^{28}Si(α,nγ) 2014Do04,2012Do07

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 184,29 (2022)	24-Jun-2022

2014Do04, 2012Do07: Eα=22 MeV. Target=120 μg/cm^2 ^{28}Si. Measured Eγ, Iγ, γγ-coin, γ(θ) using Gammasphere array at ATLAS-ANL facility. Deduced levels, J, π, reaction rates for ^{30}P(p,γ)^{31}S of astrophysical interest. Comparison of level energies and J^π values with shell-model calculations, and with levels and J^π assignments in the mirror nucleus ^{31}P.

All data are from 2014Do04. Eγ and γ(θ) data for levels above 6 MeV are the same as in authors′ previous publication 2012Do07.

^{31}S Levels

2014Do04 point out that a tentative level at 4602 keV *2* reported only by 1972Bh01 in (^{3}He,α) likely does not exist. Other levels in literature stated by 2014Do04 as ‘unobserved’ in their work: 5439.1 *29*; 5775.1 *15*,5/2$^+$; 5824.2 *29*,9/2$^+$; 6255.3 *5*,1/2$^+$; 6280.6 *2*,3/2$^+$; and 6402 *2*.

E(res) given under comments is deduced proton-resonance energy above S(p)=6130.65 *24* (2021Wa16).

E(level)†	Jπ‡	Comments
0.0	1/2$^+$	Jπ: from Adopted Levels.
1248.6 *1*	3/2$^+$	E(level): mirror of 1266, 3/2$^+$ level in ^{31}P.
2234.5 *1*	5/2$^+$	E(level): mirror of 2234, 5/2$^+$ level in ^{31}P.
3076.1 *10*	1/2$^+$	E(level): mirror of 3134, 1/2$^+$ level in ^{31}P.
3284.3 *1*	5/2$^+$	E(level): mirror of 3295, 5/2$^+$ level in ^{31}P.
3350.5 *2*	7/2$^+$	E(level): mirror of 3415, 7/2$^+$ level in ^{31}P.
3433.4 *5*	3/2$^+$	E(level): mirror of 3506, 3/2$^+$ level in ^{31}P.
4086.2 *16*	5/2$^+$	E(level): mirror of 4191, 5/2$^+$ level in ^{31}P.
4208.3 *5*	3/2$^+$	E(level): mirror of 4260, 3/2$^+$ level in ^{31}P.
4449.7 *2*	7/2$^-$	E(level): mirror of 4431, 7/2$^-$ level in ^{31}P.
4527.9 *2*	3/2$^+$	E(level): mirror of 4593, 3/2$^+$ level in ^{31}P.
4583.0 *2*	7/2$^+$	E(level): mirror of 4634, 7/2$^+$ level in ^{31}P.
4709.7 *8*	5/2$^+$	E(level): mirror of 4783, 5/2$^+$ level in ^{31}P.
4867.8 *4*	1/2$^+$	E(level): mirror of 5015, (3/2$^+$) level in ^{31}P.
4971.3 *20*	3/2$^-$	E(level): mirror of 5015, 3/2$^-$ level in ^{31}P.
5023.1 *3*	5/2$^+$	E(level): mirror of 5116, 5/2$^+$ level in ^{31}P.
5158.7 *20*	1/2$^+$	E(level): mirror of 5257, 1/2$^+$ level in ^{31}P.
5301.1 *3*	9/2$^+$	E(level): mirror of 5343, 9/2$^+$ level in ^{31}P.
5400.7 *9*	5/2$^+$	E(level): mirror of 5530, (5/2)$^+$ level in ^{31}P.
5518.3 *3*	5/2$^+$	E(level): mirror of 5672, 5/2 level in ^{31}P.
5675.8 *7*	7/2$^+$	E(level): mirror of 5774, (7/2)$^+$ level in ^{31}P.
5891.5 *20*	3/2$^+$	E(level): mirror of 6158, (1/2,3/2,5/2) level in ^{31}P.
5976.8 *7*	(9/2$^+$)	E(level): mirror of 6078, 9/2$^+$ level in ^{31}P.
6138.3 *6*	(3/2,7/2)$^+$	E(res)=7.4 keV *21*. E(level): mirror of 6233, (7/2)$^+$ level in ^{31}P. Jπ: 3/2$^+$ in Figure 6 of 2014Do04.
6157.5 *4*	7/2$^+$	E(res)=27.6 keV *6*. E(level): mirror of 6399, 7/2$^{(-)}$ level in ^{31}P, by parity is inconsistent.
6326.7 *5*	3/2$^-$	E(res)=196.1 keV *6*. E(level): mirror of 6496, 3/2$^-$ level in ^{31}P.
6357.0 *2*	5/2$^-$	E(res)=226.4 keV *5*. E(level): mirror of 6594, (5/2)$^-$ level in ^{31}P.
6375.6 *3*	9/2$^-$	E(res)=246.0 keV *6*. E(level): mirror of 6502, 9/2$^-$ level in ^{31}P.
6392.1 *2*	5/2$^+$	E(res)=261.6 keV *5*.

