Neutron Pickup from ^{27}Al†

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52 levels below $E_x = 6.8$ MeV in ^{26}Al were populated with the ^{27}Al(^{3}He,α) reaction at a bombarding energy of 18 MeV. Angular distributions for 37 levels were extracted and compared with the results of distorted-wave calculations. Of these, 28 were seen to be characteristic of direct pickup; 2 with $l_n = 0$, 3 with $l_n = 1$, 10 with $l_n = 0 + 2$ and 13 with $l_n = 2$. A comparison with the results of the ^{27}Al(d,^{3}He)^{26}Mg reaction shows good agreement for known $T = 1$ states and allows several new $T = 1$ assignments to be made. Spectroscopic factors for several of the low-lying states are in good agreement with shell-model predictions.

I. INTRODUCTION

The nucleus ^{26}Al lies in a transition region between nuclei with large permanent deformations and those believed to be better described in a spherical basis. The study of ^{26}Al is therefore of some interest and has been the subject of detailed investigations utilizing the ^{24}Mg(^{3}He, p), ^{25}Mg(^{3}He, d), and ^{25}Mg(d, n) reactions,[1-4] and also γ-decay studies.[5-12] These studies have shown that the simple strong-coupling Nilsson model applied to ^{26}Al is inadequate. More sophisticated Nilsson-type calculations[13] that include both the Coriolis term and a residual interaction between the odd neutron and proton have also met with only limited success.

This report presents the results of a study of ^{26}Al using the ^{27}Al(^{3}He, α) reaction. This reaction has previously been studied by Nurzynski *et al.*[14] who reported results for six of the lowest-lying states. Results for several states below $E_x = 5.0$ MeV are given in Ref. 15. The earlier work of Hinds and Middleton[16] at 5.8-MeV bombarding energy discussed only the energy-level scheme and did not give angular distributions. The present work includes results for 52 states below 6.8 MeV in excitation together with angular distributions for all the strong transitions.

II. EXPERIMENTAL PROCEDURE AND RESULTS

A 35-μg/cm^2 self-supporting natural Al (100% ^{27}Al) target was bombarded with 18-MeV ^{3}He^{++} ions from the University of Pennsylvnia tandem Van de Graaff. The reaction α particles were detected in Ilford K-1 nuclear emulsions after being momentum-analyzed in a multiangle spectrograph.

A spectrum obtained at a laboratory angle of $7\frac{1}{2}^\circ$ is shown in Fig. 1. Groups identified as corresponding to states in ^{26}Al are labeled numerically; contaminant groups corresponding to the ground-state transitions in the ^{16}O(^{3}He, α) and ^{12}C(^{3}He, α) reactions are shown shaded. The over-all resolution is approximately 20 keV full width at half maximum.

Angular distributions (Figs. 2–4) were measured in $3\frac{3}{4}^\circ$ steps from $3\frac{3}{4}$ to 30° and thence in $7\frac{1}{2}^\circ$ steps to $52\frac{1}{2}^\circ$. The absolute cross sections were determined from the nominal target thickness and are believed to be accurate to within ±30%.

Excitation energies were calculated at four forward angles using the beam energy calculated

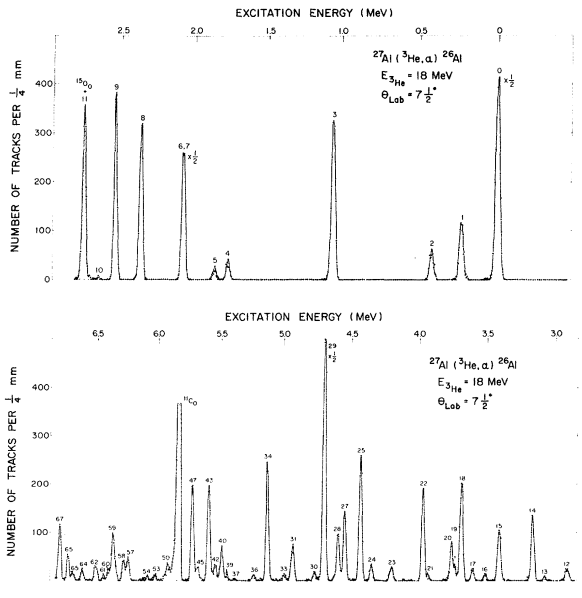

FIG. 1. Spectrum of the ^{27}Al(^{3}He,α)^{26}Al reaction at 18-MeV bombarding energy.

