^{60}Ni(^{3}He,d) 1990Se03,1981Ki06,2013Sc06

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Kazimierz Zuber, Balraj Singh	NDS 125, 1 (2015)	25-Jan-2015

2013Sc06, 2013ScZZ: E(^{3}He)=18 MeV from WNSL-Yale tandem accelerator facility. Measured deuteron spectra, $\sigma(\theta)$, spectroscopic factor C^2S using a split-pole spectrograph. FWHM ≈50 keV. Target=204 μg/cm^2 thick, 99.7% enriched. Deduced levels, J, π. DWBA analysis. Comparison with shell-model calculations.

The main purpose of the neutron adding and neutron removal reaction studies by 2013Sc06 was to obtain occupancies of neutron orbitals, proton vacancies, and energy centroids of neutron, neutron-holes, proton-single particle excitations in ^{60}Ni and ^{62}Ni, and thereby investigate closure of $0f_{7/2}$ shell. Some data details of this study are supplied in 2013ScZZ.

1990Se03: E=33 MeV. Measured $\sigma(\theta)$, θ=12.5°−115° (lab.) in steps of 2.5°, with six ΔE-E telescopes, FWHM=55 keV. Target enriched to 98.5% of ^{60}Ni. DWBA analysis.

1981Ki06: E=18 MeV. Measured $\sigma(\theta)$, θ=1.6°−40°. Magnetic spectrograph, FWHM=12-15 keV. Enriched target. J dependent effects at small angles.

1976Br36: E=18 MeV. Measured $\sigma(\theta)$, θ(c.m.)=5°−90°, magnetic spectrograph, FWHM≈20 keV. Enriched target.

1968Pu03 (also 1966Ro13): E=16.4 MeV. Measured deuteron spectra, $\sigma(\theta)$, DWBA analysis. Magnetic spectrometer FWHM=19 keV.

Others:

1979Fi02, 1976Bo06: E=30.2 MeV. Measured $\sigma(\theta)$ with ΔE-E semi telescope, FWHM≈50 keV. Data for seven analog states from 6450 to 9960 keV.

1975Ba63: E=6.5, 7 MeV. Magnetic spectrometer. Data for g.s. and 470 level.

1965Bl05: data for four isobaric analog states, FWHM=70 keV.

L values and spectroscopic factors are from comparisons with DWBA calculations with normalization factor =4.42 (1981Ki06).

Most data are from 1990Se03, except as noted. There is good agreement with the data of 1976Br36, if account is taken of the different DWBA normalization constant (N=3.2 from sum-rule limits) used in 1976Br36 and (N=4.42) in 1990Se03.

All data of E≤3578 are from Adopted Levels rounded to nearest keV (1981Ki06). All data with E>3578 are from 1990Se03, except as noted.

Cross sections listed under comments are from 1968Pu03 corresponding to the value at first maximum in $\sigma(\theta)$ pattern.

$d\sigma/d\Omega$ in mb/sr (2013ScZZ)

Level	10° (^{3}He,d)	25° (^{3}He,d)
0	11.10	3.08
475	5.66	1.47
970	0.34	1.28
1311	0.11	0.25
1394	0.095	0.16
1933	1.48	0.43
2089	0.42	0.12
2203	0.10	0.23
2358	0.51	0.13
2472	0.081	0.007
2721	0.22	1.00
2840	1.48	0.50
2933	0.072	0.024
3019	0.31	0.15
3092	1.22	0.38
3406	2.33	1.57
3578	0.41	0.58
3863	0.68	0.28

2013Sc06 quote level energies from 1999-NDS for A=61 (1999Bh04); these values are close to those in Adopted levels here

The uncertainties in cross sections are ≈4% for σ>1 mb/sr, ≈7% for 0.1<σ< 1.0 mb/sr, and ≈18% for σ< 0.1 mb/sr at their respective

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maxima. The uncertainties arising from possible contaminants or
previously unidentified states for very weak transitions could be
≈0.02  mb/sr.
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^{61}Cu Levels

