^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 179, 1 (2022)	30-Nov-2021

(p,p′) measurements:

1988Fu01,1982Fu02: E=65 MeV proton beam from the RCNP cyclotron. Scattered protons were momentum-analyzed with the magnetic spectrograph RAIDEN (FWHM≈15 keV) and detected with a gas proportional counter. Measured Ep, $\sigma(\theta=8°$ to 70°). Deduced levels, J, π, L-transfers, deformation parameters from DWBA analysis. Comparisons available data. For the purpose of the parity assignment, α spectra at θ=13° and 16° of (α,α') with E=70 MeV wwere also measured for comparison with proton spectra, since in the α spectra only natural-parity states are present. Report 195 levels.

1972Gr27: E=25-40 MeV protons from the Michigan State University sector-focused cyclotron. Scattered protons were detected with two surface-barrier Ge(Li) detectors. Measured Ep, $\sigma(\theta=13°$ to 97°). Deduced levels, L-transfers, deformation parameters from DWBA analysis. Comparisons with available data. Report 29 levels.

2017Ma28: E=295 MeV proton beam was produced from the accelerator at the Research Center for Nuclear Physics (RCNP) in Osaka, Japan. Target was a self-supporting metallic ^{48}Ca foil (95.2% enriched) with a thickness of 1.87 mg/cm^2. Scattered protons were momentum-analyzed with the Grand Raiden magnetic spectrometer (FWHM=25 keV). Measured $\sigma(E_p,\theta)$. Deduced levels, J, π, M1 transition strengths from Multipole-Decomposition Analysis (MDA). Comparisons with available data. Report 41 high-lying levels above 7000 keV.

1969Te03: E=12 MeV proton beam at Saclay. Scattered protons were detected with surface-barrier detectors (FWHM=20-25 keV). Measured Ep, $\sigma(\theta_{c.m.}=30°$ to 150°). Deduced levels, J,π, L-transfers, deformation parameters from DWBA analysis. Comparisons with available data. Report 46 levels. 1969Te03 also report data on (p,p′γ).

1982Be14: E=44.4 MeV proton beam from the isochronous cyclotron JULIC. Measured Ep, $\sigma(\theta_{c.m.}=7.3°$ to 80°) using the 3Q2D magnetic spectrometer BIG KARL (FWHM=7-10 keV) with a multi-wire proportional counter and an additional plastic scintillator. Deduced levels. DWBA analysis. Report 22 high-lying levels above 9000 keV.

1966Ma13: E=11.5 MeV proton from the Argonne tandem. Measured proton spectra at θ=35°, 50°, 75° and 105°. Deduced levels.

1966La05: E=10 MeV proton from the Universitat Heidelberg tandem. Measured Ep, $\sigma(\theta_{c.m.}=30°$ to 160°). Deduced levels, L-transfers from DWBA analysis.

(pol p,p′) measurements:

1984Se10: E=159.8 MeV polarized protons from the Indiana University Cyclotron Facility. Scattered protons were momentum-analyzed with a Q2D magnetic spectrometer (FWHM≈70 keV at θ<35° and ≈100 keV at larger angles). Measured Ep, $\sigma(\theta=6°$ to 49.5°g), analyzing power. Deduced levels, J, π from DWIA analysis. Report 36 levels. The authors note that above 6.7 MeV there is a significant probability that a peak may consist of more than one state. Report 27 levels.

1985Se14: E=500 MeV polarized proton from the Los Alamos Meson Physics Facility (LAMPF). Measured $\sigma(\theta)$ and analyzing power, θ(c.m.)=5° to 30° using a high-resolution spectrometer (FWHM=60-80 keV) with focal-plane polarimeters. Deduced levels, J, π, deformation parameters from DWBA analysis.

1994Fe05: E=201.4 MeV *2*, 317.8 MeV *3* polarized protons from the Indiana University Cyclotron Facility. Measured $\sigma(\theta)$ and analyzing power, θ=5° to 39°, 2° steps, at 318 MeV and 5.86° to 55.27° at 201 MeV; high-resolution spectrometer with focal-plane polarimeters. FWHM≈35 to ≈55 keV at 318 MeV and 30 to 50 keV at 201 MeV. Extended random phase approximation calculations. 1994Fe05 observed all states below 7 MeV reported by 1984Se10.

Others: 2007Ta27, 1984Na02, 1983Cr01, 1983HoZS, 1983McZW, 1982Be14, 1982DjZY, 1982GaZS, 1982ImZZ, 1982Re07, 1980Fa07, 1980Ad03, 1978SmZO, 1977AuZW, 1971BoZQ, 1971LoZY, 1970Ma54.