from the positions of the two intense contaminant groups. The present study yields a Q_0 value of 7522 ± 10 keV for the ^{27}Al(^{3}He, α) reaction, in good agreement with the value 7521 ± 3 keV obtained from the masses.[17] The excitation energies of ^{26}Al levels obtained are shown in Table I in comparison with values from the literature. Except for closely spaced doublets, the expected uncertainty in these excitation energies is ±10 keV.

For the low-lying states the present excitation energies agree well with those from the literature. However, for states above about 3.5 MeV, the present energies are 5–15 keV higher than those previously reported. The origin of this discrepancy is not known, but it is in most cases small enough to allow a one-to-one correspondence to be made between previously known levels and those observed in the present work.

III. DISTORTED-WAVE ANALYSIS

A distorted-wave analysis of the angular distributions was performed using the code DWUCK.[18] The calculations assumed the local zero-range approximation with no lower radial cutoff. The

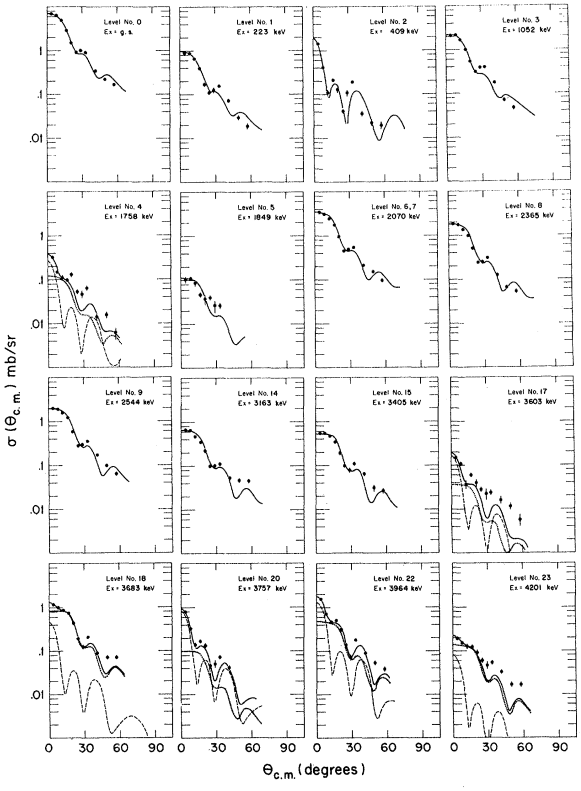

FIG. 2. Angular distributions of ^{27}Al(^{3}He, α)^{26}Al transitions with shapes characteristic of direct pickup. The l_n values are listed in Table I.

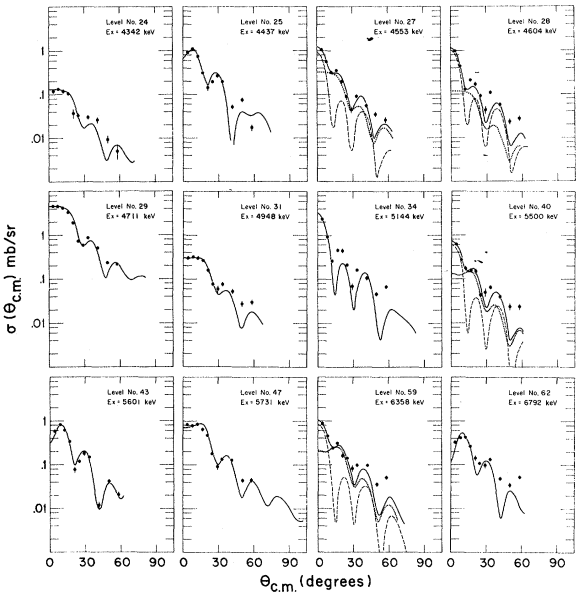

FIG. 3. Angular distributions of ^{27}Al(^{3}He, α)^{26}Al transitions with shapes characteristic of direct pickup. The l_n values are listed in Table I.