E(level)[†]	L[‡]	(2J+1)C^{2}S	Comments
0	1	2.16[c]	dσ/dΩ=8.3 mb/sr. (2J+1)C^{2}S: 1.71 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
477	1	0.96[d]	dσ/dΩ=3.5 mb/sr. (2J+1)C^{2}S: 0.82 for J^π=1/2$^-$ (2013Sc06,2013ScZZ).
972	3	3.26[e]	dσ/dΩ=0.56 mb/sr.
1306[a]	3	0.40[f]	dσ/dΩ=0.13 mb/sr.
1390[a]	3	0.36[e]	dσ/dΩ=0.15 mb/sr.
1702			
1904	3	0.06[e]	
1940	1	0.22[c]	dσ/dΩ=1.0 mb/sr. (2J+1)C^{2}S: 0.19 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
2104	1	0.06[d]	dσ/dΩ=0.32 mb/sr. (2J+1)C^{2}S: 0.054 for J^π=1/2$^-$ (2013Sc06,2013ScZZ).
2216	3	0.56[e]	dσ/dΩ=0.08 mb/sr.
2368	1	0.07[c]	dσ/dΩ=0.26 mb/sr. (2J+1)C^{2}S: 0.065 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
2390	3	0.08[f]	dσ/dΩ=0.03 mb/sr.
2478	1	0.01[c]	L: 1976Br36 obtain L=(2). dσ/dΩ=0.02 mb/sr. (2J+1)C^{2}S: 0.010 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
2629			dσ/dΩ=0.01 mb/sr.
2680	1	0.04[c]	dσ/dΩ=0.05 mb/sr.
2711	4	2.80[g]	dσ/dΩ=0.74 mb/sr.
2794	3	0.13[e]	dσ/dΩ=0.3 mb/sr.
2846[#a]	1[b]	0.04[d]	dσ/dΩ=1.6 mb/sr. (2J+1)C^{2}S: 0.38 for J^π=1/2$^-$,3/2$^-$ (2013Sc06,2013ScZZ).
2857[#a]	1[b]		
2942	1	0.004	dσ/dΩ=0.04 mb/sr. (2J+1)C^{2}S: 0.009 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
3019	1	0.06[c]	dσ/dΩ=0.06 mb/sr. (2J+1)C^{2}S: 0.040 for J^π=3/2$^-$ (2013Sc06,2013ScZZ).
3063[a]	1	0.11[d]	dσ/dΩ=0.09 mb/sr.
3094[a]	1	0.08[d]	dσ/dΩ=0.07 mb/sr.
3276	(4)	0.14[g]	E(level), L and C^{2}S′ from 1976Br36. C^{2}S′ renormalized to N=4.42. dσ/dΩ=0.03 mb/sr.
3411	2	0.59[h]	dσ/dΩ=1.92 mb/sr.
3526			
3588	2	0.20[h]	dσ/dΩ=0.18 mb/sr.
3708			dσ/dΩ=0.09 mb/sr.
3790			dσ/dΩ=0.03 mb/sr.
3860	1	0.13[d]	dσ/dΩ=0.12 mb/sr. (2J+1)C^{2}S: 0.093 for J^π=1/2$^-$,3/2$^-$ (2013Sc06,2013ScZZ).
3943	1	0.14[d]	dσ/dΩ=0.02 mb/sr.
3970			
4013			dσ/dΩ=0.05 mb/sr.
4102			dσ/dΩ=0.03 mb/sr.
4273			dσ/dΩ=0.03 mb/sr.

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^{60}Ni(^{3}He,d) 1990Se03,1981Ki06,2013Sc06 (continued)

^{61}Cu Levels (continued)

