POSITIVE PARITY LEVELS IN ^{36}S OBSERVED IN THE ^{37}Cl(d, ^{3}He)^{36}S REACTION*

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Transitions to the ^{36}S ground state and excited states at 3.30, 4.57, 6.51, 7.11 and 7.69 MeV were observed in the reaction ^{37}Cl(d, ^{3}He)^{36}S at a bombarding energy of 28.9 MeV. Using distorted wave analysis, l-values and strength coefficients C^2S were extracted from the measured angular distributions. The results are in reasonable agreement with calculations by Glaudemans et al.

The nucleus $^{36}_{16}S_{20}$ is interesting from the shell model point of view. The neutron number 20 corresponds to a major shell closure, and one expects among the low-lying levels positive-parity states with configurations resulting from the coupling of four proton holes in the 2s-1d shell. The experimental information previously available for this nucleus has come from an unpublished investigation of the ^{34}S(t, p)^{36}S reaction [1]. We have studied the ^{37}Cl(d, ^{3}He)^{36}S reaction in order to identify levels in ^{36}S formed by the removal of an additional proton from the ground state of ^{37}Cl, which presumably has a predominant three-hole configuration.

A carbon-backed target consisting of NaCl enriched to more than 99% in ^{37}Cl was bombarded with 28.9 MeV deuterons from The University of Michigan 83-inch cyclotron. In most cases, the ^{3}He ions were detected either in nuclear emulsions following magnetic analysis, or in a surface barrier counter telescope used in conjunc-

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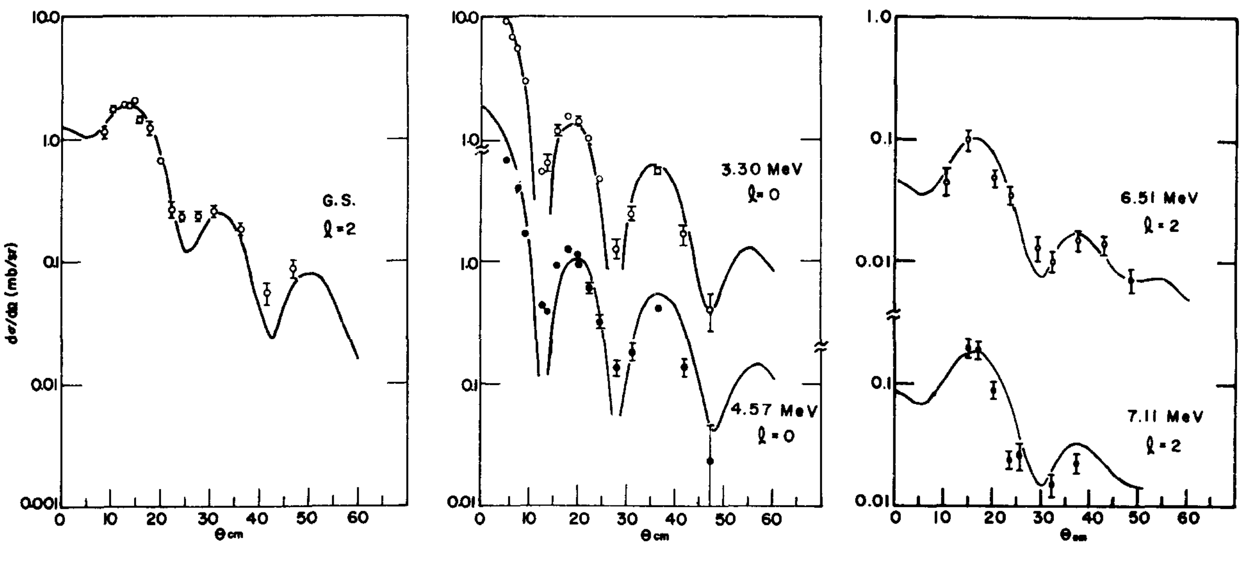

Fig. 1. Angular distributions measured for transitions in the reaction ^{37}Cl(d, ^{3}He)^{26}S at E_d = 28.9 MeV leading to states in ^{36}S. The solid lines are predictions from the distorted wave calculation discussed in the text.

tion with a pulse multiplier for particle identification. Additional forward-angle data were taken with a position-sensitive detector placed in the focal plane of the magnetic spectrograph. We observe transitions to the ^{36}S ground state and excited states at 3.30 ± 0.015, 4.57 ± 0.015, 6.51 ± 0.015, 7.11 ± 0.020 and 7.69 ± 0.025 MeV*. Our excitation energies are in good agreement with those obtained for the first two levels by Puttaswamy and Yntema in a recent $^{37}Cl(d,{}^{3}He)^{36}S$ experiment [2].

