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THE (t,d) REACTION ON THE NI ISOTOPES WITH POLARIZED TRITONS

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ABSTRACT

The ($\vec{t}$,d) reaction has been measured on targets of ^{58,60,62,64}Ni with 17 MeV polarized tritons. Spectroscopic factors, angular momentum and total spin transfer were obtained from the differential cross section and A_y values of levels up to 3.5 MeV in excitation energy. The present ($\vec{t}$,d) measurement enables a better description of the $9/2^+$ and $5/2^+$ states which show significant shell crossing effects as a function of increasing neutron number.

The (t,d) reaction favors a higher angular momentum transfer than does the (d,p) reaction and thus can be used more easily to study higher spin states. In addition, the (t,d) reaction has strongly absorbed particles in both entrance and exit channels and thus produces a sharp diffraction pattern in the measured angular distributions which is well described by distorted wave (DW) theory. It has been shown[1] that this strong absorption characteristic also yields significant values of analyzing powers (A_y) for a polarized triton beam, and that J^π values may be easily extracted from these data.

The Ni isotopes represent an extremely interesting nuclear region where the ($\vec{t}$,d) reaction is a very useful tool because of the large range of angular momenta associated with the particle states. As the shell fills in going away from N=28, the $g_{9/2}$ orbital drops rapidly due to pairing forces and produces a deformation tendency in the heavier Ni isotopes as suggested by Hartree-Fock calculations. This tendency also produces a major shell crossing of other orbitals, principally the $d_{5/2}$. Thus significant deviations occur from expected shell model spacing of the single particle orbitals.

The experiments were done using a 17 MeV polarized triton beam of average intensity 45 na and polarization 0.75 at the LASL Van de Graaff facility. Metallic Ni targets of ~ 300 μgm/cm^2 thickness were bombarded and the resulting reaction deuterons were detected by a helical focal plane detector in a Q3D magnetic spectrometer.[2] The average resolution was 15-18 keV as caused by the target thickness. Cross sections as small as 2 μb/sr were measured using the full Q3D solid angle (14.3 msr). The polarization was measured at the beginning and end of each run and the spin flipped at the source for each angle. The entire procedure was computer controlled.

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Approximately 25-30 levels were measured in $^{59,61,63,65}Ni$ up to an excitation energy of ~3.5 MeV. Typical analyzing powers for $1/2^-$, $3/2^-$, $9/2^+$ and $5/2^+$ states in ^{63}Ni are shown in Fig. 1 where they are compared with DW calculations. These calculations were done using published triton parameters (with an added spin-orbit potential) and deuteron parameters. The DW results reasonably describe the A_y data and fit the differential cross sections very well. A slight phase shift between data and calculation is noted in this figure but no adjustments of DW parameters were made to account for this. The principal sensitivity is in the deuteron parameters

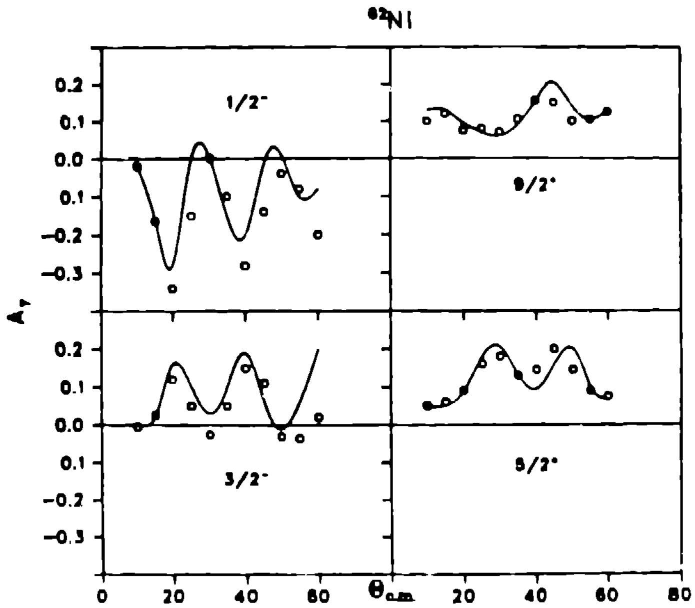

Fig. 1. Typical values for the $^{62}Ni(\vec{t},d)$ reaction.