^{48}Ca Levels

B(M1)↑ given under comments are spin-flip-M1 transition strengths extracted from the partial M1 cross sections σ_{M1} at 0° which are also given under comments and deduced from the MDA analysis of measured angular distributions (2017Ma28).

Neutron (M_n) and proton (M_p) moments given under comments are from the analysis of 1994Fe05. No uncertainties are given for M_p since ρ_p was held fixed in the fitting procedure. See 1994Fe05 for comparisons to earlier inelastic scattering results.

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	J^{π}[@]	L[g]	β_LR(fm)[h]	Comments
0.0	0^+			
3830[‡] *2*	2^+	2	0.61	E(level): from 1972Gr27. Others: 3818 *10* (1966La05), 3833 *4* (1966Ma13), 3835 *10* (1969Te03), and 3832 *7* (1988Fu01), 3832 (1984Se10). β_LR(fm): others: 0.70 (1972Gr27), 0.61 (1985Se14), 0.95 (1969Te03). M_n=9.46 fm^2 *21*, M_p=4.04 fm^2.
4283 *6*	0^+[&]	0	0.05	E(level): weighted average of 4272 *10* (1966La05), 4284 *6* (1966Ma13), 4286 *10* (1969Te03), and 4284 *7* (1988Fu01).
4505[‡] *1*	3^-	3	0.76	E(level): from 1972Gr27. Others: 4498 *10* (1966La05), 4506 *4* (1966Ma13), 4512 *10* (1969Te03), and 4507 *7* (1988Fu01), 4507 (1984Se10). β_LR(fm): others: 0.81 (1972Gr27), 0.84 (1985Se14), 1.09 (1969Te03). May contain a small contribution from the 4503, 4^+, state (1988Fu01). M_n=36.3 fm^3 *12*, M_p=31.78 fm^3. 1994Fe05 investigated the possibility of contributions to $\sigma(\theta)$ and the analyzing power from the 4503,4^+, state and found the effect to be negligible.
4611[‡] *4*	(3^+)[a]	(4)	0.22	E(level): weighted average of 4604 *10* (1966La05), 4613 *4* (1966Ma13), 4619 *10* (1969Te03), 4608 *4* (1972Gr27), and 4612 *7* (1988Fu01). Other: 4613 (1984Se10). J^{π}: 2 from 1969Te03 is discrepant. L,β_LR(fm): from 1972Gr27. Other: β_LR=0.44 (1969Te03). configuration: $(\nu,p_{3/2}f_{7/2})^{-1}$ (1988Fu01).
5146[‡] *4*	5^-	5	0.16	E(level): from 1972Gr27. Others: 5130 *20* (1966La05), 5146 *5* (1966Ma13), and 5152 *10* (1969Te03), 5147 *7* (1988Fu01), 5147 (1984Se10). J^{π}: other: (4) from 1984Se10 is inconsistent. β_LR(fm): other: 0.22 (1972Gr27), 0.83 (1969Te03).
5257 *5*	(5^+)[a]	(5)		E(level): weighted average of 5266 *10* (1966La05), 5265 *10* (1969Te03), 5252 *5* (1972Gr27), and 5260 *7* (1988Fu01). J^{π}: 4^- may also fit $\sigma(\theta)$ (evaluator). L: from 1972Gr27. β_LR(fm): other: 0.11 (1972Gr27). configuration: $(\nu,p_{3/2}f_{7/2})^{-1}$ (1988Fu01).
5311 *6*	$(1)^-$[b]	1		E(level): weighted average of 5322 *10* (1969Te03), 5304 *6* (1972Gr27), and 5314 *7* (1988Fu01).
5369[‡] *3*	3^-	3	0.38	E(level): weighted average of 5368 *5* (1966Ma13), 5376 *10* (1969Te03), 5368 *3* (1972Gr27), and 5370 *7* (1988Fu01). Other: 5370 *20* (1966La05), 5368 (1984Se10). J^{π}: other: (4) from 1969Te03 is discrepant. β_LR(fm): other: 0.46 (1972Gr27). M_n=18.4 fm^3 *6*, M_p=16.23 fm^3.
5462[‡] *7*	0^+[&c]	0	0.08	E(level): weighted average of 5464 *10* (1969Te03) and 5461 *7* (1988Fu01).
5729 *3*	5^-	5	0.37	E(level): from 1972Gr27. Others: 5724 *10* (1966La05), 5728 *8* (1966Ma13), 5737 *10* (1969Te03), and 5730 *7* (1988Fu01), 5729 (1984Se10). J^{π}: other: (3) from 1969Te03 is discrepant. β_LR(fm): other: 0.46 (1972Gr27). M_n=315 fm^5 *26*, M_p=328.5 fm^5.
6104 *3*	(4^-)[f]			E(level): from 1972Gr27. Others: 6096 *10* (1966La05), 6106 *7* (1966Ma13), 6108 *10* (1969Te03), and 6105 *7* (1988Fu01), 6104 (1984Se10). J^{π}: other: (4) from 1984Se10. β_LR(fm): other: 0.15 (1972Gr27). configuration: $-0.896\pi(f_{7/2},s^{-1}_{1/2})_{4-} + 0.441\pi(f_{7/2},d^{-1}_{3/2})_{4-}$ (1988Fu01).
6342 *2*	4^+	4	0.32	E(level): from 1972Gr27. Others: 6340 *20* (1966La05), 6338 *10* (1966Ma13), 6351 *10* (1969Te03), and 6345 *7* (1988Fu01), 6342 (1984Se10). β_LR(fm): other: 0.37 (1972Gr27). M_n=100 fm^4 *3*, M_p=49.25 fm^4.
6614 *7*	(1^-)	(1)		E(level): weighted average of 6610 *20* (1966La05), 6618 *10* (1969Te03), and 6612 *7* (1988Fu01).
6648 *5*	4^+	4	0.24	E(level): from 1972Gr27. Others: 6654 *10* (1969Te03), 6648 *7* (1988Fu01), 6648

