^{32}S(p,p),(pol p,p):res 1958Ol16,1973Ab05,1974Fi02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 199,1 (2025)	30-Sep-2024

Also includes (p,p′γ) from 1958Ol16, 1980Va02.

(p,p):

1958Ol16: E=1.5-4.0 MeV proton beams (6 and 4 keV steps) were produced from the Duke University Van de Graaff accelerator. Target was H_2S gas of natural sulphur. Scattered protons were detected with a thin (≈0.3 mm) CsI crystal (FWHM=7% for 3 MeV protons). Measured $\sigma(E_p,\theta)$. Deduced resonance energies, levels, J, π, widths from the R-matrix analysis based on the single-level approximation of the dispersion theory. 1958Ol16 also reported data from (p,p′γ).

1973Ab05: E=4.0-5.5 MeV proton beams (2, 5 or 10 keV steps) were produced from the 5.5-MeV Van de Graaff accelerator of the Laboratori Nazionali di Legnaro. Target was prepared by evaporating Sb_2S_3 on carbon backings of 20 $\mu g/cm^2$. Scattered protons were detected with surface-barrier silicon detectors with 700 or 1000 μm depletion depth (FWHM=40 keV for 4.8 MeV protons). Measured $\sigma(E_p,\theta)$. Deduced resonance energies, levels,J, π, widths from R-matrix analysis.

1974Fi02: E=3.36-3.40 MeV (2 keV step) and 3.8-5.0 MeV (1 keV step) proton beam was produced from the University of Auckland folded Tandem Electrostatic Accelerator. Target was a thin layer of Sb_2S_3 (natural sulphur) evaporated onto a thin carbon backing. Scattered protons were detected with four silicon detectors at four different angles. Measured $s(E_p,\theta)$. Deduced resonance energies, levels, J, π, widths from the R-matrix analysis with single-level approximation.

1970Ab15: E=3.28-3.38 MeV proton beams were produced from the Van de Graaff ion accelerator of Padua University. Target were thin films of CdS made from natural sulphur, evaporated onto carbon backings of 20 or 40 $\mu g/cm^2$ thickness. Scattered protons were detected with a solid-state detector (FWHM=30 keV for 3 MeV protons). Measured $\sigma(E_p,\theta)$. Deduced resonance energies, levels, J, π, widths from the R-matrix analysis.

1980Wa28: E=5.276 MeV. R-matrix analysis.

2002Py01: E≈3.37 MeV proton beam was produced from the University of Notre Dame FN-model Tandem accelerator. Measured $\sigma(E_p,\theta)$. Deduced resonance levels, J, π, mass access (T=3/2) = −15455.6 keV *8*.

Additional information 1.

(pol p,p):

1976Ik03: E=3.00-3.80 (20 keV step) MeV polarized proton beams were produced from TUNL Lamb-shift polarized-ion source (FWHM<1 keV, intensity of 3 μA). Targets were natural Sb_2S_3 evaporated onto carbon foils. Scattered protons were detected with surface-barrier silicon detectors. Measured $\sigma(E,\theta)$. Deduced resonance parameters.

1992Wi13: E=6.4-7.7 polarized proton beams at TUNL. Measured $\sigma(E,\theta)$. Deduced resonance levels, J, π, widths from R-matrix analysis.

(p,p′γ):

1980Va02: E=3.379 and 3.711 MeV proton beams at Join Institute for Nuclear Research. Measured $\sigma(E,\theta)$. Deduced resonance levels, J, π, widths.

1972Lo19,1971Lo21: 2.5-3.0 MeV polarized proton beams were produced from a charge-exchange accelerator with a polarized negative ion injector at the Physico-technical Institute, Academy of Sciences, Ukrainian SSR. Measured $\sigma(E_p,\theta)$. Deduced resonance energies, J, π, L, widths from the multi-channel R-matrix analysis.

^{33}Cl Levels

Γ_{p0} and $\Gamma_{p'}$ values given under comments are from 1973Ab05 for elastic scattering channel (to ^{32}S ground state) and inelastic scattering, respectively, unless otherwise noted.

