^{25}Mg(^{3}He,d)^{26}Al to high spin states

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Proton stripping with the 55.2 MeV ^{25}Mg(^{3}He,d)^{26}Al reaction has been used to populate 6^- states known from other reactions or by analogy to the states excited in ^{26}Mg by electron scattering. Spectroscopic factors are, in general, in good agreement with those obtained in a lower resolution study of the ^{25}Mg(α,t)^{26}Al reaction, when similar reaction distorted-wave Born approximation calculations are made. More high-lying states are found in the (^{3}He,d) study than in the (α,t) work. The differences between scattering and single-proton stripping excitation of the simple stretched states are confirmed.

I. INTRODUCTION

As part of a program to establish the spectroscopic features of the stretched 6^- $(d_{5/2}^{-1}f_{7/2})$ states in mass 26, we have measured cross sections for the ^{25}Mg(^{3}He,d)^{26}Al reaction. These proton stripping results explicitly give the $f_{7/2}$ single-particle strengths based on the $\frac{5}{2}^+$ ground state of the target. Cross sections were also measured for several 5^- and 4^- states of ^{26}Al.

Although the (^{3}He,d) results could seem to be redundant, since the (α,t) single-proton spectroscopic factors[1] have already been reported, there are several advantages to the work reported here. The better resolution of 55 keV at high excitations, compared to 90 keV obtained for the (α,t) study, gives cleaner results and several higher states. The (α,t) reaction emphasizes the higher angular momentum transfers such as for the desired $f_{7/2}$ transitions, but gave rather unstructured angular distributions. A test of our DWBA reaction models is accomplished by also using the (^{3}He,d) reaction. If the same spectroscopic factors are obtained, the validity of the results is confirmed. In the (α,t) work, the 6^- $T=1$ analogs of several states known from electron scattering studies[2] on ^{26}Mg were not investigated. Since we desire the most comprehensive comparison of the ensemble of 6^- states, we have more thoroughly investigated the appropriate region of the ^{26}Al spectrum for these analogs.

The DWBA reaction calculations that we have compared to the (^{3}He,d) data are based on the same models, reaction codes, and parameters that were used for the ^{25}Mg(α,t)^{26}Al work,[1] for neutron stripping ^{25}Mg($\alpha,^3$He)^{26}Mg,[3] for the neutron pickup ^{27}Al(p,d)^{26}Al,[4] and for the electron scattering analysis with a ^{26}Mg target.[5] Since the desired spectroscopic factors are quite sensitive to some of these choices, this consistency is valuable to provide results that may be compared for a variety of reactions. Some results from a reanalysis of the ^{25}Mg(α,t)^{26}Al data[1] were also obtained, based on more recent spectroscopic information.

It has been shown theoretically in the lead region that correlations among the nucleons lead to a distribution of shell occupancy that quenches electron scattering form factors for stretched magnetic transitions.[6] For mass 26, we have the opportunity to determine these occupancies for the stretched states by pickup reactions, as in Ref. 4, and by stripping reactions to the states which are analogs of those examined by electron scattering. In a simpler nucleus than the lead region, we are thus able to carry out a systematic test of this origin for quenching the high multipole magnetic response of complex nuclei.

II. EXPERIMENTAL METHODS

The (^{3}He,d) spectra with excitation energies below 9.5 MeV were obtained with the 55.20 MeV ^{3}He beam of the Institute for Nuclear Study (INS) sector-focused cyclotron and a target of 97.9% enriched ^{25}Mg. A second run at 55.34 MeV gave spectra up to 16 MeV of excitation. Reaction products were analyzed by a magnetic spectrometer and detector system as described for our work on the (p,d) reaction.[4] An overall resolution of 38 keV was obtained at low excitations, with 55 keV at higher excitations. Sample spectra are shown as Figs. 1, 2, and 3, with the latter emphasizing the close doublet of 5^- states at 8.0 MeV. Our excitation energy calibration was based on well-known states of ^{26}Al and prominent light impurities. The uncertainties in excitation energies are estimated to be ± 5 keV below 8 MeV, ± 10 keV below 9.5 MeV, ± 15 keV up to 12.8 MeV, and ± 20 keV above this.