E(level)[†]	L[‡]	(2J+1)C^2S	Comments
4296			
4349	0	0.21	Configuration=($2s_{1/2}$). dσ/dΩ=0.07 mb/sr.
4420	3	0.45[e]	dσ/dΩ=0.04 mb/sr.
4477			dσ/dΩ=0.08 mb/sr.
4523			dσ/dΩ=0.05 mb/sr.
4581			dσ/dΩ=0.08 mb/sr.
4621	1	0.18[d]	dσ/dΩ=0.06 mb/sr.
4738			
4790			dσ/dΩ=0.03 mb/sr.
4827	3	0.30[e]	
4860			
4900			dσ/dΩ=0.06 mb/sr.
4925			dσ/dΩ=0.04 mb/sr.
4973			dσ/dΩ=0.05 mb/sr.
5042	4	0.29[g]	dσ/dΩ=0.15 mb/sr.
5081			dσ/dΩ=0.03 mb/sr.
5111			dσ/dΩ=0.07 mb/sr.
5170			dσ/dΩ=0.07 mb/sr.
5235			
5329	4	0.60[g]	dσ/dΩ=0.08 mb/sr.
5383	4	0.74[g]	dσ/dΩ=0.06 mb/sr.
5433			dσ/dΩ=0.16 mb/sr.
5463			dσ/dΩ=0.15 mb/sr.
5532			dσ/dΩ=0.22 mb/sr.
5574			dσ/dΩ=0.17 mb/sr.
5624			
5669			dσ/dΩ=0.11 mb/sr.
5704	2	0.22[h]	
5788	0	0.21	(2J+1)C^2S: for configuration=$3s_{1/2}$. dσ/dΩ=0.06 mb/sr.
5829			
5872			dσ/dΩ=0.05 mb/sr.
5937			dσ/dΩ=0.09 mb/sr.
6004			
6045			
6075			
6119			dσ/dΩ=0.20 mb/sr.
6149			
6216			dσ/dΩ=0.14 mb/sr.
6314			dσ/dΩ=0.13 mb/sr.
6350			
6402[&]	1		dσ/dΩ=0.30 mb/sr.
6457	1+3	1.58+2.28[ce]	dσ/dΩ=0.36 mb/sr. E(level): probable analog of $3/2^-$, g.s. and 5/2-, 67-keV in ^{61}Ni. $C^2\hat{S}$(2J+1)=2.28 for configuration=$1f_{5/2}$. May correspond to 6450 *40* + 6520 *40* (1976Bo06).
6543			dσ/dΩ=0.10 mb/sr.
6650[&]	1		dσ/dΩ=0.18 mb/sr.
6701	1	1.29[d]	E(level): probable analog of 1/2-, 283-keV in ^{61}Ni. May correspond to 6740 *40* (1976Bo06).
6712			dσ/dΩ=0.12 mb/sr.
6860[@] *40*			
6954			dσ/dΩ=0.15 mb/sr.

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^{60}Ni(^{3}He,d) 1990Se03,1981Ki06,2013Sc06 (continued)

^{61}Cu Levels (continued)

E(level)[†]	L[‡]	(2J+1)C^2S	Comments
6980[@] *40*			
7192			
7401	3	0.90[e]	
7520			dσ/dΩ=0.21 mb/sr.
7589			
7643	1+3	0.40+0.61[ce]	dσ/dΩ=0.16 mb/sr. E(level): probable analogs of 3/2-, 1100-keV, 5/2-, 1132-keV, 3/2-, 1185-keV levels in ^{61}Ni.
8177			dσ/dΩ=0.10 mb/sr.
8504			dσ/dΩ=0.25 mb/sr.
8561	4	3.32[g]	E(level): probable analog of $9/2^+$, 2122-keV level in ^{61}Ni.
8670[@] *40*			
9142	2+4	0.43+0.71[gh]	
9963	4	2.55[g]	

† From 1990Se03 unless otherwise stated.
‡ From DWBA analysis of $\sigma(\theta)$.
# $J^\pi=(1/2)^-$, L=^{1}·C^2S'=0.23 for unresolved doublet.
@ From 1976Bo06. For proton decay of some analog states, see 1979Fi02.
& Level from 1968Pu03, identified as an analog state.
a Rounded values from Adopted Levels, unresolved doublets at 1334, 2851, 3078 and 6457 keV.
b L=1 unresolved doublet (E=2851) (1990Se03).
c For configuration=$2p_{3/2}$ for L=1.
d For configuration=$2p_{1/2}$ for L=1.
e For configuration=$1f_{5/2}$ for L=3.
f For configuration=$1f_{7/2}$ for L=3.
g For configuration=$1g_{9/2}$ for L=4.
h For configuration=$2d_{5/2}$ for L=2.