

$^{32}\text{S}(\text{d,p}),(\text{pol d,p})$ 1958En51,1975Li09,1976Bo18

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

$J^\pi(^{32}\text{S g.s.})=0^+$.

(d,p) measurements:

1958En51: $E_d=6.006$ and 6.542 MeV deuterons were produced from the MIT-ONR electro-static generator. Target was prepared by evaporating natural sulfur onto Formvar films. Reaction products were momentum-analyzed with a high-resolution, broad-range magnetic spectrograph (FWHM=9 keV). Measured E_p . Deduced levels. Report 104 levels up to 8015.

1975Li09: $E_d=12$ MeV deuteron beam was produced at the Center for Nuclear Studies at the University of Texas. Target was $100 \mu\text{g}/\text{cm}^2$ natural PbS prepared by evaporation onto thin carbon foils. Reaction products were detected with a single high-resolution lithium-drifted silicon detector (FWHM=14 keV). Measured $\sigma(E_p, \theta)$, $\theta_{c.m.} \approx 10^\circ$ to 70° . Deduced levels, J, π , L, spectroscopic factors from DWBA analysis. Report levels from 8585 to 9460.

1976Bo18: $E_d=12$ MeV deuteron beam was produced from the 6 MV E(n) Tandem Van de Graaff of the Max-Planck-Institut Heidelberg. Target was a self-supporting CdS foil of about $100 \mu\text{g}/\text{cm}^2$. Protons were recorded in Buechner type magnetic spectrograph with Ilford L4(50 μm) emulsions, FWHM=23 keV. Measured $\sigma(E_p)$. Deduced levels, J, π , L transfers, widths from the analysis of the cross-section ratio of (d,p) to the total neutron cross-section. Comparisons with available data.

Report levels from 8673 to 9666.

1970Bo36: $E_d=12.3$ MeV deuteron was produced from the 120 cm cyclotron of the Institute of Nuclear Physics in Krakow. Target was prepared by evaporating natural sulphur (95.06% ^{32}S , $1.28 \text{ mg}/\text{cm}^2$) on a thin gold backing. Protons were analyzed by means of a broad range magnetic spectrograph and recorded in nuclear emulsions. Total resolution FWHM=250 keV. Measured $\sigma(E_p, \theta)$, $\theta_{c.m.}=20^\circ$ to 120° . Deduced levels, J, π , L, spectroscopic factors from the DWBA analysis of the data. Report levels up to 3220.

1971Me12: $E_d=18$ MeV deuteron was produced from the Yale MP tandem Van de Graaff accelerator. Target was H_2S gas of natural isotopic composition. Reaction products were detected with a $\Delta\text{E-E}$ telescope of silicon surface-barrier detectors (1500 and 2000 μm thick). Total resolution FWHM=60 keV. Measured $\sigma(E_p, \theta)$, $\theta_{c.m.}=10^\circ$ to 90° . Deduced levels, J, π , L, spectroscopic factors from DWBA analysis. Report levels up to 7610.

[Additional information 1.](#)

Others:

2008La07: $E_d=1.975\text{-}2.600$ MeV from the 5.5 MV TN11 Tandem accelerator of NSCR "Demokritos", Greece. Target was TiS_2 evaporated onto a carbon foil. Protons were detected with a Si surface-barrier detector. Measured $\sigma(E_p, E_d)$.

1998He19: $E_d=1.0\text{-}2.7$ MeV from the HVEC AN2500 Van de Graaff accelerator. Targets were a thin CdS and a thick ZnS. Measured $\sigma(E_p, E_d)$.

1990Pi05: $E_d=12.3$ MeV deuteron from the U120 cyclotron of the Nuclear Physics Institute of the Czechoslovak Academy of Sciences at Rez. Protons were analyzed by a multi-angle magnetic spectrograph and recorded by 700 mm nuclear emulsion plates. Measured $\sigma(E_p, \theta)$. Deduced levels of 3220 and 5710 keV from measured $Q(\beta^-)$ values. Deduced levels mainly for other nuclei.

1977Ba84: $E_d=1.0\text{-}5.0$ MeV on Ag_2S evaporated on thin Ag backings. Measured $\sigma(E_p)$.

1974Bo34: $E_d=12$ MeV. $100 \mu\text{g}/\text{cm}^2$ CdS target. Measured $\sigma(E_p)$. Deduced L.