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	J^π[@]	L[g]	β_LR(fm)[h]	Comments
				(1984Se10). β_LR(fm): other: 0.25 (1972Gr27).
6684 *7*	2^-[a]	1,2		E(level): weighted average of 6687 *10* (1969Te03) and 6683 *7* (1988Fu01).
6755	(0,1,2)			E(level),J^π: from 1984Se10.
6794 *6*	2^+	2	0.10	E(level): weighted average of 6790 *20* (1966La05), 6795 *6* (1972Gr27), and 6794 *7* (1988Fu01).
6826 *7*		(3)	0.05	E(level): weighted average of 6820 *10* (1969Te03), and 6829 *7* (1988Fu01).
6898 *7*	(5^+)	(2)+(5)	0.05+0.08	E(level): weighted average of 6897 *8* (1972Gr27), 6896 *10* (1969Te03), and 6899 *7* (1988Fu01). Other: 6897 (1984Se10). J^π: data appear to be consistent with the assumption that this peak is a multiplet consisting of a 2^- and a 5^+ state; ≥3 from 1984Se10. L: other: 5 from 1972Gr27. β_LR(fm): other: 0.15 (1972Gr27).
7011 *7*	3^-	3	0.13	J^π: other: (0,1,2) from 1984Se10 is discrepant.
7019 *7*				E(level): from 1972Gr27.
7030 *7*		3+6	0.06+0.13	E(level): other: 7028 *10* from 1969Te03.
7299 *5*	3^-[f]	3[f]	0.05	E(level): weighted average of 7305 *10* (1969Te03), 7298 *5* (1972Gr27), 7303 *7* (1988Fu01), and 7285 *10* (2017Ma28).
7385 *10*	3^-,(1^-)			E(level),J^π: from 2017Ma28.
7401 *4*	(2^-)[a]	(3)		E(level): from 1972Gr27. Others: 7402 *10* (1969Te03) and 7399 *7* (1988Fu01). L: from 1972Gr27, inconsistent with J^π=(2^-) from 1988Fu01. Other: 1,2 from 1988Fu01 with L=2 inconsistent with J^π=(2^-). β_LR(fm): other: 0.15 (1972Gr27).
7443 *7*				E(level): weighted average of 7444 *10* (1969Te03) and 7442 *7* (1988Fu01).
7468 *5*	4^+	4	0.11	E(level): from 1972Gr27. Other: 7469 *7* (1988Fu01).
7494 *7*	(3)			E(level): from 1988Fu01. Other: 7500 (1984Se10). J^π: from 1984Se10.
7537 *7*	3^-	3	0.08	E(level): from 1988Fu01. Other: 7536 *8* (1972Gr27).
7580 *7*				E(level): weighted average of 7589 *10* (1969Te03) and 7575 *7* (1988Fu01).
7650 *10*	3^-,1^+			B(M1)↑=0.008 *5* σ_{M1}(0°)(mb/sr)=0.015 *9*. E(level): weighted average of 7652 *10* (1969Te03) and 7648 *10* (2017Ma28). J^π: from 2017Ma28.
7659 *3*	3^-	3	0.41	E(level): from 1972Gr27. Others: 7666 *10* (1969Te03), 7661 *7* (1988Fu01), 7659 (1984Se10). β_LR(fm): other: 0.49 (1972Gr27).
7797 *8*	4^+	4	0.19	β_LR(fm): other: 0.22 (1972Gr27). E(level): weighted average of 7784 *10* (1969Te03), 7801 *8* (1972Gr27), and 7800 *7* (1988Fu01). Other: 7800 (1984Se10).
7911 *7*	3^-	3	0.06	
7957 *7*	$(4)^+$[b]	4	0.08	E(level): weighted average of 7970 *20* (1966La05), 7957 *10* (1969Te03), and 7956 *7* (1988Fu01).
8001 *8*				J^π: natural parity state from presence in (α,α′) spectra.
8023 *8*	2^+	2	0.10	E(level): weighted average of 8026 *8* (1988Fu01) and 8018 *10* (2017Ma28).
8045 *8*	(0,1)			E(level): weighted average of 8041 *10* (1969Te03) and 8047 *8* (1972Gr27). Other: 8047 (1984Se10). J^π: from 1984Se10.
8065 *8*	5^-	5	0.14	E(level): weighted average of 8069 *10* (1969Te03) and 8063 *8* (1988Fu01).
8082 *10*				E(level): from 1969Te03.
8119 *8*		2	0.04	
8178 *8*	4^+	4	0.05	
8236 *8*		5	0.12	
8248 *8*	4^+	4	0.21	E(level): weighted average of 8247 *10* (1969Te03) and 8248 *8* (1988Fu01).
8274 *6*	4^+	4	0.25	E(level): weighted average of 8276 *10* (1969Te03), 8269 *6* (1972Gr27), and 8283 *8* (1988Fu01). Other: 8269 (1984Se10). β_LR(fm): other: 0.22 (1972Gr27).

