^{32}S(p,d),(pol p,d)   2007Ma48,2020Se16,2022Bu13

History

Type	Author	Citation	Literature Cutoff Date
Update	Jun Chen and Balraj Singh	ENSDF	12-Nov-2022

Includes (p,dγ) from 2022Bu13.

2022Bu13: (p,d), E(p)=33.0 MeV. Targets were 178 $\mu g/cm^2$ ZnS on 5 $\mu g/cm^2$ natural carbon backing. Measured deuteron spectra, Eγ, angular distribution of deuterons, protons from the decay of excited states of ^{31}S, dp- and dγ-coin using the Hyperion Array with 12 Compton-suppressed HPGe detectors, ΔE-E telescope of silicon detectors downstream from the target and a Si detector upstream from the target at the K150 cyclotron facility of Texas A&M University. DWBA analysis of $\sigma(\theta)$ data. Data for six levels between 6872 and 8071 keV of astrophysical interest analyzed.

2020Se16: (p,d), E=34.5 MeV protons from the Wright Nuclear Structure Laboratory (WNSL) at Yale University. Targets were 249 $\mu g/cm^2$ 25 CsS on a 20 $\mu g/cm^2$ natural carbon foil and 10.4 $\mu g/cm^2$ 4 ^{32}S implanted into a ^{12}C foil. Reaction products were momentum-analyzed with a high-resolution Enge split-pole magnetic spectrograph, with FWHM≈38 keV for CdS target, and ≈30 keV for implanted target. Measured $\sigma(\theta)$ at θ=10° to 62°. Deduced levels from 3284 to 10800 keV, J^π from DWBA analysis. Discussed astrophysical implications for ^{30}P(p,γ) reaction rate.

2007Ma48: (p,d), E=32 MeV beam provided by Tandem accelerator at ORNL. ZnS target. Deuterons detected using SIDAR silicon detector array. FWHM=80 keV in the first set of runs and 130 keV in the second set. DWBA analysis of measured angular distributions of deuteron groups. The paper also contains evaluation of 66 levels in ^{31}S.

1977Pl03: (pol p,d), E=18-24 MeV protons from the Saclay cyclotron. Enriched InS target (99.5% ^{32}S). Deuterons detected through E-ΔE silicon telescopes within a scattering chamber. FWHM=150 keV. Measured angular distributions. DWBA analysis. Other papers by the same group: 1975Pl03, 1973Go42, 1972Es04.

1975Ka10: (p,d), E=185 MeV protons. Magnetic spectrometer with FWHM=260 keV. Natural S targets. Measured deuteron spectra and angular distributions. DWBA analysis.

1971Ma58: (pol p,d), E=24.5 MeV protons from the Saclay cyclotron. Measured angular distributions and asymmetries using silicon E-ΔE telescopes in a scattering chamber. DWBA analysis. FWHM=80-150 keV.

1968Ko11: (p,d), E=33.6 MeV protons from Michigan State University cyclotron. Deuterons detected through E-ΔE FWHM=120 keV silicon telescopes within a scattering chamber. Natural H_2S gas cell target (95% ^{32}S). Measured angular distributions (θ_{lab}= 10°−155°), deuteron spectra. DWBA analysis.

Other: 1967Gl01, 1963Ka26.

All cross sections (dσ/dΩ) listed are from 1975Ka10 for E(p)=185 MeV and correspond to the angle where the cross section reaches a maximum.

^{31}S Levels

E(level)[†]	J^π	L[†]	C^2S[&]	Comments
0	$1/2^+$	0	1.0	L: from 1968Ko11, 1971Ma58, 1973Go42, 1975Ka10. C^2S: other: 0.8 (1971Ma58). J^π: from L-transfer and Ay(θ) (1968Ko11,1971Ma58,1973Go42). dσ/dΩ(max)=0.62 mb/sr.
1240 10	$3/2^+$	2	1.25	E(level): from 1240 20 (1968K011), 1240 10 (1975Ka10). L: from 1968Ko11, 1971Ma58, 1973Go42, 1975Ka10. C^2S: other: 0.66 (1971Ma58). J^π: from L-transfer and Ay(θ) (1971Ma58,1977Pl03). dσ/dΩ(max)=1.20 mb/sr.
2238 10	$5/2^+$	2	2.80	E(level): from 2230 20 (1968Ko11), 2240 10 (1975Ka10). E(level): from 1968Ko11. L: from 1968Ko11, 1971Ma58, 1973Go42, 1975Ka10. C^2S: other: 2 (1971Ma58). J^π: from L-transfer and Ay(θ) (1971Ma58,1977Pl03). dσ/dΩ(max)=2.30 mb/sr.
3050 20				E(level): from 1968Ko11.
3285 20		(2,0)	0.74	E(level): from 3290 20 (1968Ko11) and 3280 20 (1975Ka10). Energy of 3284.7 from literature used for calibration in 2020Se16. E(level),L: from 1968Ko11; L=2 is favored.