E(level)[†]	J^π[‡]	Γ[‡]	L[‡]	E_p(lab)(keV)[‡]	Comments
4119 *2*	3/2⁻	8.5 keV *15*	1	1900 *2*	
4516 *4*	1/2⁻	55 keV *5*	1	2310 *4*	
4777 *3*	7/2⁻	0.25 keV *5*	3	2579 *3*	J^π,L: from 1972Lo19. J^π=5/2⁻,7/2⁻ from 1958Ol16. Γ: other: 1.0 keV *5* (1972Lo19). E_p(lab)(keV): weighted average of 2578 *3* (1958Ol16) and 2580 *3* (1972Lo19). Γ_{p0}≈0.25 keV from Γ_{p0}/Γ≈1 and Γ=0.25 keV *5* (1958Ol16).
5002 *2*	3/2⁻	6.0 keV *20*	1	2811 *2*	E_p(lab)(keV): weighted average of 2810 *2* (1958Ol16) and 2814 *3*

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^{32}S(p,p),(pol p,p):res 1958Ol16,1973Ab05,1974Fi02 (continued)

^{33}Cl Levels (continued)

E(level)†	J^π‡	Γ‡	L‡	E_p(lab)(keV)‡	Comments
					(1972Lo19). Γ: same value also from 1972Lo19. $\Gamma_{p'}\approx1.5$ eV (1958Ol16).
5090 *2*	7/2⁻	≤0.5 keV	3	2902 *2*	J^π: from 1972Lo19. Other: 5/2⁻,7/2⁻ from 1958Ol16. Γ: other: ≈0.5 (1972Lo19). $\Gamma_{p0}/\Gamma\approx1$, $\Gamma_{p'}\approx1.0$ eV (1958Ol16).
5105 *2*	3/2⁺	1.5 keV *5*	2	2917 *2*	J^π,Γ,L,E_p(lab)(keV): same results from 1972Lo19. $\Gamma_{p0}\approx1.5$ from $\Gamma_{p0}/\Gamma\approx1$ and Γ=1.5 keV *5*, $\Gamma_{p'}\approx1.8$ eV (1958Ol16).
5117 *15*	1/2⁻	298 keV *31*	1	2923 *15*	1972Lo19 consider the resonance at E_p=2895 *30* reported in 1958Ol16 the same one as seen by them at E_p=2930 *15*. J^π,L: from both 1958Ol16 and 1972Lo19. Γ: weighted average of 360 keV *60* (1958Ol16) and 283 keV *30* (1972Lo19). E_p(lab)(keV): weighted average of 2895 *30* (1958Ol16) and 2930 *15* (1972Lo19).
5276 *2*	5/2⁻	0.34 keV *6*	3	3094 *2*	Γ_{p0}=0.29 keV *5* and $\Gamma_{p'}$=0.05 keV *2* from Γ_{p0}/Γ=0.85 *5* and Γ=0.34 keV *6* (1958Ol16).
5374 *2*	5/2⁺	0.44 keV *8*	2	3195 *2*	Γ_{p0}=0.43 keV and $\Gamma_{p'}$=0.01 keV from Γ_{p0}/Γ=0.98 keV and Γ=0.44 keV *8* (1958Ol16).
5448 *1*	1/2⁺	30 keV *2*	0	3271 *1*	E_p(lab)(keV): weighted average of 3273 *4* (1958Ol16) and 3271 *1* (1970Ab15). Γ: weighted average of 32 keV *4* (1958Ol16), 30 keV *2* (1970Ab15), and 30 keV *4* (1976Ik03). Γ_{p0}=30 keV *1* (1970Ab15), 30 keV *4* (1976Ik03).
5548 *1*	1/2⁺	105 eV *9*	0	3374.7 *8*	Additional information 2. J^π,L: from 1970Ab15, 1974Fi02, 2002Py01. Γ: weighted average of 100 eV *25* (1970Ab15), 150 eV *50* (1974Fi02), 115 eV *15* (1976Ik03), 100 eV *9* (1992Wi13). E_p(lab)(keV): from 2002Py01. Others: 3375 *3* (1974Fi02), 3370 *1* (1970Ab15), 3379 *2* (1958Ol16). Γ_{p0}=100 eV *25* (1970Ab15), 98 eV *9* (1992Wi13), 115 eV *15* (1976Ik03).
5555 *1*	7/2⁻	0.73 keV *13*	3	3381.5 *8*	J^π,L: from 1958Ol16, 1970Ab15, 1976Ik03, 2002Py01. Γ: weighted average of 1.00 keV *20* (1958Ol16), 0.60 keV *10* (1970Ab15) and 1.0 keV *2* (1976Ik03). E_p(lab)(keV): from 2002Py01. Others: 3379 *2* (1958Ol16), 3377 *1* (1970Ab15), 3379 *7* (1980Va02). Γ_{p0}=0.20 keV *5* (1970Ab15), 0.4 keV (1976Ik03). Γ_{p0}=0.40 keV *9* and $\Gamma_{p'}$=0.60 keV *13* from Γ_{p0}/Γ=0.40 *4* and Γ=1.00 keV *20* (1958Ol16).
5651 *10*	3/2⁻	100 keV *10*	1	3480 *10*	Γ: from 1976Ik03. Other: 100 keV *15* (1958Ol16). Γ_{p0}=100 keV *10* (1976Ik03).
5738 *5*	1/2⁺	40 keV *5*	0	3570 *5*	Γ: from 1958Ol16 and 1976Ik03. Γ_{p0}=40 keV *5* (1976Ik03).
5879 *2*	5/2⁻	1.50 keV *30*	3	3716 *2*	Γ: other: 1.5 keV *5* (1976Ik03). E_p(lab)(keV): other: 3718 *10* (1980Va02). Γ_{p0}=0.75 keV (1976Ik03). Γ_{p0}=0.84 keV *21* and $\Gamma_{p'}$=0.66 *18* from Γ_{p0}/Γ=0.56 *8* and Γ=1.50 keV *30* (1958Ol16).
6150 *3*	5/2⁺	0.40 keV *10*	2	3995 *3*	J^π,Γ,L,E_p(lab)(keV): from R-matrix analysis in 1974Fi02.
6192 *3*	3/2⁻	1.0 keV *2*	1	4039 *3*	J^π,Γ,L,E_p(lab)(keV): from R-matrix analysis in 1974Fi02.
6203 *3*	3/2⁺	5.0 keV *5*	2	4050 *3*	Γ_{p0}=3.7 keV *4* (1973Ab05). Γ: other: 5.0 *10* (1974Fi02). J^π: 3/2⁺ in 1974Fi02 gives a better fit to the data than 5/2⁺ in 1973Ab05.