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^{28}Si(α,nγ) 2014Do04,2012Do07 (continued)

^{31}S Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	Comments
		E(level): mirror of 6461, 5/2$^+$ level in ^{31}P.
6393.5 *2*	11/2$^+$	E(res)=263.3 keV *4*. E(level): mirror of 6453, 11/2$^+$ level in ^{31}P.
6541.6 *4*	3/2$^-$	E(res)=411.0 keV *6*. E(level): mirror of 6610, 3/2$^-$ level in ^{31}P.
6582.5 *20*	(5/2,7/2)$^-$	E(res)=452.2 keV *21*. E(level): mirror of 6842, (5/2)$^-$ level in ^{31}P.
6635.2 *3*	9/2$^-$	E(res)=505.2 keV *8*. E(level): mirror of 6796, 9/2$^-$ level in ^{31}P.

† From least-squares fit to Eγ data; reduced χ^2=2.5 is somewhat larger than critical χ^2=2.1.
‡ As given in 2014Do04, based on previous assignments, and from $\gamma(\theta)$ data in the present work.

γ(^{31}S)

R_{ADO}=[Iγ($\approx$0°)+Iγ($\approx$180°)]/Iγ($\approx$90°). Expected ratios are: 1.05 *3* for ΔJ=0; 0.55 *2* for ΔJ=1, pure dipole; $\approx$0.80 for ΔJ=1, D+Q; 1.30 *2* for ΔJ=2 transitions. 2012Do07 call these ratios DCO, but it seems the measurement does not involve $\gamma\gamma$ angular correlations and gates on transitions with known multipolarities. Thus the evaluators use ADO meaning angular distribution intensity ratios from oriented nuclei. The ADO ratios are from 2012Do07.

