^{98}Mo(p,p′),(p,p) 1992Pi08,1990Pi14

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen, Balraj Singh	NDS 164, 1 (2020)	15-Feb-2020

Includes (p,p′γ), (p,p′ ce), (pol p,p).

1992Pi08, 1990Pi14: E=30.7 MeV proton beam was produced from the KVI cyclotron. Target was 97% enriched ^{98}Mo with thickness of the order of 1 mg/cm^2. Scattered particles were momentum-analyzed with the KVI QMG/2 magnetic spectrograph (FWHM=15 keV) and detected by a multiwire drift chamber backed by a scintillator. Measured $\sigma(\theta)$ from 7.5° to 37.5°. Deduced levels, J, π, L-transfers, transition strengths, deformation parameters from coupled-channel analysis and IBA-model analysis. Uncertainty on cross sections is 10% for absolute and 5% for relative values. The data are reported for octupole excitations by 1990Pi14 and those for hexadecapole transitions by 1992Pi08.

2014He12: (p,p′γ),E(p)=6.7 MeV, pulsed (every 82.47 ns) beam from ATLAS-ANL facility. Target=98.7% enriched ^{98}Mo 3 mg/cm^2 thick. Measured scattered protons and E0 conversion electrons using an annular silicon detector. Gamma rays were detected using Gammasphere array with 100 HPGe Compton-suppressed detectors. Deduced upper limit for two-photon emission branch for 735, E0 transition. Comparison with previous results for two-photon emissions for E0 transitions in ^{16}O, ^{48}Ca and ^{90}Zr, and with theoretical estimates.

Others:

1972Aw03: E=14.7 MeV. FWHM=60 keV, measured $\sigma(\theta)$, DWBA and coupled-channel calculations, data for 15 levels.

1971Lu07: E=15 MeV. FWHM=50 keV, coupled-channel calculations, data for 11 levels. Integrated cross sections are given for all levels.

Others (dealing with data for first few states):

1997Ah08: (pol p,p) E=65 MeV. Analyzed $\sigma(\theta)$, deduced optical-model parameters.
1996De23: E=18, 25.6 MeV. Analyzed $\sigma(\theta)$ data.
1995Wa07: E=12-26 MeV. Measured $\sigma(\theta)$.
1994Ri01: E=120, 160, 200 MeV. Measured $\sigma(\theta)$.
1992Ke07: reanalysis of (p,p′) data of 1971Lu07 and 1972Aw03.
1987Wa27: E=18 MeV. Measured angle-integrated proton spectra, Hauser-Feshbach calculations.
1985Fl01: (p,p) E=2-7 MeV. Measured excitation function.
1983Ce02, 1982Ce04: E=22.3 MeV. Measured $\sigma(\theta)$, DWBA and coupled-channel analysis. Data for two 2$^+$ and first 3$^-$ states.
Additional information 1.
1982Sa19: (pol p,p) E=65 MeV. Measured $\sigma(\theta)$ and Ay(θ).
1975RaYL: E=12, 17 MeV.
1975Bu04: E=12.5 MeV. FWHM=50 keV, measured $\sigma(\theta)$, data for six states.
1973InZY: E=14.5 MeV. (p,p′γ) data for 9 levels.
1972Bu18: E=8.16 MeV. (p,p′ ce), measured ce(t) for 735 level.
1971AnZV: (p,p′ ce), ce(t) data for 735 level.
1971Hi08 (also 1969Hi02): E=11-14.2 MeV. Measured excitation function for g.s. and 2$^+$.
1970Co01 (also 1971CoYY): E=6-8.7 MeV. (p,p′ ce) data for 735 E0.
1970Ke03: E=6-8 MeV. Measured $\sigma(\theta)$ data for three states.
Analysis of (p,p) data: 1997Ro22 (E=8.5-25 MeV), 1983An21, 1982Gu20 (E=3-10 MeV).
Analysis of (pol p,p) data at E=65 MeV: 1997Ah08, 1998Do16.

^{98}Mo Levels

B(E4)(W.u.) values given under comments are deduced by 1992Pi08 from the average of isoscalar matrix elements from their (p,p′) and (d,d′) data if both are available, unless otherwise noted. %EWSR is also from 1992Pi08.

E(level)†	J$^\pi$‡	T$_{1/2}$	L†	Comments
0	0$^+$		0	
736 *10*	0$^+$	21.8 ns *9*	(0)	E(level): from 1971Lu07, 740 in 1975Bu04. L: from 1975Bu04. T$_{1/2}$: from ce(t) data (1972Bu18). Others: 22 ns *2* (1971AnZV), 1970Co01.