Elastic scattering cross sections taken for the same target and conditions are shown in Fig. 4. A search for optical model parameters to fit these data also included a nor-

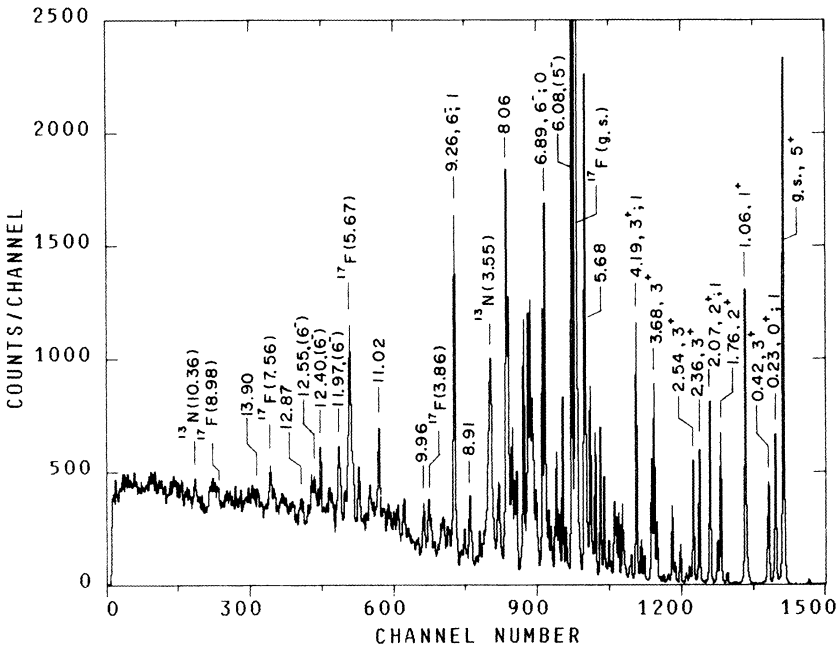

FIG. 1. A spectrum showing the low-lying states of ^{26}Al excited in the ^{25}Mg(^{3}He,d)^{26}Al reaction at 10°.

malization factor to correct for uncertainties in the target thickness and solid angle. This factor was also used for the stripping cross sections, which we estimate are known to an absolute uncertainty of ±10%. The three highest 6^{-} states analyzed in this work have an additional ±30% uncertainty due the underlying continuum.

Data for two prominent peaks in the ^{25}Mg(α,t)^{26}Al spectra of Ref. 1 were analyzed to complement the present results. Strong peaks were calibrated at 5.674 and 6.080 MeV, with uncertainties of ±10 keV. Angular distributions are shown in Fig. 5. We identify these with strong peaks seen in the present work at 5.682 and 6.083 MeV.