1973Or04: $E_d=2.8$ and 3.1 MeV. Measured $\sigma(E_p, \theta)$. Deduced levels, L, spectroscopic factors from the DWBA analysis of the data.

1967Mo04: $E_d=2.541$ MeV deuteron beam was produced from the MIT-ONR tandem accelerator. Target was prepared by evaporating CdS (natural sulfur) of about $90 \mu\text{g}/\text{cm}^2$ onto a glass slide. Reaction products were detected with an array of 16 Au-Si surface-barrier detectors. Total resolution FWHM=30 keV. Measured $\sigma(E_p, \theta)$. Deduced levels.

1966Sc09: $E_d=9$ and 12 MeV deuteron beams were produced from the Argonne tandem accelerator. Target was PbS. Reaction products were detected with Si surface-barrier detectors. Measured $\sigma(E_p, \theta)$. Deduced J, π , L for 0, 0.84, 2.31, 2.94 and 3.22 MeV levels.

1966Sa07: $E_d=1.5\text{-}2.5$ MeV from the 2.5 MeV electrostatic accelerator of the Egyptian Atomic Energy Establishment. Measured $\sigma(E_p, E_d, \theta)$.

1953Ho80: $E=8.0$ MeV. Measured $\sigma(E_p, \theta_{\text{uoted}})$. Deduced levels, J, π , L-transfers, spectroscopic factors.

1951St19: $E_d=1.81$ MeV. Measured E_p . Deduced $Q(\beta^-)$ value.

1949Da16: $E_d=3.22$ MeV deuteron produced from the Yale University cyclotron. Target was H_2S gas. Proton energies determined by absorption method. Measured $\sigma(E_p)$, p- γ coin. Deduced levels, $Q(\beta^-)$ value. Report levels up to 6300.

Additional (d,p) references: [1960Ma48](#), [1958Te13](#), [1958Ch39](#), [1960Ma32](#), [1975VaYG](#), [1977So07](#).

(pol d,p) measurements:

1971Eg01,1972Eg03: $E_d=13.8$ MeV polarized deuteron beam on sulfur target. Measured vector analyzing power. Deduced J^π for the ground state.

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1980An36: $E_d=1.8\text{-}3.0$ MeV polarized beam on natural sulphur. Two pairs of silicon-drifted solid-state detectors. Measured vector analyzing power $\langle iT_{11} \rangle$.

 ^{33}S Levels

<u>E(level)[‡]</u>	<u>J^π#</u>	<u>L#</u>	<u>C²S[†]#</u>	<u>Comments</u>
0	3/2 ⁺	2	0.93	L: also from 1953Ho80, 1966Sc09, 1970Bo36, 1971Eg01. C ² S: other: 0.81 (1970Bo36).
839 5	1/2 ⁺	0	0.32	E(level): others: 790 50 (1949Da16), 841 8 (1967Mo04). L: also from 1953Ho80, 1966Sc09, 1973Or04, 1970Bo36. C ² S: others: 0.24 3 (1973Or04), 0.80 (1970Bo36).
1965 6	5/2 ⁺	2	<0.002	E(level): others: 1900 50 (1949Da16), 1965 8 (1967Mo04). L: from 1970Bo36.
2314 6	3/2 ⁺	2	0.066	E(level): others: 2313 8 (1967Mo04), 2170 50 (1949Da16). L: also from 1966Sc09, 1970Bo36.
2869 6	3/2 ⁺ ,5/2 ⁺	2	0.10,0.05	E(level): others: 2869 8 (1967Mo04), 2850 50 (1949Da16). L: also from 1970Bo36.
2936 6	7/2 ⁻	3	0.57	E(level): other: 2937 8 (1967Mo04). L: also from 1953Ho80, 1966Sc09, 1970Bo36. C ² S: other: 0.49 (1970Bo36).
2971 6 3220.53 20	3/2 ⁻	1	0.48	E(level): other: 2970 8 (1967Mo04). E(level): from 1990Pi05. Others: 3222 6 (1958En51), 3224 8 (1967Mo04), 3150 50 (1949Da16). Additional information 2. L: also from 1953Ho80, 1966Sc09, 1970Bo36, 1973Or04. C ² S: others: 1.26 (1970Bo36), 0.13 2 (1973Or04).
3832 6 3935 6 4049 6 4095 6 4145 6 4211 6	3/2 ⁻	1	0.075	E(level): other: 4150 50 (1949Da16). L: also from 1953Ho80, 1973Or04. C ² S: other: 0.035 15 (1973Or04).
4377 6 4425 6 4732 6				E(level): other: 4420 50 (1949Da16). E(level): other: 4700 50 (1949Da16). L: see comment for 4747 level.
4747 6	(1/2 ⁺)	(0)	0.015 3	E(level): 4732 and 4747 cannot be resolved in 1973Or04. L: from 1973Or04 for unresolved 4732+4747 peaks. The J ^π assignments for 4732 and 4747 levels suggest L=0 belongs to only the 4747 level. C ² S: from 1973Or04.
4869 6 4919 6	1/2 ⁻	1	0.044	E(level): others: 4890 (1953Ho80); 4919+4941 not resolved in 1971Me12. L: also from 1953Ho80, 1973Or04. C ² S: other: 0.035 10 (1973Or04).
4941 6 5177 6 5210 6 5272 6 5287 6 5340 6 5351 6 5399 6	5/2 ⁻ ,7/2 ⁻	3	0.07,0.036	E(level): other: 5100 50 (1949Da16).
5479 6	1/2 ⁺	0	0.008 2	L,C ² S: from 1973Or04.
5597 6	(1/2 ⁺)	(0)	0.015 3	E(level): 5597,5613 and 5622 are unresolved in 1973Or04. L,C ² S: from 1973Or04 for 5597+5613+5622.
5613 6		(0)		L,C ² S: see comments for at 5597 level.