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	Jπ[@]	L[g]	β_LR(fm)[h]	Comments
8356 *8*	5⁻	5	0.13	
8386 *8*	1⁻&(6)⁺	1+6	0.16[i]	E(level): weighted average of 8384 *10* (1969Te03), 8385 *10* (1972Gr27), 8388 *8* (1988Fu01), and 8385 *10* (2017Ma28). Other: 8385 (1984Se10). Jπ: 1⁻,3⁻ from 2017Ma28. β_LR(fm): other: 0.25 (1972Gr27).
8441 *8*	3⁻	3	0.10	E(level): weighted average of 8443 *10* (1969Te03) and 8439 *8* (1988Fu01).
8478 *8*		4	0.07	E(level): weighted average of 8488 *10* (1969Te03) and 8471 *8* (1988Fu01).
8523 *5*	3⁻	3	0.27	E(level): weighted average of 8527 *10* (1969Te03), 8522 *5* (1972Gr27), 8524 *8* (1988Fu01), and 8520 *10* (2017Ma28). Jπ: other: 3⁻,1⁺ from 2017Ma28. β_LR(fm): other: 0.26 (1972Gr27). σ_{M1}(0°)(mb/sr)=0.012 *5*. B(M1)↑=0.007 *3* for Jπ=1⁺ (2017Ma28).
8565 *7*	(6)	(6)	0.22	E(level): weighted average of 8562 *7* (1972Gr27) and 8570 *8* (1988Fu01). Other: 8572 (1984Se10). Jπ: 6⁻ from (e,e′) studies; but the existence of this L(p,p′)=(6) state in (α,α′) spectra is uncertain (1988Fu01) and thus a tentative J=(6) is assigned by 1988Fu01; . Other: (3) from 1984Se10 discrepant. β_LR(fm): other: 0.27 (1972Gr27).
8586 *10*				E(level): from 1969Te03.
8609 *6*	3⁻	3	0.24	E(level): weighted average of 8603 *10* (1969Te03), 8608 *6* (1972Gr27), and 8615 *8* (1988Fu01). Other: 8609 (1984Se10). β_LR(fm): other: 0.27 (1972Gr27).
8680 *7*	(3⁺)[a]			β_LR(fm): other: 0.07 (1972Gr27). E(level): weighted average of 8680 *7* (1972Gr27), 8672 *10* (1969Te03) and 8685 *8* (1988Fu01).
8698 *8*	[d]			
8788 *8*				E(level): other: 8790 *10* (1969Te03).
8797 *8*	4⁺&(6⁺)	4+6	0.21+0.30	
8806 *5*		5	0.41	E(level),L,β_LR(fm): from 1972Gr27. Others: 8811 *10* (1969Te03), 8811 (1984Se10).
8831 *8*		3	0.06	E(level): weighted average of 8825 *10* (1969Te03) and 8835 *8* (1988Fu01).
8866 *8*	(5)⁻[b]	5	0.16	
8886 *6*	2⁺	2	0.25	E(level): weighted average of 8888 *10* (1969Te03), 8885 *6* (1972Gr27), 8883 *8* (1988Fu01), and 8893 *10* (2017Ma28). Other: 8885 (1984Se10). L: other: (5) from 1972Gr27 is inconsistent. β_LR(fm): other: 0.30 (1972Gr27).
8920 *8*				E(level): weighted average of 8922 *10* (1969Te03) and 8918 *8* (1988Fu01),
8947 *8*				
8964 *10*				E(level): from 1969Te03.
8982 *8*	3⁻	3	0.17	
9027 *9*	1⁻	1		E(level): other: 9010 (1984Se10). Jπ: other: <4 (1984Se10).
9047 *9*	2⁺	2	0.10	E(level): weighted average of 9049 *10* (1982Be14), 9049 *9* (1988Fu01), and 9043 *10* (2017Ma28). Other: 1⁻,2⁺ from 2017Ma28.
9079 *9*				
9123 *9*	1⁺,2⁺,3⁺&(7⁻)[e]	2+(8)	0.05[i]	E(level): weighted average of 9130 *10* (1969Te03) and 9117 *9* (1988Fu01).
9158 *9*	(4)⁺[b]	4	0.08	E(level): other: 9150 (1984Se10). Jπ: other: >4 (1984Se10).
9176 *9*	2⁺	2	0.10	
9211 *9*	(3)⁻&(6⁻,7⁻)[e]	3+(7)	0.07[i]	E(level): weighted average of 9207 *10* (1969Te03) and 9214 *9* (1988Fu01).
9229	8			E(level),Jπ: from 1984Se10.
9232 *9*		(1)		
9285 *10*				E(level): from 1982Be14.
9294 *9*	1⁻&(8⁻)[e]	1+(8)		E(level): weighted average of 9285 *10* (1982Be14), 9297 *9* (1988Fu01), and 9298 *10* (2017Ma28).