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^{98}Mo(p,p′),(p,p) 1992Pi08,1990Pi14 (continued)

^{98}Mo Levels (continued)

E(level)†	Jπ‡	L†	β_L†	Comments
				Strength parameter for 735 E0=0.0273 *25* (1971AnZV).
787 *2*	2^+	2	0.180 *14*	β_L: from reanalysis (by 1992Ke07) of data from 1972Aw03 or 0.175 *13* of data from 1971Lu07. Others: 0.172 (1990Pi14), 0.154 (1975Bu04), 0.16 (1972Aw03), 0.17 (1971Lu07). B(E2)(W.u.)=21.5 *32* or 22.7 *34* (reanalysis by 1992Ke07 of data from 1971Lu07 and 1972Aw03), 21 *6* (1975Bu04).
1433 *2*		2	0.052	β_L: from 1975Bu04. B(E2)(W.u.)=1.0 *3* (1975Bu04).
1510 *2*		4	−0.023	β_L: other: 0.045 (1975Bu04), B(E2)(W.u.)=1.6 *5* (1975Bu04). B(E4)(W.u.)=1.47 *36*, %EWSR=0.042.
1760 *2*		2	0.03	β_L: from 1971Lu07. B(E2)(W.u.)=0.7 (1971Lu07).
1871 *2*		2		
2018 *2*		3	0.210 *16*	β_L: from reanalysis (by 1992Ke07) of data from 1972Aw03 or 0.205 *26* of data from 1971Lu07. Others: 0.197 (1990Pi14), 0.20 (1972Aw03,1971Lu07), 0.19 (1975Bu04). B(E3)(W.u.)=30 *5* or 32 *5* (reanalysis by 1992Ke07 of data from 1971Lu07 and 1972Aw03), 27 *8* (1975Bu04). γ-ray branching ratios given by 1973InZY from (p,p′γ) are: 2018γ/1230γ/259γ=20/70/10.
2209 *2*		0		
2224 *2*		4	−0.037	β_L: other: 0.07 (1972Aw03). 1971Lu07 give β_2=β_4=0.06 for a 2208 group (J^π=2^+,4^+). B(E4)(W.u.)=3.44 *24* (1992Pi08), 1.6 *5* (1975Bu04); %EWSR=0.144.
2240 *2*		4	+0.017	B(E4)(W.u.)=0.87 *18*, %EWSR=0.037.
2333 *2*		2		
2334 *2*		4	−0.056	The analysis assumes overlapping 2333 and 2334 levels (1992Pi08). L,β_L: 1971Lu07 give L=6, β_6=0.11 for a 2343 group. 1972Aw03 give β_4=0.09. B(E4)(W.u.)=8.1 *18* (1992Pi08), 7.1 *20* (1975Bu04); %EWSR=0.037.
2350 *2*		2		
2369 *2*		2		
2419 *2*		2		
2450? *10*		(4)	0.04	E(level),L,β_L: from 1971Lu07 only. B(E4)(W.u.)=1.6. It is possible that 2450 is the composite of 2419 and 2484 levels from 1992Pi08.
2484 *2*		3		
2509 *2*		1		
2525 *5*		(1)		β_L: 1972Aw03 and 1971Lu07 give L=3 for a 2530 group. β_3=0.06 (1971Lu07), 0.05 (1972Aw03). B(E3)(W.u.)=3.2 (1971Lu07), but 1992Pi08 suggest a doublet near this energy (2525 and 2537).
2537 *5*		(1)		
2560 *5*				J^π=2^- is suggested (1990Pi14) from cross section data. The population of this unnatural parity state is probably through a two-step process.
2574 *5*		4	−0.042	B(E4)(W.u.)=8.3 *10* (1992Pi08), 5.1 *15* (1975Bu04); %EWSR=0.404.
2600? *10*		3	0.07	E(level),L,β_L: from 1972Aw03 only. It may be a composite of 2574 and 2621 levels from 1992Pi08.
2621 *5*		5	0.016#	
2680 *5*		(4,5)		E(level): 1975Bu04 report a 6^+ level at 2690.
2699 *5*		(4)		E(level): 1975Bu04 report a 6^+ level at 2690.
2733 *5*		2		
2796 *5*		5	0.012#	
2810 *5*		2		
2837 *5*		6		
2855 *5*		4	−0.015	B(E4)(W.u.)=0.60 *19* (1992Pi08), 1.6 *5* (1975Bu04); %EWSR=0.032.
2906 *5*		4	−0.027	β_L: 0.04 (1972Aw03). B(E4)(W.u.)=3.84 *55*, %EWSR=0.211.
2920 *5*		2		
2963 *5*		3	0.014#	
2978 *5*		(4)	+0.042	β_L: 0.05 for a 3000 *10* group (1972Aw03).