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$^{32}\text{S}(\text{d,p}),(\text{pol d,p})$ 1958En51,1975Li09,1976Bo18 (continued) ^{33}S Levels (continued)

E(level) [‡]	J ^π #	L#	C ² S [†] #	Comments
5622 6		(0)		E(level): other: 5630 50 (1949Da16). L,C ² S: see comments for at 5597 level.
5710.13 23	1/2 ⁻	1	0.53	E(level): from 1990Pi05. Other: 5711 6 (1958En51). L: also from 1953Ho80, 1973Or04. C ² S: other: 0.11 2 (1973Or04).
5864 6				
5888 6	3/2 ⁻	1	0.11	L: (1) also from 1973Or04. C ² S: other: 0.025 8 (1973Or04).
5915 6				
5982 6				
6067 6				
6079? 6				
6101 6				
6131 6				
6234 6				
6261 6				
6310 6				E(level): other: 6300 50 (1949Da16).
6326 6				
6360 6				
6372 6				
6416 6		(1)		E(level): 6416 and 6427 can not be resolved in 1973Or04. L: from 1973Or04 for 6416+6427.
6427 6	1/2 ⁻ ,3/2 ⁻	1	0.18,0.08	
6487 6	(1/2 ⁺)	(0)	0.011 2	L,C ² S: from 1973Or04.
6513 6				
6526 6				
6559 6				
6616 6	(1/2 ⁺)	(0)	0.009 2	L,C ² S: from 1973Or04.
6676 6				
6690 6	5/2 ⁻ ,7/2 ⁻	3	0.18,0.09	E(level): other: 6692 9 (1971Me12).
6710 6				
6720 6				
6788 6				
6892 6				
6903 6				
6965 6				
6999 6				
7017 6				
7037 6				
7133 6				
7164 6				
7183 6				
7190 6	3/2 ⁻	1	0.046	
7254 6				
7330 6				
7335? 6				
7353 6				
7359 6				
7369 6				
7401 6				
7413 6				
7452 6	1/2 ⁻ ,3/2 ⁻	1	0.26,0.12	
7460 6				
7475 6				
7482 6				
7503 6				

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$^{32}\text{S}(\text{d,p}),(\text{pol d,p})$ [1958En51](#),[1975Li09](#),[1976Bo18](#) (continued) ^{33}S Levels (continued)