E$_\gamma$	I$_\gamma$	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	Mult.	Comments
986.0 *2*	1.0 *2*	2234.5	5/2$^+$	1248.6	3/2$^+$		
1049.8 *2*	6.7 *2*	3284.3	5/2$^+$	2234.5	5/2$^+$		
1091.2 *4*	3.1 *2*	6393.5	11/2$^+$	5301.1	9/2$^+$	D[†]	A_2=−0.37 *5*; A_4=−0.01 *1* E$_\gamma$: level-energy difference=1092.3. R_{ADO}=0.47 *2*.
1164.9 *2*	28.3 *5*	4449.7	7/2$^-$	3284.3	5/2$^+$	D[†]	A_2=−0.26 *1*; A_4=0.00 *1* E$_\gamma$: level-energy difference=1165.3.
1232.1 *2*	3.5 *2*	4583.0	7/2$^+$	3350.5	7/2$^+$	D[‡]	A_2=+0.27 *3*; A_4=−0.04 *3*
1248.5 *1*	100.0	1248.6	3/2$^+$	0.0	1/2$^+$	D[†]	A_2=−0.16 *1*; A_4=−0.03 *2*
1298.7 *1*	2.8 *2*	4583.0	7/2$^+$	3284.3	5/2$^+$	D[†]	A_2=−0.77 *2*; A_4=−0.05 *2*
1393.8 *6*	0.8 *2*	5976.8	(9/2$^+$)	4583.0	7/2$^+$		
1425.3 *8*	0.3 *1*	4709.7	5/2$^+$	3284.3	5/2$^+$		
1672.6 *2*	1.0 *2*	5023.1	5/2$^+$	3350.5	7/2$^+$	D[†]	A_2=−0.27 *4*; A_4=−0.04 *4*
1707.6 *3*	1.7 *2*	6157.5	7/2$^+$	4449.7	7/2$^-$	D[‡]	A_2=+0.22 *2*; A_4=−0.07 *3* R_{ADO}=1.08 *7*.
1827.5 *10*	0.4 *1*	3076.1	1/2$^+$	1248.6	3/2$^+$		A_2=+0.09 *3*; A_4=−0.04 *4* Mult.: ΔJ=1 from 2014Do04, but $\gamma(\theta)$ should be isotropic for J(3076)=1/2.
1925.7 *2*	9.6 *2*	6375.6	9/2$^-$	4449.7	7/2$^-$	D[†]	A_2=−0.39 *1*; A_4=−0.02 *1* R_{ADO}=0.44 *2*.
1950.3 *2*	14.5 *2*	5301.1	9/2$^+$	3350.5	7/2$^+$	D[†]	A_2=−0.28 *1*; A_4=−0.02 *1*
2035.5 *2*	35.8 *7*	3284.3	5/2$^+$	1248.6	3/2$^+$	D[†]	A_2=−0.70 *3*; A_4=0.00 *2*
2050.2 *8*	1.9 *2*	5400.7	5/2$^+$	3350.5	7/2$^+$	D[†]	A_2=−0.42 *6*; A_4=−0.07 *8*
2101.7 *2*	49.8 *3*	3350.5	7/2$^+$	1248.6	3/2$^+$	Q[#]	A_2=+0.40 *1*; A_4=−0.10 *1*
2166.7 *10*	0.5 *1*	5518.3	5/2$^+$	3350.5	7/2$^+$		
2184.7 *5*	0.4 *1*	3433.4	3/2$^+$	1248.6	3/2$^+$		
2184.9 *4*	1.6 *2*	6635.2	9/2$^-$	4449.7	7/2$^-$		

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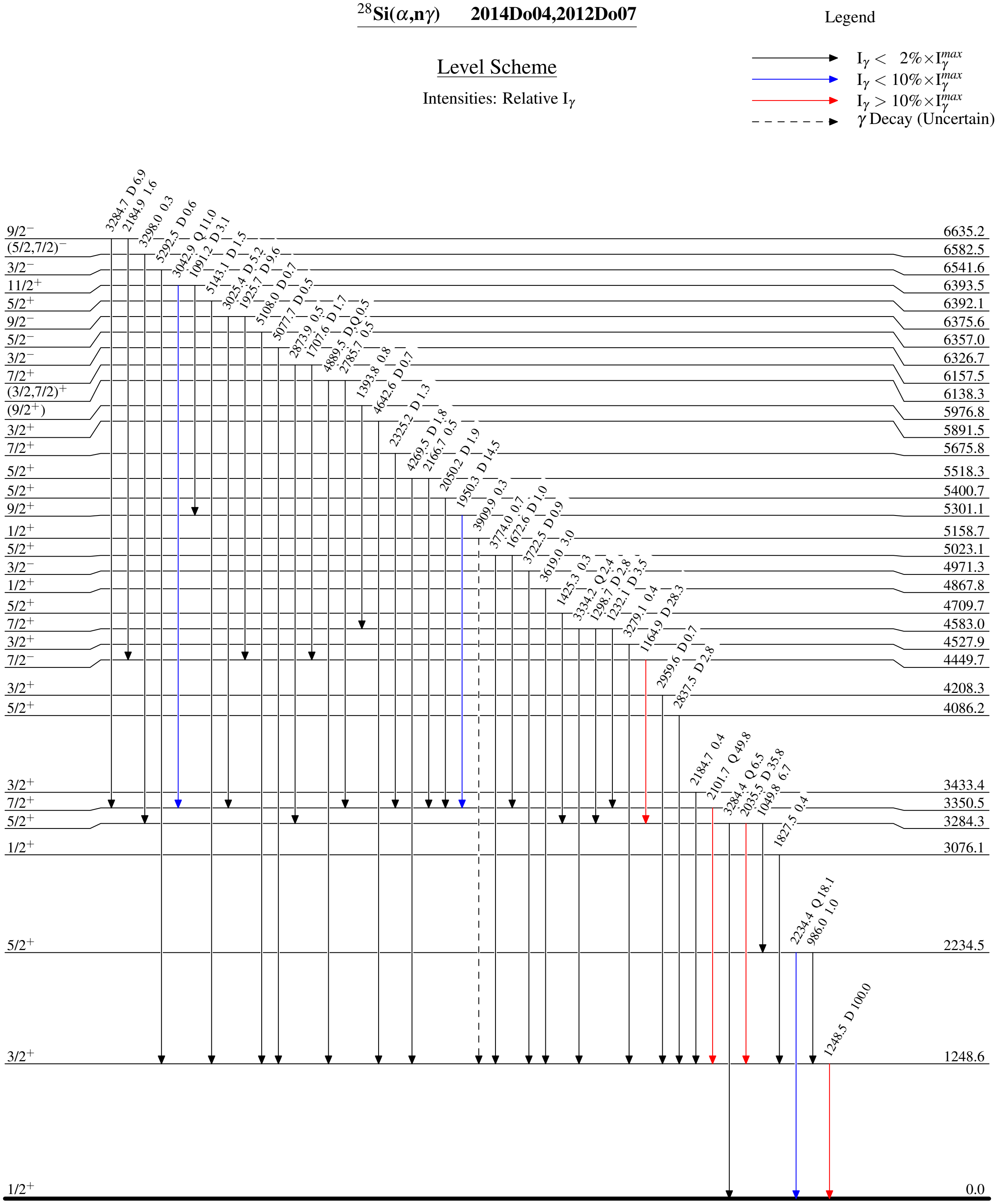
^{28}Si(α,nγ) 2014Do04,2012Do07 (continued)