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	Jπ[@]	L[g]	β_LR(fm)[h]	Comments
				Jπ: other: 1⁻,2⁺ from 2017Ma28.
9307	8			E(level),Jπ: from 1984Se10.
9334 *9*				
9366 *9*		6	0.09	E(level): weighted average of 9364 *10* (1982Be14) and 9367 *9* (1988Fu01).
9383 *10*	1⁺,2⁺			B(M1)↑=0.020 *2* σ_{M1}(0°)(mb/sr)=0.035 *1*. E(level),Jπ: from 2017Ma28.
9430 *9*		3	0.05	
9465 *9*	1⁻	1		E(level): weighted average of 9461 *10* (1982Be14), 9461 *9* (1988Fu01), and 9475 *10* (2017Ma28). Jπ: other: 1⁻,3⁻ from 2017Ma28.
9496 *9*				
9540 *9*	1⁻	1		E(level): weighted average of 9536 *10* (1982Be14), 9537 *9* (1988Fu01), and 9548 *10* (2017Ma28). Jπ: other: 1⁻,3⁻ from 2017Ma28.
9568 *9*		(6)	0.10	E(level): weighted average of 9569 *10* (1982Be14) and 9568 *9* (1988Fu01).
9621 *9*	4⁺	4	0.13	E(level): weighted average of 9621 *10* (1982Be14) and 9621 *9* (1988Fu01).
9645 *9*		3	0.10	E(level): weighted average of 9638 *9* (1988Fu01) and 9653 *10* (2017Ma28).
9691 *9*		(1)		
9728 *9*		3	0.14	E(level): weighted average of 9730 *10* (1982Be14) and 9727 *9* (1988Fu01).
9765 *9*	3⁻	3	0.18	E(level): weighted average of 9766 *10* (1982Be14) and 9764 *9* (1988Fu01).
9784 *9*		(4)	0.07	
9816 *9*	(1)⁻[b]	1		E(level): weighted average of 9810 *9* (1988Fu01) and 9823 *10* (2017Ma28).
9862 *9*	3⁻	3	0.10	E(level): weighted average of 9865 *10* (1982Be14) and 9860 *9* (1988Fu01).
9894 *7*		3+(6)	0.06+0.08	E(level): other: 9895 *10* (1982Be14).
9921 *9*	3⁻	3	0.10	E(level): weighted average of 9923 *10* (1982Be14) and 9920 *9* (1988Fu01).
9942 *9*		3	0.07	
9973 *10*	1⁺			B(M1)↑=0.037 *3* σ_{M1}(0°)(mb/sr)=0.063. E(level),Jπ: from 2017Ma28.
9993 *9*	4⁺	4	0.09	E(level): weighted average of 9995 *10* (1982Be14) and 9992 *9* (1988Fu01).
10065 *10*	(4)⁺[b]	4	0.07	
10081 *10*	(3)⁻[b]	3	0.07	E(level): weighted average of 10083 *10* (1982Be14) and 10078 *10* (1988Fu01).
10108 *10*	4⁺	4	0.12	E(level): weighted average of 10109 *10* (1982Be14) and 10107 *10* (1988Fu01).
10126 *10*	1⁻	1		E(level): weighted average of 10126 *10* (1982Be14) and 10125 *10* (1988Fu01).
10138 *10*				B(M1)↑=0.148 *13* σ_{M1}(0°)(mb/sr)=0.255 *9*. E(level): from 2017Ma28.
10151 *10*	3⁻	3	0.11	E(level): weighted average of 10152 *10* (1982Be14) and 10150 *10* (1988Fu01).
10178 *10*	3⁻	3	0.12	
10191 *10*	3⁻	3	0.10	E(level): other: 10186 *10* (1982Be14) could be a doublet corresponding to 10178+10191.
10211 *10*	1⁺	0		E(level): weighted average of 10212 *10* (1982Be14) and 10210 *10* (1988Fu01). Other: 10220 *40* (1984Se10), 10230 (2016Bi05). Jπ: J=1,2 from σ(θ), unnatural parity state from absence of peak in (α,α′) spectra, ≠2⁻ or 1⁻ from comparison to ^{40}Ca(p,p′) (1982Fu02); 1⁺ from ΔL=0 spin-flip transition (2016Bi05). L: from characteristic very sharp forward peaking of σ(θ) (1983Cr01). Other: 1 from 1988Fu01 inconsistent with J^π=1⁺. B(M1)=3.85 *32*−4.63 *38* μ_N^2 (2016Bi05). The range is due to taking into consideration two extreme factors; with and without quenching factor: 3.85 *32* μ_N^2 is the value without quenching and 4.63 *38* μ_N^2 is with quenching. Little evidence for splitting of the magnetic dipole (1991Ba26,1990Ba14); see ^{48}Ca(pol p,p′): GDR,GQR. 1983Cr01 observed 15 additional states between 7.7 MeV and 12.7 MeV. Seven of these states are within 42 keV of those reported by 1983St09. The others observed by