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^{32}S(p,d),(pol p,d)   2007Ma48,2020Se16,2022Bu13 (continued)

^{31}S Levels (continued)

E(level)[†]	L[†]	C^{2}S[&]	Comments
			C^{2}S: from 1975Ka10.
			dσ/dΩ(max)=0.78 mb/sr.
3353[‡] *5*			
3438[‡] *3*			
4084 *2*	2	0.77	E(level): ^{31}P mirror state=4190.
			E(level): weighted average of 4083 *3* (2020Se16) and 4085 *2* (2007Ma48). Others: 4090 *20* (1968Ko11), 4080 *20* (1975Ka10).
			L: from 1968Ko11, 1975Ka10.
			C^{2}S: 0.97 (1975Ka10).
			dσ/dΩ(max)=1.00 mb/sr.
4449 *3*	3	0.15	^{31}P mirror state=4431.
			E(level): weighted average of 4450 *3* (2020Se16) and 4446 *6* (2007Ma48). Others: 4450 *20* (1968Ko11), 4440 *40* (1975Ka10).
			L: from 1975Ka10.
			C^{2}S: other: 0.97 (1975Ka10).
			dσ/dΩ(max)=0.34 mb/sr.
4518[‡] *6*			
4580[‡] *3*			
4711 *2*	2	0.40	^{31}P mirror state=4783.
			E(level): weighted average of 4712 *2* (2020Se16) and 4707 *3* (2007Ma48). Others: 4720 *20* (1968Ko11), 4710 *30* (1975Ka10).
			L: from 1975Ka10 and 2007Ma48. Other: (0) (1968Ko11).
			C^{2}S: from 2007Ma48. Other: 0.46 1975Ka10, 0.07 (1968Ko11) if L=0.
			dσ/dΩ(max)=0.44 mb/sr.
4978 *5*		0.01	^{31}P mirror state=5015.
			E(level): weighted average of 4975 *4* (2020Se16) and 4988 *8* (2007Ma48). Other: 4990 *70* (1975Ka10).
			dσ/dΩ(max)=0.1 mb/sr.
5023[‡] *3*			
5155 *5*	0	0.11	^{31}P mirror state=5256.
			L: from 2007Ma48. Implied L=0 in 2020Se16 from J^π=1/2$^+$ assignment.
			E(level): energy of 5156.3 keV from literature used for calibration (2020Se16).
			C^{2}S: other: <0.07 (1975Ka10).
5301 *2*	4		E(level): from 2020Se16. Other: 5331 *5* (2007Ma48), 5290 *70* (1975Ka10).
			dσ/dΩ(max)=0.055 mb/sr.
			L: implied from 7/2$^+$,9/2$^+$ assignment in 2020Se16.
5402 *2*			E(level): from 2020Se16. Other: 5420 *20* (1968Ko11).
			J^π: 5/2$^{(-)}$ is assigned in 2020Se16 implying L=(3), but the authors point out that angular distribution in 2020Se16 is featureless.
5516 *4*	2	0.10	E(level): weighted average of 5517 *2* (2020Se16) and 5497 *10* (2007Ma48).
			^{31}P mirror state=5559.
			L: from 2007Ma48. L=2 also implied from 3/2$^+$,5/2$^+$ assignment in 2020Se16.
5678 *3*			E(level): from 2020Se16. Other: 5700 *20* (1968Ko11).
5777 *3*	2	0.17	E(level): weighted average of 5775 *2* (2020Se16) and 5781 *3* (2007Ma48).
			^{31}P mirror state=5892.
			L: from 2007Ma48.
5829[‡] *4*			
5893 *3*	(2)	0.24	E(level): from 2020Se16. Others: 5959 *10* (doublet in 2007Ma48), 5880 *60* (1975Ka10).
			L,C^{2}S: from 1975Ka10.
			dσ/dΩ(max)=0.33 mb/sr.
5979 *3*	2	0.15	E(level): from 2020Se16. Others: 5959 *10* (doublet in 2007Ma48); 5990 *20* (1968Ko11).
			L: from 2007Ma48.
6139[‡] *4*			
6170 *20*			E(level): from 1968Ko11. Tentative 6159 *3* in 2020Se16.