Table 1 contains the information obtained in the present experiment for the $^{62}Ni(\vec{t},d)^{63}Ni$ reaction; other isotopes will be described in a later report. This table also contains previous results[3] for comparison. The spectroscopic factors obtained in the present work compare well with other results except for the $9/2^+$ state. This discrepancy exists for all the targets when comparing the (t,d) and (d,p) data. However, the (t,d) results give an excellent fit to A_y and fit $d\sigma/d\Omega$ better than do the (d,p) results. The new A_y data confirm most of the suggested spin values and assign several new ones.

Examination of the systematic trend of the $9/2^+$, $5/2^+$ and $1/2^+$ major fragments shows a trend where the $9/2^+$ state drops steeply in excitation energy between ^{59}Ni and ^{63}Ni from over 3 MeV to near 1 MeV and then levels out. This fragment contains ~40% of the total $g_{9/2}$ strength. This trend deviates from that suggested by shell model calculations. The $5/2^+$ strength does not drop as sharply but does drop from above 3.5 MeV in ^{59}Ni to below 2 MeV in ^{65}Ni with about 1/5 of the total strength in one level. This represents a considerable

Table I. ^{62}Ni($\vec{t}$,d) Results

Level	Ex (keV)	Previous Results: Assumed J^π	Previous Results: (2J+1) S	Present Results: ℓ Transfer	Present Results: J^π	Present Results: (2J+1) S
1	0	$1/2^-$	0.85	1	$1/2^-$	0.74
2	89	$5/2^-$	3.40	3	$5/2^-$	3.42
3	155	$3/2^-$	1.15	1	$3/2^-$	0.95
4	518	$3/2^-$	0.32	1	$3/2^-$	0.27
5	(905)				$(9/2^+)$	
6	1001	$1/2^-$	0.82	1	$1/2^-$	0.55
7	(1064)			(1)	$(1/2^-)$	0.033
8	(1145)			(1)	$(3/2^-)$	0.014
9	(1255)					
10	1294	$(9/2^+)$	5.72	4	$9/2^+$	4.20
11	(1324)	$3/2^-$		1	$3/2^-$	0.093
12	(1557)			3	$5/2^-$	0.20
13	(1720)					
14	1787	$5/2^-,7/2^-$				
15	1899	$(5/2,7/2^-)$		1	$(3/2^-)$	0.030
16	2149	$1/2,3/2^-$		1	$(3/2^-)$	0.025
17	2297	$5/2^+$	1.99	2	$5/2^+$	1.3?
18	2345			2	$5/2^+$	0.02?
19	2519	$(9/2^+)$	2.59	4	$9/2^+$	2.04
20	2700	$1/2^+$	0.10	1	$1/2^-$	0.10
21	2822				ℓ-1/2	
22	29[illegible]	$1/2^+$	0.23	0	$1/2^+$	0.11
23	3010				ℓ-1/2	
24	3092		0.04	1	$1/2^-$	[illegible]
25	[illegible]	$5/2,7/2^-$		(3)	$(7/2^-)$	0.17
26	[illegible]	$5/2^+$	0.43		ℓ+1/2	
27	[illegible]	$5/2,7/2^+$		2	$5/2^+$	0.6?
28	[illegible]				ℓ+1/2	
29	[illegible]	$3/2,5/2^+$		2	$5/2^+$	[illegible]

washing out of the shell gap at N=50 and is characteristic of a nucleus going deformed. The low spin $1/2^+$ states are not as perturbed.

The present results have confirmed or added to our knowledge of the spin values in the odd Ni nuclei as well as indicating the trend toward deformation of the heavier Ni isotopes.

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