γ(^{31}S) (continued)

E_γ	I_γ	E_i(level)	J^π_i	E_f	J^π_f	Mult.	Comments
2234.4 *2*	18.1 *4*	2234.5	5/2+	0.0	1/2+	Q#	A_2=+0.20 *2*; A_4=−0.28 *2*
2325.2 *6*	1.3 *2*	5675.8	7/2+	3350.5	7/2+	D‡	A_2=+0.21 *6*; A_4=−0.09 *6*
2785.7 *20*	0.5 *1*	6138.3	(3/2,7/2)+	3350.5	7/2+		
2837.5 *16*	2.8 *2*	4086.2	5/2+	1248.6	3/2+	D†	A_2=−0.12 *2*; A_4=−0.06 *3*
2873.9 *6*	0.5 *1*	6157.5	7/2+	3284.3	5/2+		
2959.6 *5*	0.7 *1*	4208.3	3/2+	1248.6	3/2+	D†	A_2=+0.12 *3*; A_4=−0.04 *3*
3025.4 *3*	5.2 *2*	6375.6	9/2−	3350.5	7/2+	D†	A_2=−0.46 *1*; A_4=−0.01 *2* R_{ADO}=0.58 *2*.
3042.9 *1*	11.0 *2*	6393.5	11/2+	3350.5	7/2+	Q#	A_2=+0.26 *1*; A_4=−0.26 *1* R_{ADO}=1.33 *3*.
3279.1 *2*	0.4 *1*	4527.9	3/2+	1248.6	3/2+		
3284.4 *2*	6.5 *2*	3284.3	5/2+	0.0	1/2+	Q#	A_2=+0.15 *2*; A_4=−0.17 *2*
3284.7 *2*	6.9 *2*	6635.2	9/2−	3350.5	7/2+	D†	A_2=−0.48 *1*; A_4=−0.02 *2* R_{ADO}=0.49 *3*.
3298.0 *20*	0.3 *1*	6582.5	(5/2,7/2)−	3284.3	5/2+		
3334.2 *8*	2.4 *2*	4583.0	7/2+	1248.6	3/2+	Q#	A_2=+0.27 *4*; A_4=−0.27 *4*
3619.0 *3*	3.0 *2*	4867.8	1/2+	1248.6	3/2+		A_2=−0.04 *2*; A_4=−0.07 *2* Mult.: ΔJ=1 from 2014Do04, but γ(θ) should be isotropic for J(4868)=1/2.
3722.5 *20*	0.9 *2*	4971.3	3/2−	1248.6	3/2+	D	A_2=+0.08 *7*; A_4=+0.05 *11* Mult.: ΔJ=0 or 1, dipole transition.
3774.0 *30*	0.7 *1*	5023.1	5/2+	1248.6	3/2+		
3909.9@ *20*	0.3 *1*	5158.7	1/2+	1248.6	3/2+		
4269.5 *3*	1.8 *4*	5518.3	5/2+	1248.6	3/2+	D†	A_2=−0.38 *2*; A_4=−0.06 *3*
4642.6 *20*	0.7 *1*	5891.5	3/2+	1248.6	3/2+	D‡	A_2=+0.16 *11*; A_4=+0.07 *9*
4889.5 *6*	0.5 *1*	6138.3	(3/2,7/2)+	1248.6	3/2+	D,Q	A_2=+0.15 *12*; A_4=+0.03 *14* R_{ADO}=1.12 *24*. Mult.: ΔJ=0 dipole or ΔJ=2 quadrupole transition.
5077.7 *5*	0.5 *1*	6326.7	3/2−	1248.6	3/2+	D‡	A_2=+0.14 *7*; A_4=+0.10 *9* R_{ADO}=0.90 *24*.
5108.0 *2*	0.7 *1*	6357.0	5/2−	1248.6	3/2+	D†	A_2=−0.25 *5*; A_4=−0.01 *7* R_{ADO}=0.49 *11*.
5143.1 *2*	1.5 *1*	6392.1	5/2+	1248.6	3/2+	D†	A_2=−0.25 *3*; A_4=−0.09 *3* R_{ADO}=0.75 *3*.
5292.5 *4*	0.6 *1*	6541.6	3/2−	1248.6	3/2+	D‡	A_2=+0.13 *4*; A_4=−0.03 *6* R_{ADO}=0.94 *15*.