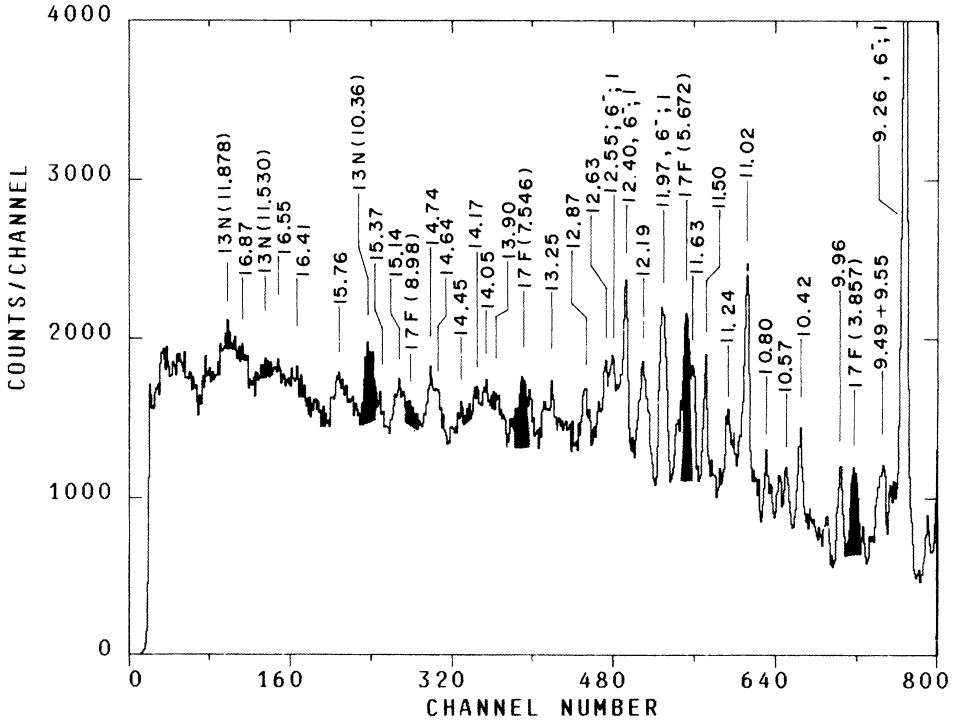

FIG. 2. A spectrum to show the higher states excited in the ^{25}Mg(^{3}He,d)^{26}Al reaction, at an angle of 10°. Prominent impurity peaks are cross hatched.

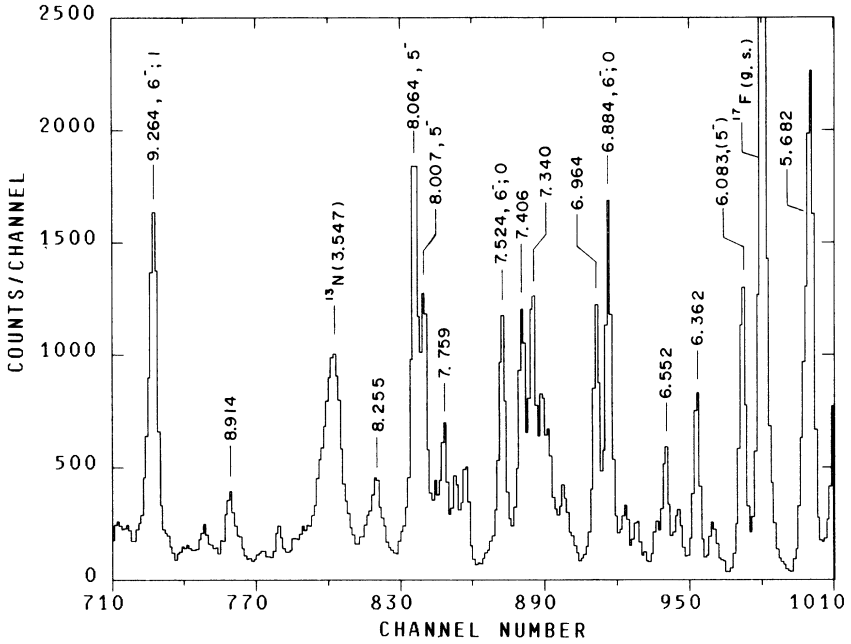

FIG. 3. An expanded spectrum from the ^{25}Mg(^{3}He,d)^{26}Al reaction at 10° to show the 8.0 MeV 5$^-$ doublet and several important 6$^-$ peaks.

III. REACTION CALCULATIONS

Stripping cross sections for the (^{3}He,d) reaction have been compared to results of DWBA calculations to check the l assignments and to assign spectroscopic factors. All calculations for bound final proton states have been carried out in the exact-finite-range EFR(q) method used for the (α,t) analysis[1] using the code DWUCK5.[7] The structure of the light particle was obtained from electron scattering analyses, and extended to $q = 10$ fm^{-1}. Spectroscopic factors are defined by the expressions in Ref. 1, with stripping to a single state $J;T$ exhausting the single-particle strength giving a unit spectroscopic factor. All reported spectroscopic factors will thus be fractions of this single-particle standard.