$l_n = 0$, 1, and 2 curves shown in Figs. 2 and 3 were calculated assuming $2s_{1/2}$, $1p_{1/2}$, and $1d_{5/2}$ pickup, respectively.

Several optical-model parameter sets taken from the literature[19] were used in attempts to fit the angular distributions and these are listed in Table II. Examples of the shapes obtained using these parameter sets are presented in Fig. 5, together with the data for the ground-state (5^+) and 0.42-MeV (3^+) levels of ^{26}Al. These two angular distributions are believed to be characteristic of pure $l_n = 2$ and $l_n = 0$, respectively. The quality of fits obtained with the various parameter sets do not

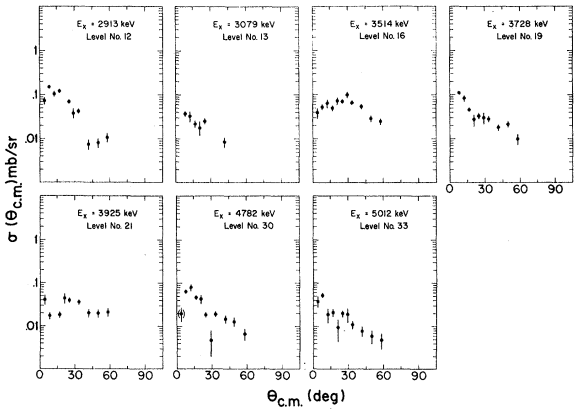

FIG. 4. Angular distributions of ^{27}Al(^{3}He, α)^{26}Al transitions not characteristic of direct pickup.

TABLE I. Results for the $^{27}Al(^{3}He,\alpha)^{26}Al$ reaction.

Level No.	E_x (keV) Present [a]	Lit.	l_n	NC^2S	$C^2S/C^2S_{g.s.}$	C^2S ($N=28.5$)	J^{π} [b]
0	0	0	2	29.82	1.00	1.05	5^+
1	223	228	2	4.08	0.14	0.14	0^+, $T=1$
2	409	417	0	3.56	0.12	0.12	3^+
3	1052	1058	2	9.12	0.31	0.32	1^+
4	1758	1759	0	0.32	0.01	0.01	2^+
			2	0.48	0.02	0.02	
5	1849	1850	(2)	0.48	0.02	0.02	1^+
							4^+
6, 7 [c]	2070	2070	2	14.88	0.50	0.52	2^+, $T=1$
							1^+
8	2365	2365	2	7.86	0.26	0.28	3^+
9	2544	2545	2	8.88	0.30	0.31	3^+
10	2674	2661	n.s.				$(2,3)^+$
11	2738	2740	n.s.				1^+
12	2913	2913	n.s.				2^+
13	3079	3074	n.s.				$(2,3)^+$
14	3163	3159	2	3.06	0.10	0.11	2^+, $T=1$
15	3405	3405	2	2.52	0.08	0.09	5^+
16	3514	3507	n.s.				6^+
17	3603	3594	0	0.12	0.004	0.004	$(2,3)^+$
			2	0.18	0.006	0.006	
18 [c]	3683	3675	0	0.36	0.01	0.01	$(2,3)^+$
			2	4.08	0.14	0.14	
19	3728	3719	n.s.				1^+
20 [c]	3757	3745	0	0.62	0.02	0.02	$(2,3)^+$
			2	0.48	0.016	0.017	0^+, $T=1$
21	3925	3918	n.s.				
22 [c]	3964	3960	0	0.94	0.03	0.03	3^+
			2	2.52	0.08	0.09	
23 [c]	4201	4202	0	0.06	0.002	0.002	3^+, $T=1$
			2	0.90	0.03	0.03	
24	4355	4342	2	0.72	0.02	0.03	$(0\rightarrow 5)^+$
25 [d]	4437	...	1	0.69	0.02	0.02	$(1\rightarrow 4)^-$
27	4553	4541	0	0.60	0.02	0.02	$(2,3)^+$
			2	1.80	0.06	0.06	
28	4604	4595	0	0.64	0.02	0.02	$(2,3)^+$
			2	0.66	0.02	0.02	
29	4711	4699	2	25.56	0.86	0.90	$(0\rightarrow 5)^+$
30	4782	4766	n.s.				
31	4948	4935	2	1.74	0.06	0.06	$(0\rightarrow 5)^+$
33	5012	5002	n.s.				
34	5144	5126	0	1.78	0.06	0.06	$(2,3)^+$
36	5249	5238	...				
37	5404	5390	...				
39	5474	5485	...				
40	5500	5506	0	0.33	0.01	0.01	$(2,3)^+$
			2	0.95	0.03	0.03	
42	5549	5536	...				
43	5601	5580	1	5.00	0.17	0.18	$(1\rightarrow 4)^-$
45	5688	5690	...				
47	5731	5715	2	5.38	0.18	0.19	$(0\rightarrow 5)^+$
50	5928	5910	...				
53	6032	6020	...				
54	6083	6080	...				