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^{98}Mo(p,p′),(p,p) 1992Pi08,1990Pi14 (continued)

^{98}Mo Levels (continued)

E(level)†	L†	β_L†	Comments
			B(E4)(W.u.)=5.27 *78*, %EWSR=0.296.
3022 *5*	5	0.082#	
3049 *5*	4	−0.018	E(level): 1975Bu04 report a 4^+ level at 3020 with B(E4)(W.u.)=6.4 *19*. B(E4)(W.u.)=1.50 *17*, %EWSR=0.086.
3060? *10*	5	0.08	E(level),L,β_L: from 1972Aw03 only. It may be a composite of 3049 and 3067 from 1992Pi08.
3067 *5*			J$^\pi$: 1992Pi08 suggest (2^+,2^-).
3096 *5*	(6)		
3106 *5*	2		
3125 *5*	(3)		
3152 *5*	2		
3167 *5*	4	+0.016	B(E4)(W.u.)=0.73 *9*, %EWSR=0.044.
3214 *5*	3	0.023#	B(E3)(W.u.)=1.2 *4* (1975Bu04).
3263 *5*	1		
3276 *5*	(3,4)	−0.014	β_L: for L=4. B(E4)(W.u.)=0.52 *10*, %EWSR=0.031.
3305 *5*	5	0.023#	
3328 *5*	4	−0.014	B(E4)(W.u.)=1.37 *19*, %EWSR=0.086.
3344 *5*	2		
3389 *5*	2		
3401 *5*	4	−0.016	B(E4)(W.u.)=1.11 *22*, %EWSR=0.071.
3421 *5*	4	−0.028	B(E4)(W.u.)=1.95 *16*, %EWSR=0.126.
3464 *5*	(4)	−0.011	β_L: 0.04 (1972Aw03). B(E4)(W.u.)=0.62 *12*, %EWSR=0.041.
3485 *5*	2		
3499 *5*	(4)	−0.014	B(E4)(W.u.)=0.52 *10*, %EWSR=0.035.
3524 *5*	(6)		
3560 *5*	4	+0.028	B(E4)(W.u.)=2.00 *26*, %EWSR=0.135.
3598 *5*	4	+0.010	B(E4)(W.u.)=0.29 *3*, %EWSR=0.019.
3626 *5*	4	−0.015	B(E4)(W.u.)=0.96 *17*, %EWSR=0.066.
3639 *5*	4	−0.0065	B(E4)(W.u.)=0.61 *18*, %EWSR=0.042.
3664 *5*	4	−0.019	B(E4)(W.u.)=0.98 *11*, %EWSR=0.068.
3682 *5*	4	−0.010	B(E4)(W.u.)=0.62 *13*, %EWSR=0.043.
3710 *5*	5	0.010#	
3724 *5*	4	−0.016	B(E4)(W.u.)=0.71 *7*, %EWSR=0.050.
3737 *5*	4	−0.013	B(E4)(W.u.)=0.52 *8*, %EWSR=0.036.
3757 *5*	5	0.015#	
3778 *5*	4	+0.016	B(E4)(W.u.)=0.80 *13*, %EWSR=0.057.
3793 *5*	5	0.022#	
3824 *5*			
3847 *5*			
3993 *5*	5		
4117 *5*	(4,5)		

† From 1992Pi08, unless otherwise stated. 1992Pi08 give a combined list of energies (see table 1 in 1992Pi08) from (p,p′) and (d,d′) and it is assumed that level for which β_L is not given in column #4 of Table 3 (1992Pi08) is not populated in (p,p′), even though it is listed in Table 1 of 1992Pi08.

‡ From the Adopted Levels.

From 1990Pi14.

^{98}Mo(p,p′),(p,p) 1992Pi08,1990Pi14 (continued)

$\gamma(^{98}Mo)$

E_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult.	Comments
735	736	0^+	0	0^+	E0	Branching ratio for two photon emission: $\Gamma_{\gamma\gamma}/\Gamma<0.0001$ at 95% confidence level (2014He12). Two methods were used, one based on direct population of 735, 0^+ state, and the second based on population of 735, 0^+ level through 1024γ from 1758,2^+ level.
787	787	2^+	0	0^+		
1024	1760		736	0^+		

† From 2014He12.

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Level Scheme