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	Jπ[@]	L[g]	β_LR(fm)[h]	Comments
				1983Cr01 and reported by 1983St09 do not appear to be correlated in energy. 1983Cr01 place an upper limit of 5% of the reported B(M1)↑ strength to any other level.
10265 *10*				
10288 *10*				B(M1)↑=0.080 *8* σ_{M1}(0°)(mb/sr)=0.137 *1*. E(level): from 2017Ma28.
10319 *10*	3⁻	3	0.08	E(level): weighted average of 10319 *10* (1982Be14) and 10318 *10* (1988Fu01).
10345 *10*	3⁻	3	0.11	E(level): from 1982Be14 and 1988Fu01.
10350 *10*				B(M1)↑=0.040 *13* σ_{M1}(0°)(mb/sr)=0.069 *22*. E(level): from 2017Ma28.
10370 *10*	(2)⁺[b]	2	0.04	
10390 *10*				B(M1)↑=0.023 *2* σ_{M1}(0°)(mb/sr)=0.040 *1*. E(level): from 2017Ma28.
10399 *10*		4	0.07	
10433 *10*		2	0.04	
10483 *10*	3⁻	3	0.11	
10521 *10*	(2)⁺[b]	2	0.05	
10535 *10*		(1)		B(M1)↑=0.010 *3* σ_{M1}(0°)(mb/sr)=0.017 *4*. E(level): weighted average of 10531 *10* (1988Fu01) and 10538 *10* (2017Ma28). L: from 1988Fu01.
10571 *10*		1,2		B(M1)↑=0.060 *8* σ_{M1}(0°)(mb/sr)=0.103 *12*. E(level): weighted average of 10563 *10* (1988Fu01) and 10578 *10* (2017Ma28). L: from 1988Fu01.
10586 *10*	(4)⁺[b]	4	0.08	
10610 *10*				B(M1)↑=0.031 *4* σ_{M1}(0°)(mb/sr)=0.053 *6*. E(level): from 2017Ma28.
10611 *10*	3⁻	3	0.13	
10623 *10*				
10645 *10*				B(M1)↑=0.020 *4* σ_{M1}(0°)(mb/sr)=0.034 *6*. E(level): from 2017Ma28.
10648 *10*	(3)⁻[b]	3	0.10	
10686[#] *10*	3⁻	3	0.14	
10708 *10*				E(level): from 1982Be14.
10731[#] *10*	2⁺	2	0.07	
10764 *10*				B(M1)↑=0.059 *29* σ_{M1}(0°)(mb/sr)=0.102 *48*. E(level): weighted average of 10765 *10* (1988Fu01) and 10763 *10* (2017Ma28).
10765 *10*				
10782 *10*				
10803 *10*	(3⁻)	(3)	0.07	
10822 *10*	3⁻	3	0.09	
10857 *10*	2⁺	2	0.08	
10872 *10*		6	0.09	
10883 *10*	(2⁺)	(2)	0.06	
10916 *10*	(3)⁻[b]	3	0.11	
10935 *10*				B(M1)↑=0.011 *8* σ_{M1}(0°)(mb/sr)=0.018 *13*. E(level): weighted average of 10936 *10* (1988Fu01) and 10933 *10* (2017Ma28).