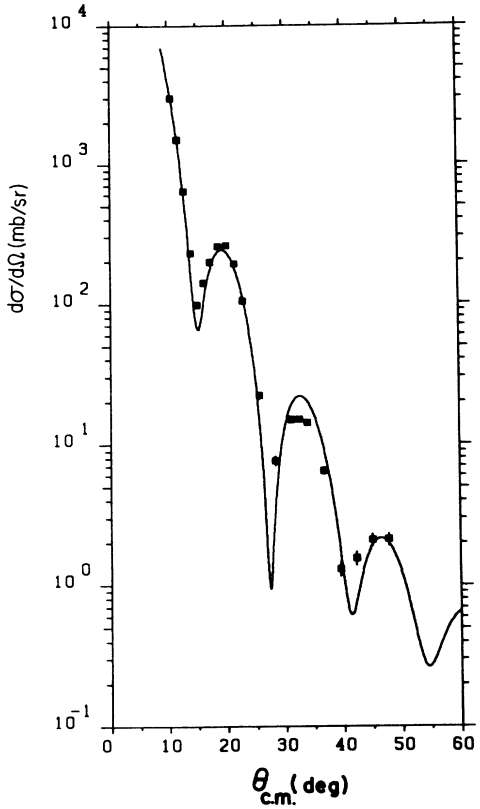

FIG. 4. Angular distribution for elastic scattering of 55.2 MeV ^{3}He from ^{26}Mg and the fit obtained with the optical model using the parameters listed in Table I.

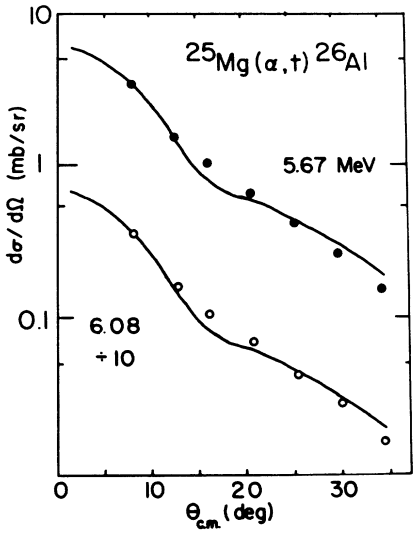

FIG. 5. Reanalyzed data from the ^{25}Mg(α,t)^{26}Al reaction from Ref. 1 for prominent peaks at 5.67 and 6.08 MeV. Cross sections for these peaks seen in the (^{3}He,d) reaction are shown in Fig. 6. No spin assignments are available, but good fits are found with the $f_{7/2}$ EFR stripping calculation, as shown by the solid curves.

TABLE I. Optical model parameters for the DWBA calculations reported for the (^{3}He,d) reaction at 55.2 MeV, determined for the ^{3}He case by elastic scattering measured on ^{25}Mg.

	^{3}He	d[a]	
V	−116.0	−69.68	MeV
r_0	1.14	1.23	fm
a	0.782	0.74	fm
W_V	−20.6	−2.97	MeV
r_W	1.59	1.26	fm
a_W	0.762	0.75	fm
$4W_D$	0	44.08	MeV
V_{SO}	0	−20.4	MeV
r_{SO}		1.20	fm
a_{SO}		0.35	fm
r_C	1.4	1.3	fm
β (nonlocal)	0.25	0.54	fm
J_R/A_1A_2	371	382	MeV fm^3

[a]K. Hatanaka *et al.*, Nucl. Phys. **A340**, 93 (1980).

Optical model parameters used for the distortions are listed in Table I. Those for ^{3}He were determined by a fit to elastic scattering data at 55.2 MeV obtained during the same series of experiments used for the stripping and (^{3}He,α) pickup reactions.[4] Deuteron parameters are from Ref. 8, determined from 33 MeV deuteron elastic scattering. Since the proton is stripped into a state bound by a Woods-Saxon potential with radius $1.25A^{1/3}$ fm, with diffuseness $a=0.65$ fm, these potentials are approximately well matched. This bound state geometry is just as used for the (α,t) reaction.[1] All optical model parameters for the present work, the neutron[2] and proton stripping[1] and the neutron pickup by (p,d) and (^{3}He,α) reactions,[4] belong to the same family, with real volume integrals J_R/A_1A_2 near 400 MeV fm^3. Relative results will thus be particularly reliable in this program.