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^{32}S(p,d),(pol p,d)   **2007Ma48,2020Se16,2022Bu13 (continued)**

<u>^{31}S Levels (continued)</u>

E(level)[†]	J^{π}	L[†]	C^{2}S[&]	Comments
6255 *2*		0	0.12	^{31}P mirror state=6337.
				E(level): from 2022Bu13. Others: 6267 *5* (2007Ma48), 6320 *50* (1975Ka10). In 2020Se16,
				6255.6 from literature was used for calibration.
				L: from 2007Ma48.
				C^{2}S: other: <0.2 (1975Ka10).
				dσ/dΩ(max)=0.21 mb/sr.
6377[‡] *3*		5		L: implied from J^{π}=9/2$^-$,11/2$^-$ assigned in 2020Se16.
6390.8[‡] *17*		2		L: implied from J^{π}=3/2$^+$,5/2$^+$ assigned in 2020Se16.
6411 *9*				^{31}P mirror state=6454.
				E(level): 6400 *20* (1968Ko11).
6542 *3*				E(level): from 2020Se16. Other: 6546 *15* (2007Ma48).
				^{31}P mirror state=6594.
				J^{π}: tentative (7/2$^+$,9/2$^-$,11/2$^+$) in 2020S16, implying L=(4,5,6). Authors point out that
				angular distribution is featureless.
6585[‡] *3*				
6636[‡] *2*				J^{π}: 7/2$^+$,9/2,11/2$^+$ in 2020Se16, implying L=4,5,6.
6720[@]				
6749[@]				
6833.9 *12*		(5,4)		E(level): from 2020Se16. Other: 6848 *9* (doublet in 2007Ma48).
				J^{π}: 9/2$^-$,11/2$^-$,7/2$^+$ assigned in 2020Se16, implying L=5,4, with a better fit for L=5.
				^{31}P mirror state=7080 or 6825.
6872 *6*		0+2		E(level),J^{π}: level reported by 2022Bu13, with J^{π}=(1/2,3/2,5/2)$^+$ from L(d,t).
				L: from 2022Bu13, with estimated mixing ratio of 50% for each L-value. Also 3/2$^+$,5/2$^+$ in
				2020Se16, implying L=2.
				Measured Γ_{p0}/Γ=0.53 +*5*−*17* (2022Bu13).
				E(p)(res)=741 keV *6* (2022Bu13).
6960 *4*				
7041 *6*	5/2$^+$	2	0.79	^{31}P mirror state=7158.
				E(level): weighted average of 7036 *7* (2022Bu13) and 7044 *6* (2007Ma48). Others: 7050 *20*
				(1968Ko11), 7020 *40* (1975Ka10). Energy of 7035.4 from literature used for calibration in
				2020Se16.
				L: from 2022Bu13, 1968Ko11 and 1975Ka10.
				C^{2}S: other: 0.54 (1975Ka10), 1.00 (1968Ko11).
				J^{π}: from L-transfer and other arguments, 5/2$^+$ assigned by 2022Bu13. Other: 3/2
				(1968Ko11).
				dσ/dΩ(max)=0.85 mb/sr.
				Measured Γ_{p0}/Γ=0.93 +*14*−*10* (2022Bu13).
				E(p)(res)=905 keV *7* (2022Bu13).
7157.7 *11*		2		E(level): from 2020Se16. Other: 7171 *8* (2022Bu13).
				L: from 2022Bu13, and implied from 3/2$^+$,5/2$^+$ assignment in 2020Se16.
				Measured Γ_{p0}/Γ=0.30 +*9*−*6* (2022Bu13).
				E(p)(res)=1040 keV *8* (2022Bu13).
7197?[#] *2*				
7306[‡] *9*				
7469[‡] *3*				
7517 *3*				E(level): weighted average of 7518 *2* (2020Se16) and 7510 *6* (2007Ma48).
7584[‡] *2*				
7640[‡] *9*				
7728 *4*		0+2		E(level): from 2007Ma48. Others: 7710 *40* (1975Ka10); energy of 7724 keV from literature
				used for calibration in 2020Se16.
				L: from 2007Ma48. Other: (1) (1975Ka10).
				C^{2}S: 3.0 from 1975Ka10 if L=1.