TABLE I *(Continued)*

Level No.	E_x (keV) Present[a]	Lit.	l_n	NC^2S	$C^2S/C^2S_{g.s.}$	C^2S ($N=28.5$)	J^π[b]
58	6286	6260	•••				
59	6358	6351	0	0.43	0.01	0.02	$(2,3)^+$
			2	1.91	0.06	0.07	
60	6409	6388	•••				
61	6454	6424	•••				
62	6503	6487	•••				
64	6611	6613	•••				
65	6690	6684	•••				
66	6729	6727	•••				
67	6792	6806	1	3.28	0.11	0.12	$(1\rightarrow 4)^-$

[a] All excitation energies ±10 keV.
[b] Refs. 1–12 and present work.
[c] Known doublet or triplet.
[d] New level.

differ greatly from one another. The curves shown in Figs. 2 and 3 were calculated using parameter set C for helions (^{3}He) and set Y for α particles.

For pickup, the experimentally measured cross section is related to the cross section calculated with the code DWUCK by the expression[18]

$$\sigma_{\exp}(\Theta) = NC^2 \sum_{lj} S_{lj} \frac{\sigma_{\mathrm{DWUCK}(\Theta)}}{2j+1},$$

where j is the transferred angular momentum and C is an isospin Clebsch-Gordan coefficient of the form $\langle T_f T_{z_f} t t_z | T_i T_{z_i} \rangle$, where the suffixes i and f refer to the initial and final states. For the (^{3}He, α) reaction on ^{27}Al we have $C^2 = 1$ for $T_f = 0$ and $C^2 = \frac{1}{3}$ for $T_f = 1$.

The quantity N is an over-all normalization factor which embodies the overlap between the projectile and the transferred and outgoing particles together with the strength and form of the interaction causing the transfer. Since the value of this factor is not well determined for the (^{3}He, α) reaction, we therefore resort to empirical means in order to obtain absolute spectroscopic strengths from the present study (see Sec. IV). The values of NC^2S and $C^2S/C^2S_{g.s.}$ obtained from the distorted-wave analysis are given in Table I.

Since the ground state of ^{27}Al has spin-parity $\frac{5}{2}^+$, $1d_{5/2}$ pickup can populate states having $J^\pi = 0^+ - 5^+$ whereas with $2s_{1/2}$ pickup only $J^\pi = 2^+$ and 3^+ are allowed. The observation of an $l_n = 0$ component in an angular distribution therefore establishes the spin-parity of that state as either 2^+ or 3^+. In the present study an apparently pure $l_n = 0$ angular distribution was observed for only two states, those at $E_x = 409$ and 5144 keV. These observations are consistent with the previously known spin-parity of these levels of 3^+ and $(2,3)^+$, respectively.

Admixed $l_n = 0 + 2$ angular distributions were observed for states at $E_x = 1758$, 3603, 3683, 3757, 3964, 4201, 4553, 4604, 5500, and 6358 keV. The state at 1758 keV is known[10] to have $J^\pi = 2^+$, while the 3603-, 3683-, and 3757-keV levels are known to have $J^\pi = (2,3)^+$, the latter two being members of closely-spaced doublets. The "level" observed at 3964 keV in the present study is known to be a doublet with 10-keV separation. The lower member of this doublet has previously been assigned $J = 3$ or 1, while the upper member has $J = 1$ or 0.