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	Jπ[@]	L[g]	β_LR(fm)[h]	Comments
10955 *10*	4+	4	0.12	
11013 *11*				
11037 *11*	(2+)	(2)	0.05	
11050 *11*		(4)	0.07	
11098 *11*	2+&4+	2+4	0.07+0.09	
11125 *11*		4	0.06	
11153 *11*				
11183 *11*	(5−)	(5)	0.09	
11219 *11*	[d]			
11227 *10*				B(M1)↑=0.012 *3* σ_{M1}(0°)(mb/sr)=0.020 *5*. E(level): weighted average of 11230 *11* (1988Fu01) and 11225 *10* (2017Ma28).
11248 *11*	(4)+[b]	4	0.09	
11281 *11*	2+	2	0.05	
11329 *11*	3−	3	0.07	
11376 *11*	3−	3	0.14	
11383 *10*				B(M1)↑=0.003 *2* σ_{M1}(0°)(mb/sr)=0.005 *3*. E(level): from 2017Ma28.
11421 *11*				
11433 *11*		2	0.06	
11447 *11*		3	0.06	
11466 *11*				
11485 *11*		(3)	0.05	
11508 *11*	2+	2	0.10	
11513 *10*				B(M1)↑=0.021 *15* σ_{M1}(0°)(mb/sr)=0.036 *26*.
11530 *11*	3−	3	0.10	
11550 *11*	[d]			
11563 *10*				B(M1)↑=0.039 *5* σ_{M1}(0°)(mb/sr)=0.066 *7*.
11589 *11*		1		
11622 *11*	(4+)	(4)	0.09	
11639 *11*		(2)	0.04	
11671 *11*	(4−,5−,6−)&(8−)[ae]	(5)+(8,9)	0.06[i]	
11693 *11*	5−	5	0.11	
11695 *10*				B(M1)↑=0.025 *9* σ_{M1}(0°)(mb/sr)=0.043 *15*.
11715 *11*		(2)	0.05	
11725 *10*				B(M1)↑=0.014 *9* σ_{M1}(0°)(mb/sr)=0.024 *14*.
11752 *11*	(2)+[b]	2	0.05	
11773 *11*	[d]			
11816 *11*		3	0.05	
11828 *11*				
11843 *10*				B(M1)↑=0.030 *4* σ_{M1}(0°)(mb/sr)=0.051 *6*.
11848 *11*	[d]			
11913 *11*	3−	3	0.09	
11945 *11*	(0)+[c]	0	0.07	
11967 *11*	(0)+[c]	0	0.07	
11990 *10*				B(M1)↑=0.047 *5* σ_{M1}(0°)(mb/sr)=0.079 *5*.
12009 *12*	(3−)	(3)	0.10	

