1858.6 *5*	(6^+)	(6)	0.06	R(7.5°/16°)=0.65. R(26°/16°)=1.19. σ(integral)=1.28 μb F.
1863.9 *5*	(2^+)	(2)	8.10	R(7.5°/16°)=0.75. R(26°/16°)=0.79. σ(integral)=1.47 μb.
1878.9[‡] *5*	(3^-)	(3)	110	R(7.5°/16°)=1.05. R(26°/16°)=0.91. σ(integral)=1.93 μb.
1898.2 *4*	(2^+)	(2)	140	R(7.5°/16°)=0.84. R(26°/16°)=0.81. σ(integral)=2.55 μb.
1903.9[h] *4*	(6^+)	(6)	0.07	R(7.5°/16°)=0.69. R(26°/16°)=1.58. σ(integral)=1.54 μb.
1908.9[‡] *7*	0^+	0	1.30	R(7.5°/16°)=2.17. R(26°/16°)=1.91. σ(integral)=4.56 μb.
1925.4 *4*	$4^+,5^-$	4,5	21.0	R(7.5°/16°)=0.61. R(26°/16°)=1.73. σ(integral)=0.54 μb.
1938.3[‡] *4*	(4^+)	(4)	0.67	R(7.5°/16°)=1.06. R(26°/16°)=0.76. σ(integral)=1.99 μb.
1947.8 *7*	(2^+)	(2)	3.50	R(7.5°/16°)=1.02. R(26°/16°)=0.75. σ(integral)=0.77 μb.
1959.7 *6*	(2^+)	(2)	1.50	R(7.5°/16°)=0.10. R(26°/16°)=1.69. σ(integral)=0.43 μb.
1971.7 *4*	$(2^+,3^-)$	(2,3)	3.10	R(7.5°/16°)=0.66. R(26°/16°)=0.81. σ(integral)=0.79 μb.
1981.9[‡] *4*	(3^-)	(3)	2.60	R(7.5°/16°)=1.68. R(26°/16°)=0.77. σ(integral)=1.70 μb.
1993.9 *5*	(3^-)	(3)	2.80	R(7.5°/16°)=0.97. R(26°/16°)=0.72. σ(integral)=1.80 μb.
2010.4 *6*	(2^+)	(2)	13.0	R(7.5°/16°)=0.46. R(26°/16°)=0.43. σ(integral)=0.76 μb.
2030.3 *4*	2^+	2	16.0	R(7.5°/16°)=0.54. R(26°/16°)=0.23. σ(integral)=0.84 μb.
2044.7 *5*	0^+	0	3.10	R(7.5°/16°)=9.22. R(26°/16°)=4.56. σ(integral)=0.57 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=0.4.
2052.1[‡] *4*	(6^+)	(6)	180	R(7.5°/16°)=0.72. R(26°/16°)=1.30. σ(integral)=3.70 μb.
2069.6 *5*	2^+	2	6.10	R(7.5°/16°)=0.76. R(26°/16°)=0.56. σ(integral)=1.38 μb.
2079.9 *5*	0^+	0	25.9	R(7.5°/16°)=17.08. R(26°/16°)=13.13. σ(integral)=4.62 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=2.1.
2091.2 *7*	(6^+)	(6)	35.0	R(7.5°/16°)=0.62. R(26°/16°)=0.82. σ(integral)=1.20 μb.
2111.6[‡] *5*	(2^+)	(2)	11.0	R(7.5°/16°)=0.70. R(26°/16°)=0.71. σ(integral)=2.57 μb.
2131.3 *6*	0^+	0	120	R(7.5°/16°)=6.84. R(26°/16°)=4.53. σ(integral)=24.8 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=11.8.
2152.8[‡] *4*	(4^+)	(4)	98.0	R(7.5°/16°)=1.30. R(26°/16°)=0.90. σ(integral)=4.13 μb.
2159.4 *6*	0^+	0	8.10	R(7.5°/16°)=3.78. R(26°/16°)=1.54. σ(integral)=1.18 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=0.7.
2170.3[‡] *4*	(2^+)	(2)	26.0	R(7.5°/16°)=1.0 R(26°/16°)=0.85. σ(integral)=5.61 μb.
2198.2[‡] *4*	2^+	2	19.5	R(7.5°/16°)=0.59. R(26°/16°)=0.62. σ(integral)=3.81 μb.
2215.9[‡] *4*	(4^+)	(4)	130	R(7.5°/16°)=1.40. R(26°/16°)=1.15. σ(integral)=6.00 μb.
2235.2 *7*	(4^+)	(4)	61.0	R(7.5°/16°)=0.98. R(26°/16°)=0.86. σ(integral)=2.82 μb.
2290.0 *7*	0^+	0	61.0	R(7.5°/16°)=9.96. R(26°/16°)=5.75. σ(integral)=11.0 μb. $(d\sigma/d\Omega)_{expt}/(d\sigma/d\Omega)_{CHUCK3}$(2004Wi06)=5.9.
2302.9 *5*	(4^+)	(4)	62.0	R(7.5°/16°)=1.09. R(26°/16°)=0.84. σ(integral)=2.75 μb.
2323.2 *5*	2^+	2	16.0	R(7.5°/16°)=0.41. R(26°/16°)=0.62. σ(integral)=2.24 μb.
2335.9[‡] *5*	$(4^+,0^+)$	(4,0)	370	R(7.5°/16°)=2.13. R(26°/16°)=1.65. σ(integral)=17.1 μb for 4^+. σ(integral)=4.50 μb, σ(expt.)/σ(calc.)=25.0 for 0^+.
2344.2 *5*	(3^-)	(3)	10.0	R(7.5°/16°)=0.77. R(26°/16°)=0.58. σ(integral)=6.65 μb.