TABLE II. Optical-model parameters used in the distorted-wave Born-approximation analysis of the ^{27}Al(^{3}He, α)^{26}Al reaction.

		V_0 (MeV)	$r_0 = r_{so}$ (fm)	$a_0 = a_{so}$ (fm)	W (MeV)	$W' = 4W_D$ (MeV)	r_0' (fm)	a_0' (fm)	r_c (fm)	V_{so} (MeV)
^{27}Al+^{3}He	(A)	130.0	1.31	0.61	24	•••	1.43	1.01	1.40	10
	(B)	125.0	1.31	0.61	24	•••	1.43	1.01	1.40	10
	(C)	130.0	1.31	0.61	16	•••	1.43	1.01	1.40	10
^{26}Al+α	(Y)	180.0	1.42	0.56	16.5	•••	1.42	0.56	1.40	•••
	(Z)	180.0	1.35	0.60	17	•••	1.35	0.60	1.40	•••
Bound state		a	1.26	0.60	•••	•••	•••	•••	•••	$\lambda = 25$

[a] The depth of the bound-state well was adjusted to give the correct binding energy as determined by the separation energy procedure $E = [20.578 - Q(^3\mathrm{He}, \alpha)]$ MeV.

The $l_n = 0$ component observed in the present work leads to an unambiguous $J^\pi = 3^+$ assignment for the lower member. The "level" observed at 4201 keV in the present study also corresponds to two states at 4191 and 4202 keV, the lower of which has previously been assigned 3^+, $T = 1$.

Characteristic $l_n = 1$ shapes were observed for states at 4437, 5601, and 6792 keV, thus requiring negative parity and $J = 1$ to 4 for these levels. The level at 4437 keV has not been previously observed and now becomes the lowest-lying known negative-parity state in ^{26}Al. The J^π limits on the other two levels are also new.

All remaining angular distributions characteristic of direct pickup exhibit $l_n = 2$ shapes, and allow new J^π assignments of 0^+ to 5^+ for the levels at 4355, 4948, and 5731 keV.

IV. $T = 1$ STATES AND THE DETERMINATION OF N

Spectroscopic factors extracted for ^{27}Al(^{3}He, α) transitions to $T = 1$ states in ^{26}Al should be identical to those extracted for ^{27}Al(d, ^{3}He) transitions to their ^{26}Mg analogs. The latter reaction has been extensively studied by several groups,[15,20] and the spectroscopic factors obtained from those studies are in close agreement. Table III shows the values of NS for $T = 1$ states from the present (^{3}He, α) study, in comparison with the values of S obtained from the (d, ^{3}He) studies. The right-hand column gives the ratios of these quantities which should in principle be equal to N, the (^{3}He, α) normalization factor.

Of the known $T = 1$ states in ^{26}Al, three of the first five are members of closely spaced doublets or triplets and only the 0.23-MeV (0^+, $T = 1$) and 3.16-MeV (2^+, $T = 1$) levels are believed to be single states. In view of the close agreement obtained for N for these two states (29.1 and 27.8), the values of C^2S given in Table I were obtained using the mean of these two values, i.e., $N = 28.5$. It should be noted that the value of N obtained in this manner is in no way intended to be absolute, but merely represents a self-consistent value for the present experiment. As such it contains all systematic errors that may be present, such as inaccuracy in the target thickness, etc. However, it is worth pointing out that the value of N thus obtained does lie well within the range of other values obtained for this quantity.[21]

The analog to the 1.81-MeV, 2^+ state of ^{26}Mg is at 2070 keV in ^{26}Al and is one of a triplet of states. The fact that NS for the triplet in the ^{27}Al(^{3}He, α) reaction is only 31.7 times the value S for the ^{26}Mg analog in the ^{27}Al(d, ^{3}He) reaction indicates that the other two members of the triplet in ^{26}Al are only very weakly excited.