† ΔJ=1, dipole transition from γ(θ) data.
‡ ΔJ=0, dipole transition from γ(θ) data.
# ΔJ=2, quadrupole transition from γ(θ) data.
@ Placement of transition in the level scheme is uncertain.



^{28}Si(α,nγ) 2014Do04,2012Do07
Level Scheme
Intensities: Relative I_γ
Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)
9/2− 6635.2
(5/2,7/2)− 6582.5
3/2− 6541.6
11/2+ 6393.5
5/2+ 6392.1
9/2− 6375.6
5/2− 6357.0
3/2− 6326.7
7/2+ 6157.5
(3/2,7/2)+ 6138.3
(9/2+) 5976.8
3/2+ 5891.5
7/2+ 5675.8
5/2+ 5518.3
5/2+ 5400.7
9/2+ 5301.1
1/2+ 5158.7
5/2+ 5023.1
3/2− 4971.3
1/2+ 4867.8
5/2+ 4709.7
7/2+ 4583.0
3/2+ 4527.9
7/2− 4449.7
3/2+ 4208.3
5/2+ 4086.2
3/2+ 3433.4
7/2+ 3350.5
5/2+ 3284.3
1/2+ 3076.1
5/2+ 2234.5
3/2+ 1248.6
1/2+ 0.0
3284.7 D 6.9
2184.9 1.6
3298.0 0.3
5292.5 D 0.6
3042.9 Q 11.0
1091.2 D 3.1
5143.1 D 1.5
3025.4 D 5.2
1925.7 D 9.6
5108.0 D 0.7
5077.7 D 0.5
2873.9 0.5
1707.6 D 1.7
4889.5 D,Q 0.5
2785.7 0.5
1393.8 0.8
4642.6 D 0.7
2325.2 D 1.3
4269.5 D 1.8
2166.7 0.5
2050.2 D 1.9
1950.3 D 14.5
3909.9 0.3
3774.0 0.7
1672.6 D 1.0
3722.5 D 0.9
3619.0 3.0
1425.3 0.3
3334.2 Q 2.4
1298.7 D 2.8
1232.1 D 3.5
3279.1 0.4
1164.9 D 28.3
2959.6 D 0.7
2837.5 D 2.8
2184.7 0.4
2101.7 Q 49.8
3284.4 Q 6.5
2035.5 D 35.8
1049.8 6.7
1827.5 0.4
2234.4 Q 18.1
986.0 1.0
1248.5 D 100.0

$^{31}_{16}S_{15}$