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

E(level)[†]	J$^{\pi}$[@]	L[g]	β_LR(fm)[h]	Comments
12029 *12*	3$^-$	3	0.08	
12051 *12*		(1)		
12090 *12*		(3)	0.05	
12107 *12*		5	0.08	
12121 *10*		1		B(M1)↑=0.048 *6* σ_{M1}(0°)(mb/sr)=0.082 *8*. E(level): weighted average of 12123 *12* (1988Fu01) and 12120 *10* (2017Ma28).
12162 *12*		4	0.08	
12176 *12*				
12216 *12*		5	0.05	
12271 *12*		(4)	0.10	
12275 *10*				B(M1)↑=0.035 *19* σ_{M1}(0°)(mb/sr)=0.059 *32*.
12318 *12*	(0)$^+$[c]	0	0.09	
12338 *10*		2	0.11	B(M1)↑=0.070 *9* E(level): from 2017Ma28. Other: 12339 *12* from 1988Fu01. σ_{M1}(0°)(mb/sr)=0.117 *13*.
12369 *12*		(4)	0.06	
12422 *12*		2	0.07	
12441 *12*		3	0.09	
12478 *10*				B(M1)↑=0.025 *13* σ_{M1}(0°)(mb/sr)=0.043 *22*. E(level): weighted average of 12476 *12* (1988Fu01) and 12480 *10* (2017Ma28).
12499 *12*				
12540 *12*		2	0.07	
12565 *12*	(0)$^+$[c]	0	0.09	
12620 *12*		2	0.07	
12623 *10*				B(M1)↑=0.054 *20* σ_{M1}(0°)(mb/sr)=0.090 *32*.
12659 *10*				B(M1)↑=0.077 *6* σ_{M1}(0°)(mb/sr)=0.129 *1*. E(level): weighted average of 12658 *12* (1988Fu01) and 12660 *10* (2017Ma28).
12667 *12*				
12693 *10*				B(M1)↑=0.035 *5* σ_{M1}(0°)(mb/sr)=0.059 *7*.
12704 *12*				
12757 *12*		2	0.06	
12798 *12*		2	0.10	
12846 *12*				
12869 *12*	(0$^+$)[c]	(0)	0.06	
12918 *10*				B(M1)↑=0.048 *40* σ_{M1}(0°)(mb/sr)=0.080 *66*.
12925 *12*		2	0.05	
12968 *12*		(3)	0.08	
13030 *13*		5	0.07	
13065 *13*		(2)	0.06	
13098 *13*		2	0.06	
13169 *13*		1		
13223 *13*				
13256 *13*		3	0.08	
13290 *13*				
13360 *13*		2	0.09	
13403 *13*		2	0.06	
13439 *13*				
13475 *13*		2	0.06	
13493 *13*				

Continued on next page (footnotes at end of table)

^{48}Ca(p,p′),(pol p,p′) 1988Fu01,1972Gr27,2017Ma28 (continued)

^{48}Ca Levels (continued)

† From 1988Fu01, unless otherwise noted.
‡ Calibration point in 1988Fu01. Energy taken from 1984Se10.
\# 10708 keV *10* state reported by 1982Be14.
@ From L(p,p′) and natural-parity state from presence in the (α,α′) spectra in 1988Fu01, unless otherwise noted. Natural parity is distinguished from unnatural parity based on observation of one-to-one correspondences of levels in (p,p′) and (α,α′) spectra (1988Fu01).
& Quite weakly excited in comparison to data at lower proton energies (1969Te03,1970Be39). This is consistent with the suggested 2p-^{2}H nature of these states (1967Bj06,1970Fe06).
[a] From DWBA analysis 1988Fu01, unnatural parity state since it was not observed in the (α,α′) spectra.
[b] Likely spin but not clearly observed in (α,α′) spectra (1988Fu01).
[c] σ(θ) show oscillatory patterns and are fitted well by DWBA assuming 0^+ (1988Fu01).
[d] Possibly a natural parity state but not clearly observed in (α,α′) spectra (1988Fu01).
[e] High-spin component from comparison to DWBA (1988Fu01).
[f] Discrepant with adopted J^π(6105)=1^-,2,3,4^+ and J^π(7299)=(2^+), respectively.
[g] From comparison to DWBA or to experimental σ(θ) of states with known spin and parity by 1988Fu01, unless otherwise noted. The tentative assignments are unlikely to be in error by more than one unit.
[h] From comparison to DWBA in 1988Fu01, unless otherwise noted. See 1988Fu01 for %EWSR (Energy-Weighted Sum Rule) derived from these deformation lengths.
[i] For L(8388)=6, L(9117)=2, L(9214)=3, and L(11671)=5, respectively, in 1988Fu01.