At the high-momentum mismatch of the (α,t) reaction, angular distributions do not give clear evidence of the l transfer, but high-l states are enhanced. As seen in Figs. 1–3, the (^{3}He,d) reaction gives less relative enhancement to the high-spin states but still gives a good reaction yield. Angular distributions for the (^{3}He,d) reaction show more sensitivity to the l value. Only when the correct l value has been used to analyze a state will the spectroscopic factors for the (^{3}He,d) and (α,t) reactions agree.

The light-particle form factor in the EFR(q) method has magnitude $D_0(q=0)$ of -232.5 MeV fm$^{3/2}$, compared to a value of -225 MeV fm$^{3/2}$ assumed for the zero-range calculations. At $q=0.54$ fm^{-1}, the approximate value for the ^{25}Mg(^{3}He,d)^{26}Al reaction at 10 deg to a 6 MeV excited state, $D_0(q)=-27.2$ MeV fm$^{3/2}$ and $D_2(q)=120$ MeV fm$^{3/2}$. Nonlocal influences for all particles were also included in all DWBA calculations. The local energy approximation was used to approximate finite-range effects in the zero-range calculation, using the code DWUCK4,[9] using a range parameter of 0.77 fm.

Spectroscopic factors are evaluated such that stripping to an empty single-particle state of either isospin $T_f=0$ or 1 would give unity:

$$\frac{d\sigma}{d\Omega}=\frac{d\sigma}{d\Omega}\bigg|_{\rm DW} C^2sS\frac{(2J_f+1)}{(2J_i+1)} .$$

The light-particle proton spectroscopic factor is $s=2$, and the isospin Clebsch-Gordon factors C^2 are $\frac{1}{2}$ for both $T_f=0$ and $T_f=1$.

For stripping to unbound states, it was found that the EFR (DWUCK5) calculations failed to match the shape of the forward angle data. Only bound nucleon states are permitted in this reaction code, so for unbound states a binding of 0.1 MeV was used. In comparing zero-range (DWUCK4) calculations for such bound and for properly unbound transitions of the same Q value this same feature is seen. It is evidently the assumed bound state used for the DWUCK5 computations that leads to the failure to fit. Our spectroscopic factors for states above 6.31 MeV are therefore obtained from the zero-range (DWUCK4) comparisons for stripping to the unbound final states, with a correction for the ratio of EFR to zero-range predictions for the same Q value for transitions bound by 0.1 MeV. This correction, taken at 10°, was unity at the 6.1 MeV excited states and 0.835 at 16.5 MeV. Spectroscopic factors are from the fits as shown to the DWUCK4 curves, using

$$\frac{d\sigma}{d\Omega}=4.42C^2S\frac{(2J_f+1)}{(2j+1)(2J_i+1)}\frac{d\sigma}{d\Omega}({\rm DW4})R ,$$

with

$$R=\frac{d\sigma({\rm DW5})}{d\sigma({\rm DW4})}\bigg|_{\rm bound}\frac{d\sigma({\rm DW4-6.1\ MeV})}{d\sigma({\rm DW5-6.1\ MeV})} .$$

Results are summarized in Table II. For states below an excitation energy of 6.31 MeV, the EFR results are listed, while for higher states the zero-range results are shown, with the EFR correction factor.

If we had used the EFR fits shown, falling below the data at zero deg, with a correction for binding energy as used in Ref. 1 for the (α,t) reaction, spectroscopic factors obtained would be a factor of 2 lower for the 16.55 MeV peak, for instance. If these curves were instead normalized to the smallest angle data points, the spectroscopic factors would agree very closely with the converse scheme. We conclude that insistence upon fitting the forward angle data points will give equal spectroscopic factors for EFR (corrected for unbound effects) and zero-range-unbound (corrected for EFR effects) calculations.

For the ^{27}Al(p,d)^{26}Al reaction at 35 MeV to a 7.0 MeV 6^- state as in Ref. 4, the momentum transfer at the peak of the $l=3$ angular distribution is 0.63 fm^{-1}; for the ^{25}Mg(^{3}He,d)^{26}Al reaction at 55 MeV to such a 6^- state at zero deg, the same momentum transfer is obtained. We thus prefer to normalize data and calculations at zero deg. This matching is not possible for the ^{25}Mg(α,t)^{26}Al study, where larger momentum transfers are obtained.