The measured angular distributions are shown in fig. 1. The solid lines are local, zero-range distorted wave predictions computed with the Oak Ridge code JULIE. The deuteron optical parameters were taken from the average set of ref. 4 and the ^{3}He parameters are those of ref. 5 for ^{40}Ca.

* These energies have been corrected from preliminary values reported in ref. 3.

Our results are summarized in table 1. For completeness the levels quoted in ref. 1 are included. Only the ground state and the level at 3.30 MeV are observed in both the (t,p) and (d, ^{3}He) experiments. The extracted strength coefficients C^2S are listed together with the sums for pickup from the three 2s-1d orbitals. The single-particle cross sections were calculated with the usual bound-state radius and diffuseness parameters taken to be 1.20 fm and 0.65 fm, respectively. This choice of bound-state parameters and our use of the local and zero-range approximations lead us to expect that the strengths we obtain are upper limits to the true ones [7].

Levels with configurations $(2s_{\frac{1}{2}})^m(1d_{\frac{3}{2}})^n$ have been calculated for nuclei from ^{29}Si to ^{40}Ca by Glaudemans et al. [6]. For comparison the levels predicted for ^{36}S are given together with the resuling strength coefficients C^2S for pickup of a $2s_{\frac{1}{2}}$ or $1d_{\frac{3}{2}}$ proton from ^{37}Cl. The experimental

Table 1

Summary of the known level structure of ^{36}S, compared with the predictions of Glaudemans et al. The probable dominant configurations and strength coefficients C^2S are deduced from the present experiment.

Experimental					Calculated		
$^{34}S(t,p)^{36}S$ ref. 1	$^{37}Cl(d,{}^{3}He)^{36}S$ present work		probable dominant			$^{37}Cl(d,{}^{3}He)^{36}S$ ref. 6	
E_x, J^{π}	E_x, J^{π}	l_p	configuration	C^2S	E_x, J^{π}	$C^2S(s_{\frac{1}{2}})$	$C^2S(d_{\frac{3}{2}})$
0.00, 0^+	0.00, 0^+	2	$(d_{\frac{3}{2}})^{-4}$	1.41	0.00, 0^+		0.91
2.00, 0^+							
2.89, 2^+							
3.30	3.30, $(1,2)^+$	0	$(d_{\frac{3}{2}})^{-3}(s_{\frac{1}{2}})^{-1}$	1.14	2.83, 2^+	1.04	
3.36, 0^+							
4.20					4.28, 0^+		0.05
	4.57, $(1,2)^+$	0	$(d_{\frac{3}{2}})^{-}(s_{\frac{1}{2}})^{-1}$	1.35	5.75, 1^+	0.70	0.03
					6.23, 2^+	0.12	0.13
					Totals	1.86	1.12
	6.51, $(1,2,3,4)^+$	2	$(d_{\frac{3}{2}})^{-3}(d_{\frac{5}{2}})^{-1}$	0.28			
	7.11, $(1,2,3,4)^+$	2	$(d_{\frac{3}{2}})^{-3}(d_{\frac{5}{2}})^{-1}$	0.61			
	7.69						
			$\sum C^2S(d_{\frac{3}{2}})$ =	1.41			
			$\sum C^2S(s_{\frac{1}{2}})$ =	2.49			
			$\sum C^2S(d_{\frac{5}{2}})$ =	0.89			

results are in reasonable agreement with the calculation if the levels at 3.30 and 4.57 MeV are identified with the predicted 2.83 MeV 2^+ and 5.75 MeV 1^+ levels, respectively.

The states at 6.51 and 7.11 MeV may be excited by pick-up from either the $1d_{\frac{3}{2}}$ or $1d_{\frac{5}{2}}$ orbitals or from both. A small amount of $1d_{\frac{3}{2}}$ strength is predicted at 6.23 MeV in ref. 6, but the addition of all the $l = 2$ strength for these states to the ground state results in a total rather larger than expected for the $1d_{\frac{3}{2}}$ transitions. A large fraction of the $1d_{\frac{5}{2}}$ strength is clearly not observed since the total should presumably be close to the value of 6 corresponding to full occupancy of the $1d_{\frac{5}{2}}$ single particle level in the ^{37}Cl ground state.

The $(1d_{\frac{3}{2}})^{-3}(2s_{\frac{1}{2}})^{-1}$ configuration appears to be important only for the two states at 3.30 and 4.57 MeV. These levels are related through particle-hole equivalence to levels in ^{38}Ar constructed from the $(1d_{\frac{3}{2}})^{-1}(2s_{\frac{1}{2}})^{-1}$ configuration. In a study of the ^{39}K(d, ^{3}He)^{38}Ar reaction [8], we have found that the $l = 0$ strength is distributed among four levels between 3.94 and 5.52 MeV, in contrast to the result for ^{36}S. A more detailed discussion of the structure of ^{36}S and ^{38}Ar deduced from the (d, ^{3}He) reaction will appear elsewhere.

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