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^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67 (continued)

^{228}Th Levels (continued)

E(level)[†]	Jπ[†]	L	σ(expt.)/σ(calc.)$_{CHUCK3}$[&]	Comments
2356.2[‡] *5*	(2+)	(2)	21.5	R(7.5°/16°)=0.63. R(26°/16°)=0.61. σ(integral)=4.61 μb.
2375.5 *8*	(2+)	(2)	22.0	R(7.5°/16°)=0.78. R(26°/16°)=0.60. σ(integral)=4.87 μb.
2398.3[‡] *9*	(3−)	(3)	11.0	R(7.5°/16°)=0.76. R(26°/16°)=0.75. σ(integral)=7.36 μb.
2408.8 *9*	(4+)	(4)	60.0	R(7.5°/16°)=1.87. R(26°/16°)=1.28. σ(integral)=2.34 μb.
2441.7[‡] *5*	(2+)	(2)	47.0	R(7.5°/16°)=0.71. R(26°/16°)=0.51. σ(integral)=10.32 μb.
2456.8 *5*	0+	0	5.20	R(7.5°/16°)=16.18. R(26°/16°)=1.27. σ(integral)=0.53 μb.
2476.7[‡] *5*	(2+)	(2)	48.0	R(7.5°/16°)=0.62. R(26°/16°)=0.52. σ(integral)=10.38 μb.
2494.1[‡] *5*	(2+)	(2)	63.5	R(7.5°/16°)=0.65. R(26°/16°)=0.47. σ(integral)=12.74 μb.
2513.5 *7*				
2531.5 *7*				
2536.8 *9*				
2542.4 *9*				
2554.5 *5*				
2566.3 *6*				
2595.4 *5*				
2606.1 *5*				
2615.1 *9*				
2634.8 *5*				
2644.0 *3*				
2657.1 *4*				
2660.1 *5*				
2667.1 *5*				
2676.0 *6*				
2688.4 *4*				
2695.6 *7*				
2705.5 *5*				
2718.4 *5*				
2742.3 *4*				
2763.7 *4*				
2781.4 *5*				
2798.6 *8*				
2805.6 *7*				
2821.0 *5*				
2839.3 *6*				
2853.7 *5*				
2868.1 *5*				
2877.5 *8*				
2883.7 *9*				
2918.8 *6*				
2927.4 *5*				
2936.8 *9*				
2945.3 *9*				
2955.1 *8*				
2993.1 *12*				
2999.5 *10*				
3014.3 *11*				
3035.6 *9*				
3046.4 *6*				
3059.2 *5*				
3075.2 *5*				
3085.2 *8*				
3097.0 *6*				
3104.7 *6*				
3112.7 *11*				
3119.9 *9*				

Continued on next page (footnotes at end of table)

^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67 (continued)

^{228}Th Levels (continued)

E(level)†	E(level)†	E(level)†
3128.2 *10*	3186.0 *6*	3214.8 *9*
3158.8 *8*	3195.2 *6*	3225.0 *20*
3165.7 *6*	3209.6 *12*	3232.9 *13*
		3239.9 *8*

† From 2013Le21, unless otherwise noted. Measurement for levels ≥ 2510 was made only at 10°.
‡ Also in figure 2 in 2004Wi06.
# Also in 1972Ma15.
@ From 1996Ba67 only.
& From 2013Le21.
a Band(A): $K^\pi=0^-$ band.
b Band(B): $K^\pi=1^-$ band.
c Band(C): $K^\pi=2^-$ band.
d Band(D): $K^\pi=3^-$ band.
e Band(E): $K^\pi=0^+$ band.
f Band(F): $K^\pi=2^+$ band.
g Band(G): $K^\pi=4^+$ band.
h Band(H): $K^\pi=6^+$ band.

^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67

Band(D): $K^{\pi}=3^{-}$ band

(5^{-}) 1497.4

3^{-} 1343.9

Band(C): $K^{\pi}=2^{-}$ band

(5^{-}) 1296.0

Band(F): $K^{\pi}=2^{+}$ band

4^{+} 1261.6

3^{+} 1201.0

2^{+} 1153.3

Band(B): $K^{\pi}=1^{-}$ band

3^{-} 1168.0

5^{-} 1142.8

Band(E): $K^{\pi}=0^{+}$ band

6^{+} 1105.5

3^{-} 1016.4

Band(A): $K^{\pi}=0^{-}$ band

1^{-} 943.8

920.6

2^{+} 874.4

0^{+} 831.9

(7^{-}) 695.6

(5^{-}) 519.2

3^{-} 396.9

1^{-} 328.0

$^{228}_{90}Th_{138}$

^{230}Th(p,t) 2013Le21,2004Wi06,1996Ba67 (continued)

Band(H): $K^{\pi}=6^{+}$ band

(6^{+}) 1903.9

Band(G): $K^{\pi}=4^{+}$ band

(6^{+}) 1812.7

4^{+} 1643.8

$^{228}_{90}Th_{138}$