Analogs to the 3.59-MeV (0^+) and 3.94-MeV (3^+) states in ^{26}Mg are both members of doublets in ^{26}Al at $E_x = 3757$ and 4201 keV, respectively. In both cases the value of NS(^{3}He, α) is about 70 times S(^{3}He, α), indicating that the $T = 0$ members of these two doublets are appreciably excited. This is already clear in the case of the 3757-keV doublet, since its angular distribution contains a large $l_n = 0$ component and the 0^+, $T = 1$ member of the doublet cannot be reached by $l_n = 0$ transfer.

A triplet of states in ^{26}Mg at 4.3 MeV excitation was seen to have a large $l_n = 2$ spectroscopic factor, the largest observed in the ^{27}Al(d, ^{3}He) reaction. The strongest transition in the required ex-

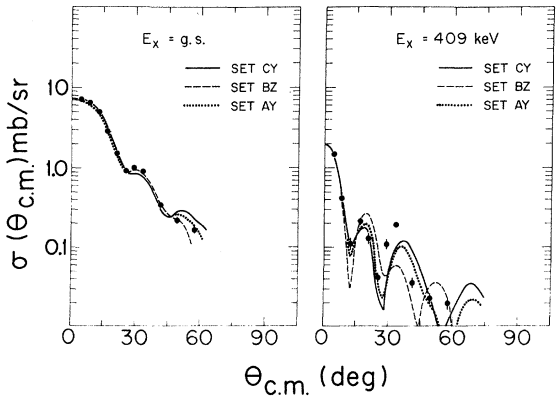

FIG. 5. Comparison between the data for the ground-state and 0.42-MeV transitions and the distorted-wave predictions using the parameter sets noted in Table II.

TABLE III. Comparison of ^{27}Al(^{3}He, α) with ^{27}Al(d, ^{3}He) for $T = 1$ states.

^{27}Al(^{3}He, α) ^{26}Al (MeV)	l_n	NS	J^π [b]	^{27}Al(d, ^{3}He) [a] S	l_p	^{26}Mg (MeV)	N
0.223	2	12.24	0^+	0.42	2	0.00	29.1
2.070 [c]	2	44.64	2^+	1.41	2	1.81	31.7
3.163	2	9.18	2^+	0.33	2	2.94	27.8
3.757 [c]	0	1.86	0^+			3.59	
	2	1.44		<0.02	2		>72.0
4.201 [c]	0	0.18	3^+			3.94	67.5
	2	2.70		0.04	2		
4.711	2	76.69	... 4^+	3.08	2	{4.31 4.33}	26.6
4.948	2	5.22	2^+			4.35	
5.144	0	5.34	2^+	0.17	0	4.83	31.4
5.731	2	16.14	4^+	0.36	2	5.48	44.8
6.358	0	1.29	$(2)^+$	<0.05	0	6.13	>25.8
	2	5.73		0.18	2		31.8

[a] References 15 and 20.
[b] Spin and parity of state in ^{26}Mg (Refs. 15 and 20).
[c] Known doublet or triplet.

citation range in ^{26}Al is that to the 4711-keV level, suggesting that this may be the $T=1$ analog of one of the three states in ^{26}Mg. On the basis of the large spectroscopic factor predicted for a 4^+, $T=1$ state at this excitation (see Sec. VI), the 4711-keV is proposed as the analog to the 4.33-MeV (4^+) member of the ^{26}Mg triplet. The (^{3}He, α) strength observed to the 4711-keV level is, however, insufficient to account for all the (d, ^{3}He) strength to the ^{26}Mg triplet. The (^{3}He, α) transition to the 4948-keV state has a moderately large $l_n=2$ spectroscopic factor, enough to account for the missing strength, strongly suggesting that this state also has $T=1$ character.

It has been previously proposed from a comparison of the results of the ^{25}Mg(d, n)^{26}Al and ^{25}Mg-(d, p)^{26}Mg reactions[4] that the 5144-keV state in ^{26}Al is the $T=1$ analog of the 4.83-MeV (2^+) state of ^{26}Mg. This is also consistent with the present results.