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^{32}S(p,d),(pol p,d)   **2007Ma48,2020Se16,2022Bu13 (continued)**

^{31}S Levels (continued)

E(level)[†]	L[†]	C^{2}S[&]	Comments
7743 *2*			dσ/dΩ(max)=0.47 mb/sr. E(level): from 2020Se16. Other: 7744 *5* (2022Bu13). Measured Γ_{p0}/Γ=0.88 +8−4 (2022Bu13). E(p)(res)=1613 keV *5* (2022Bu13).
7895[‡] *2*			
7912 *5*	0	0.06	E(level): from 2007Ma48. Others: 7912 *9* (2022Bu13), 7970 *70* (1975Ka10); energy of 7907 keV from literature used for calibration in 2020Se16. dσ/dΩ(max)=0.21 mb/sr. L: from 2007Ma48. Measured Γ_{p0}/Γ=0.20 *3* (2022Bu13). E(p)(res)=1781 keV *9* (2022Bu13).
8024?[#] *2*			
8044.5 *12*	0+2		E(level): from 2020Se16. Other: 8049 *6* in 2007Ma48 is an unresolved doublet. L: from 2007Ma48.
8071 *11*			E(level): level from 2022Bu13. Measured Γ_{p0}/Γ=0.42 +8−6 (2022Bu13). E(p)(res)=1940 keV *11* (2022Bu13).
8130[‡] *2*			
8171 *12*			E(level): from 2007Ma48.
8211?[#] *2*			
8221?[#] *4*			
8386[‡] *3*			
8422[‡] *2*			
8517 *13*	0	0.05	E(level),L: from 2007Ma48. Other: 8510 *80* (1975Ka10); energy of 8498 from literature used for calibration in 2020Se16. dσ/dΩ(max)=0.14 mb/sr.
8563[‡] *2*			
8746[‡] *3*			
8788 *3*	2	0.13	E(level): from 2020Se16. Other: 8789 *6* (2007Ma48).
8815[‡] *3*			
8904 *6*			E(level): from 2020Se16. Other: 8880 *80* (1975Ka10). dσ/dΩ(max)=0.13 mb/sr.
8973[‡] *4*			
9001[‡] *3*			
9155.2[‡]			E(level): energy from literature used for calibration in 2020Se16.
9207 *5*			E(level): weakly populated level from 2007Ma48 only.
9293?[#] *2*			
9428 *7*	2	0.19	E(level): 9432 *7* (2007Ma48), 9423 *7* (1975Ka10). Tentative 9415 *5* level in 2020Se16. dσ/dΩ(max)=0.60 mb/sr. L: from 2007Ma48.
9499?[#] *8*			
9561?[#] *10*			
9606 *14*			E(level): from 2007Ma48. Other: tentative 9612 *4* in 2020Se16.
9641?[#] *4*			
9777?[#] *2*			
9833 *7*			E(level): weighted average of 9831 *4* (2020Se16) and 9853 *12* (2007Ma48).
10146.2[‡]			E(level): energy from literature used for calibration in 2020Se16.
10282?[#] *4*			
10360?[#] *4*			
10577 *13*			E(level): tentative 10610 *5* level in 2020Se16 may correspond to weakly populated level in

^{32}S(p,d),(pol p,d)   **2007Ma48,2020Se16,2022Bu13 (continued)**

^{31}S Levels (continued)

E(level)[†]	Comments
	2007Ma48.
10800?[#] *5*	

[†] Above 4 MeV excitation, values are from 2007Ma48 and 2020Se16, unless otherwise stated.
[‡] Level reported by 2020Se16 only.
[#] Tentative level reported by 2020Se16 only.
[@] Rounded value from the Adopted Levels. 2020Se16 provide evidence for a doublet corresponding to 6720+6749.
[&] From 1975Ka10 for levels below 4 MeV, from 2007Ma48 for higher levels, unless otherwise stated.

$\gamma(^{31}$S$)$

E_γ	E_i(level)	E_f	J^π_f	Comments
6254.4 *16*	6255	0	$1/2^+$	E_γ: from 2022Bu13.

^{32}S(p,d),(pol p,d)   **2007Ma48,2020Se16,2022Bu13**

Level Scheme