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^{32}S(p,p),(pol p,p):res 1958Ol16,1973Ab05,1974Fi02 (continued)

^{33}Cl Levels (continued)

E(level)[†]	J^π[‡]	Γ[‡]	L[‡]	E_p(lab)(keV)[‡]	Comments
					L: also from 1974Fi02. E_p(lab)(keV): weighted average of 4049 *3* (1974Fi02) and 4050 *3* (1973Ab05). E_p(lab)(keV): 4050 *3* (1973Ab05).
6247 *5*	(3/2$^-$)	6.5 keV *15*	(1)	4095 *5*	Γ_{p0}=5 *1* keV (1973Ab05).
6256 *5*	(1/2$^+$,7/2$^+$)	6 keV *3*	(0,4)	4104 *5*	E_p(lab)(keV): weighted average of 4102 *5* (1973Ab05) and 4106 *5* (1974Fi02). Γ: from 1974Fi02, but Γ=15 keV *2* from 1973Ab05 is discrepant. J^π,L: L=4 and J^π=(7/2$^+$) from 1973Ab05, but L=(0) and J^π=(1/2$^+$) from 1974Fi02. Γ_{p0}=3.5 keV *7* (1973Ab05).
6290 *3*	7/2$^-$	4.0 keV *10*	3	4140 *3*	J^π,L: from 1973Ab05 and 1974Fi02. Γ: weighted average of 3.0 keV *5* (1974Fi02) and 5.0 keV *5* (1973Ab05). E_p(lab)(keV): weighted average from 4140 *3* (1973Ab05) and 4139 *3* (1974Fi02). Γ_{p0}=4.0 keV *4* (1973Ab05).
6392 *5*	3/2$^-$	69 keV *7*	1	4245 *5*	J^π,L: from 1973Ab05 and 1974Fi02. Γ: weighted average of 60 keV *20* (1974Fi02) and 70 keV *7* (1973Ab05). E_p(lab)(keV): weighted average of 4245 *5* (1973Ab05) and 4246 *10* (1974Fi02). Γ_{p0}=62 keV *6* (1973Ab05).
6626 *3*	5/2$^+$	7.6 keV *10*	2	4486 *3*	J^π,L: other: L=(2), J^π=(3/2$^+$,5/2$^+$) from 1974Fi02. Γ: weighted average of 5 keV *2* (1974Fi02) and 8.0 keV *8* (1973Ab05). E_p(lab)(keV): weighted average of 4485 *3* (1973Ab05) and 4488 *5* (1974Fi02). Γ_{p0}=4.0 keV *4* (1973Ab05).
6630 *5*	(5/2$^-$)	25 keV *3*	3	4490 *5*	Γ_{p0}=7.7 keV *8* (1973Ab05).
6698 *3*	5/2$^+$	5.5 keV *9*	2	4561 *3*	J^π,L: from 1973Ab05 and 1974Fi02. Γ: weighted average of 4.0 keV *10* (1974Fi02) and 6.0 keV *6* (1973Ab05). E_p(lab)(keV): weighted average 4560 *3* (1973Ab05) and 4561 *3* (1974Fi02). Γ_{p0}=5.3 keV *5* (1973Ab05).
6850	3/2$^+$	0.36 keV *15*		4717	J^π,Γ: from R-matrix analysis in 1992Wi13. E_p(lab)(keV): from 1992Wi13. Γ_{p0}=100 eV *15* (1992Wi13).