The strong $l_n=2$ transition to the 5731-keV state in ^{26}Al suggests that this state is probably the analog of the 5.48-MeV (4^+) state in ^{26}Mg. The fact that NS(^{3}He, α) for this level is about 45 times the value S for the corresponding state in ^{26}Mg (compared to an expected value of $N\simeq 29$) indicates that the ^{26}Al level may be an unresolved doublet—the other member having $T=0$. However, in the ^{24}Mg-(^{3}He, p) reaction,[1] the 5731-keV ^{26}Al level is observed to be populated with an angular distribution whose shape is characteristic of pure $L=4$. Thus, if another state is indeed present then it either has $J^\pi=(3,4,5)^+$ and $T=0$, or it is only weakly populated in the ^{24}Mg(^{3}He, p) reaction.

The $l_n=0$ and 2 (^{3}He, α) spectroscopic factors for the transition to the 6358-keV level in ^{26}Al agree well with those for the $l_p=0+2$ (d, ^{3}He) transition to the 6.13-MeV state in ^{26}Mg and therefore suggest a $T=1$ assignment for the ^{26}Al level.

V. SUM RULES

If the ^{27}Al ground state consists of an odd neutron in the $1d_{5/2}$ orbit, with no additional excitations, the expected values[22] for the summed spectroscopic factors are $\sum C^2S(l=2)=6$ and $\sum C^2S(l=0)=0$. The experimental values for these quantities are, respectively, 4.50 and 0.33. The presence of a small, but nevertheless significant, $l_n=0$ strength indicates the presence of correlations in the ^{27}Al ground state involving the promotion of particles into the $2s_{1/2}$ shell.

The expected[22] isospin splitting of the $1d_{5/2}$ strength leads to $\sum S_{T=1}=7.5$ and $\sum S_{T=0}=3.5$. The measured strength for the known $T=1$ states (including those assigned in the present work, but neglecting the 3757- and 4201-keV states) is 6.05, while that for the $T=0$ states equals 2.45. Each of these quantities represents approximately the same fraction of the predicted values.

The splitting of the $T=0$ and $T=1$ ($l_n=2$) centroids is 2.5 MeV which yields a value of 67.5 MeV for the strength of the symmetry potential. This is consistent with other values obtained for this quantity.

The $l_n=1$ spectroscopic factors sum to 0.32 and thus represent only a small fraction of the theoretical strength for the $1p$ shell. The majority of the negative-parity strength presumably resides at higher excitations. This is borne out by the observation of several strong $l_p=1$ transitions in the ^{27}Al(d, ^{3}He)^{26}Mg reaction at $E_x>7.0$ MeV, whereas none is seen at lower excitations.

VI. THEORETICAL SPECTROSCOPIC FACTORS

In a simple shell-model picture, the low-lying states of ^{26}Al are expected to be characterized by the coupling of a $1d_{5/2}$ proton hole and $1d_{5/2}$ neutron hole to an inert ^{28}Si core. This scheme gives rise to states with $J^\pi=0^+$ to 5^+; the even-J states having $T=1$ and the odd-J, $T=0$. In this picture the ^{27}Al ground state is simply a $1d_{5/2}$ proton hole and the neutron-pickup spectroscopic factors are then given by an expression due to Macfarlane and French,[23] viz.:

$$C^2S_{J_f}=\tfrac{1}{6}(2J_f+1),$$

where J_f refers to the spin of the ^{26}Al state within the multiplet. These are listed in Table IV.

Alternatively, a description of ^{26}Al in terms of the strong-coupling Nilsson model, although providing states with the same spins and parities as above, gives quite different predictions for the pickup spectroscopic factors. In this model the ground state of ^{27}Al is described as an odd proton and two paired neutrons in Nilsson orbital No. 9, $\frac{5}{2}^+[202]$.