E(level) [‡]	J ^π #	L#	C ² S [†] #	Comments
7560? 6				
7579? 6				
7589? 6				
7595? 6				
7601? 6				
7615 6	5/2 ⁻ ,7/2 ⁻	3	0.053,0.027	E(level): other: 7610 20 (1971Me12).
7629 6				
7658 6				
7693 6				
7711 6				
7749 6				
7766 6				
7779 6				
7797 6				
7828 6				
7840 6				
7862 6				
7892 6				
7906 6				
7983 6				
7991 6				
8015 6				
8584 10	7/2 ⁻	3	0.012	
8644 10	3/2 ⁺	2	0.021	
8670 10	1/2 ⁻	1	0.007	
8690 10		2		E(level),L: from analysis of (d,p) data in 1976Bo18 .
8729 10	7/2 ⁻	3	0.031	
8752 @ 3	1/2 ⁺	0 @		E(level),L: other: 8749 10 with L=0 (1975Li09). Γ=20 keV 3 deduced by 1976Bo18 from reanalysis of neutron resonance data in 1950Ba88 , as compared with the cross-section data in their (d,p) experiment.
8838 @ 10	1/2 ⁻ ,7/2 ⁻	1,3 @	0.005,0.002	E(level),L: other: 8839 2 with L=1 from analysis neutron resonance data (1976Bo18).
8873 10	7/2 ⁻	3	0.034	
8910 @ 2		1 @		
8926 @ 2		1 @		
8939 10	7/2 ⁻	3	0.007	
8975 10	7/2 ⁻	3	0.003	
9010 @ 3	1/2 ⁺	0 @		E(level),L: other: 9005 10 with L=0 (1975Li09). Γ=13 keV 3 deduced by 1976Bo18 from reanalysis of neutron resonance data in 1950Ba88 , as compared with the cross-section data in their (d,p) experiment.
9035 10	3/2 ⁺	2	0.0034	
9115 10				
9138 10	3/2 ⁺	2	0.027	
9175 10				
9211 @ 2	3/2 ⁺	2 @	0.011	E(level),L: other: 9209 10 with L=2 (1975Li09).
9245 10	7/2 ⁻	3	0.006	
9280 10	7/2 ⁻	3	0.007	
9318 @ 3	1/2 ⁺	0 @		E(level),L: other: 9320 10 with L=0 (1975Li09). Γ=10 keV 3 deduced by 1976Bo18 from reanalysis of neutron resonance data in 1950Ba88 , as compared with the cross-section data in their (d,p) experiment.
9350 10	7/2 ⁻	3	0.004	E(level),L: others: 1976Bo18 gives L=1 from analysis of neutron resonance at 9348 3.
9363 @ 2		1 @		
9400 @ 3	3/2 ⁺	2 @	0.021	E(level),L: other: 9400 10 with L=1 (1975Li09).
9436 @ 3		2 @		
9460 10		1		

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$^{32}\text{S}(\text{d,p}),(\text{pol d,p})$ 1958En51,1975Li09,1976Bo18 (continued) ^{33}S Levels (continued)

<u>E(level)[‡]</u>	<u>L[#]</u>	<u>Comments</u>
9539 [@] 5	1 [@]	
9564 [@] 5	2 [@]	
9607 [@] 5	0 [@]	$\Gamma=10$ keV 4 deduced by 1976Bo18 from reanalysis of neutron resonance data in 1950Ba88, as compared with the cross-section data in their (d,p) experiment.
9666 [@] 5	1 [@]	$\Gamma=11$ keV 4 deduced by 1976Bo18 from reanalysis of neutron resonance data in 1950Ba88, as compared with the cross-section data in their (d,p) experiment.

[†] Spectroscopic factor C^2S : $NgC^2S = \sigma(\theta)_{\text{exp}}/\sigma(\theta)_{\text{DWBA}}$, where N is the normalization factor and $g = (2J_f + 1)/(2J_i + 1)$. N=1.58 (1971Me12), N=1.5 (1970Bo36). When two values are given, first corresponds to L-1/2 and the second to L+1/2 transfer.

[‡] From 1958En51 up to 8015 level and from 1975Li09 above that, unless otherwise noted.

[#] From 1971Me12 up to 7615 level and from 1975Li09 above 8015, unless otherwise noted. L-transfers and spectroscopic factors are from DWBA analysis of measured $\sigma(\theta)$. Quoted J^π are given for extracting corresponding spectroscopic factors where available.

[@] From 1976Bo18, based on reanalysis of neutron resonance data in 1950Ba88 compared with (d,p) cross-section data in 1976Bo18.