6855 *3*	3/2$^+$,5/2$^+$	30 keV *10*	2	4722 *3*	Γ_{p0}=26.7 keV *27* (1973Ab05). J^π: 5/2$^+$ from 1973Ab05 and 3/2$^+$ from 1974Fi02. Γ: from 1974Fi02. Other: Γ=28 keV *3* (1973Ab05). L: from 1973Ab05 and 1974Fi02. E_p(lab)(keV): weighted average of 4721 *3* (1973Ab05) and 4726 *8* (1974Fi02).
6920 *3*	5/2$^-$	20 keV *2*	3	4790 *3*	Γ_{p0}=3.6 keV *5* (1973Ab05).
6983 *3*	3/2$^+$	10 keV *1*	2	4855 *3*	Γ_{p0}=7.0 keV *7* (1973Ab05).
6993 *3*	5/2$^-$	7.0 keV *7*	3	4865 *3*	Γ_{p0}=2.2 keV *2* (1973Ab05).
7094 *3*	5/2$^+$	18 keV *2*	2	4969 *3*	Γ_{p0}=14.9 keV *15* (1973Ab05).
7178 *8*	3/2$^-$	13.0 keV *13*	1	5055 *8*	Γ_{p0}=2.0 keV *2* (1973Ab05).
7211 *4*	5/2$^+$	2.6 keV *5*	2	5089 *4*	Γ_{p0}=1.7 keV *5* (1973Ab05).
7265 *6*	3/2$^+$	30 keV *3*	2	5145 *6*	Γ_{p0}=26.0 keV *26* (1973Ab05).
7275 *4*	3/2$^-$	20 keV *3*	1	5156 *4*	Γ_{p0}=14.9 keV *15* (1973Ab05).
7301 *3*	9/2$^+$	4.0 keV *4*	4	5183 *3*	Γ_{p0}=1.5 keV *2* (1973Ab05).
7323 *5*	7/2$^-$	3.0 keV *3*	3	5205 *5*	Γ_{p0}=0.20 keV *2* (1973Ab05).

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^{32}S(p,p),(pol p,p):res 1958Ol16,1973Ab05,1974Fi02 (continued)

^{33}Cl Levels (continued)

E(level)[†]	J^{π}[‡]	Γ[‡]	L[‡]	E_p(lab)(keV)[‡]	Comments
7392 *2*	5/2$^+$	108 eV *7*		5276 *2*	J^{π}: from 1980Wa28 and 1992Wi13. Γ: from 1992Wi13. Other: 50 eV (1980Wa28). E_p(lab)(keV): from 1980Wa28. Other: 5273 (1992Wi13). Γ_{p0}=96 eV *2* (1992Wi13), 40 eV (1980Wa28).
7399 *3*	5/2$^+$	11.0 keV *11*	2	5284 *3*	Γ_{p0}=10.4 keV *11* (1973Ab05).
7449 *4*	3/2$^-$	35.0 keV *35*	1	5335 *4*	Γ_{p0}=19 keV *4* (1973Ab05).
7471 *3*	7/2$^+$	1.50 keV *15*	4	5358 *3*	Γ_{p0}=1.30 keV *13* (1973Ab05).
7482 *4*	1/2$^+$	13.0 keV *13*	0	5369 *4*	Γ_{p0}=12.6 keV *13* (1973Ab05).

† From $E_{c.m.}$+S(p)(^{33}Cl) for proton resonances, where S(p)=2276.8 *4* from 2021Wa16 and $E_{c.m.}$=E_p(lab)×m(^{32}S)/[m(p)+m(^{32}S)].

‡ From 1958Ol16 for levels up to 5448 and from 1973Ab05 for levels above that, unless otherwise noted. Values from 1958Ol16 are based on single-level-approximation analysis of measured $\sigma(E_p)$ using dispersion theory and those from 1973Ab05 are based on R-matrix analysis.