Pickup of one of the neutrons in this orbit then gives rise to two rotational bands in ^{26}Al, one with $K^\pi=5^+$ and one with $K^\pi=0^+$. The ^{26}Al ground state would then, in this picture, be the band head of the $K=5$ band formed by the parallel coupling of the remaining neutron and proton in this orbit. The $K=0$ band formed by the antiparallel coupling is split into even-spin states with $T=1$ and odd-spin states with $T=0$. Spectroscopic factors for transitions to such states were calculated with Satchler's formula[24] using Chi's expansion coefficients of the Nilsson eigenfunctions in terms of spherical shell-model orbits.[25] The nature of the $\frac{5}{2}^+[202]$ Nilsson orbit is such that the predicted spectroscopic factors for these two bands are independent of the deformation parameter. The resulting predictions are shown in Table IV.

TABLE IV. Comparison of $l_n = 2$ spectroscopic factors with the predictions of various models.

Experiment					Shell model [a]	
E_x (MeV)	J^π	C^2S	$(1d_{5/2})^{-2}$	Nilsson	"$2s_{1/2}$-$1d_{5/2}$"	"$2s_{1/2}$-$1d_{5/2}$-$1d_{3/2}$"
0	5^+	1.05	1.83	1.00		1.00
0.223	0^+, $T=1$	0.14	0.17	0.17	0.15	0.14
1.052	1^+	0.32	0.50	0.36		0.31
1.849	1^+	(0.02)				0.02
2.070 [b]	2^+, $T=1$	0.52	0.83	0.30	0.38	0.31
2.365	3^+	0.28	1.17	0.13		c
2.544	3^+	0.31				c
3.163	2^+, $T=1$	0.11			0.14	c
3.405	5^+	0.09				0.12
4.711	$(4^+, T=1)$	0.90	1.50	0.04	0.90	c

[a] References 20, 26, and 27.
[b] Assumed experimental strength all due to 2^+, $T=1$ member of this known triplet.
[c] Not available.

It is unlikely that either of these simple models will provide an adequate description of the present results. A more likely solution is to be found in the detailed shell-model calculations that are currently being performed. Two sets of calculations exist which are applicable to the present study. One was performed for only the $T=1$ states,[20] the other includes both $T=0$ and $T=1$ states.[26,27] The former calculation assumed an inert ^{16}O core and the 10 valence nucleons were allowed to occupy the $1d_{5/2}$ and $2s_{1/2}$ orbits. The latter allowed the valence nucleons to occupy the full $2s$-$1d$ shell space but with the restriction that at least eight remain in the $1d_{5/2}$ orbit. The results of these two calculations are also given in Table IV. Also listed are the experimentally measured spectroscopic factors for those states identified with the various model states.

VII. DISCUSSION AND CONCLUSIONS

It is apparent from Table IV that the detailed shell-model calculations are by far the most successful of the various calculations of spectroscopic factors. The earlier statement[14] that a $(1d_{5/2})^{-2}$ calculation provides an adequate description of the low-lying states is incorrect. Those authors compared only relative spectroscopic factors and hence did not observe the large discrepancy between the measured and calculated values of the absolute spectroscopic factors for the ground-state transition. Also, since the 3^+ state at 409 keV is populated with essentially pure $l_n = 0$, it is clear that this state is not to be identified with the 3^+ state expected from a $(1d_{5/2})^{-2}$ calculation as suggested in Ref. 14. In fact, the $l_n = 2$ strength to known 3^+ states is quite fragmented, with the two states at 2365 and 2544 keV sharing most of the strength.

The Nilsson model correctly predicts the strengths for the ground- and first-excited-state transitions, but fails for higher excited states. A similar failure has been observed in studies of stripping to ^{26}Al.

Although the shell-model predictions are very preliminary they are in remarkable agreement with the experimental results for several of the low-lying states. It is striking that the large strength predicted for a 4^+, $T=1$ state agrees so well with that observed for the transition to the 4.711-keV state. This agreement strengthens the suggestion that this state has $T=1$ and is the analog of the 4.33-MeV ^{26}Mg state.

The fragmentation of the strength observed in the present reaction may in part be attributed to deformation—the nucleus ^{26}Al has recently been shown to possess rotational structures.[7,11,12,28] However, the good agreement between the preliminary shell-model calculations and the data is most encouraging and it will be interesting to see if further calculations of this type are able to reproduce more of the salient features of ^{26}Al and other complicated nuclei in this mass region.

VIII. ACKNOWLEDGMENTS

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