Uncertainties in spectroscopic factors due to the reaction calculations are more difficult to establish. Given the same bound state geometry as used for other reactions,[1,2,4] less uncertainty arises for the relative spectroscopic strengths. Uncertainties due to optical model pa-

TABLE II. Stripping spectroscopic factors to high-spin negative parity states of ^{26}Al from the ^{25}Mg(^{3}He,d)^{26}Al reaction. Results from the ^{25}Mg(α,t)^{26}Al reaction from Ref. 1 are also listed. All results for bound states are from the EFR(q) method, and only $f_{7/2}$ stripping is considered. Above the proton binding, the zero-range results are listed for the (^{3}He,d) experiment, after corrections for EFR effects. Even for cases of expected isospin mixing, the listed assignments are used to evaluate spectroscopic factors.

State (MeV)	$J^\pi;T$	$S(^3\text{He},d)$	$S(\alpha,t)$[a]
5.397	$4^-;0$	0.10	0.10
5.682	$(J_f^-);0$	$2.76/2J_f+1$	$3.19/2J_f+1$[b]
6.083	$(J_f^-);0$	$3.43/2J_f+1$	$3.52/2J_f+1$[b]
6.884	$6^-;0$	0.13	0.16
6.964	$3^-;1$	0.24	0.18
7.168	$4^-;0$	0.046	
7.524[c]	$6^-;0$	0.11	0.15
8.007	$5^-;(0)$	0.10	0.14
8.064	$5^-;(1)$	0.18	0.19
9.264	$6^-;1$	0.17	0.20
11.966	$6^-;1$	0.046	0.080
12.405	$6^-;1$	0.029	0.065
12.554	$6^-;1$	0.017	0.058
13.250	$6^-;1$	0.015	
14.050	$6^-;1$	0.012	
14.744	$6^-;1$	0.018	
15.371	$6^-;1$	0.0095	
16.55	$6^-;1$	0.012	d
$\sum 6^-;0$		0.24	0.31
$\sum 6^-;1$		0.33	0.40

[a]Reference 1.
[b]Analysis included in the present work.
[c]Doublet Ref. 11.
[d]A peak at 16.83 MeV in Ref. 1 seems to have been due to the (α,d) reaction.

rameters are discussed in Ref. 1, where these are found to be small. As discussed above, for forward angle comparisons DWUCK5 and DWUCK4 results agree.

IV. RESULTS AND DISCUSSION

Angular distributions and DWBA comparisons for the 4^-, 5^-, and 6^- states populated in the ^{25}Mg(^{3}He,d)^{26}Al reaction are shown in Figs. 6–10. All solid calculated curves use the EFR(q) method described in Sec. III. The 4^-, 5^-, 6^- assignments came from previous work,[10,11] up to the 9.62 MeV peak, and match the (α,t) work above that. Dashed curves are from the zero-range calculations.

Spectroscopic factors extracted from a comparison of the data to the DWBA calculations are listed in Table II, where they are compared to the (α,t) results, where available. The agreement is excellent below 10 MeV, confirming the $f_{7/2}$ nature of the stripping reactions at greatly different momentum transfers. At higher excitations, the important role of the binding energy seems to influence the two reactions differently. A peak analyzed in the (α,t) data at 16.83 MeV was probably due to the (α,d) reaction and is not included in this list.

The calibrated positions of the peaks agree very well with those obtained in recent (p,γ) studies,[10,11] and all angular distributions are consistent with those expected for $l=3$ stripping. Spins and parities are from the (p,γ) studies, when available. Further consideration of the spectroscopy of ^{26}Al may be found in Ref. 4. For the 5.39 MeV 4^- peak, a $p_{3/2}$ stripping would be possible, but the dotted $p_{3/2}$ curve compared to the data in Fig. 6 fails to agree with the stripping cross sections. Some $p_{3/2}$ contribution seems needed for the 7.168 4^- data, with the spin assignment from Ref. 10 for a state at 7.164 MeV. Only the $f_{7/2}$ fit shown is used for the spectroscopic factor. The dotted curve compared to the 6.08 MeV data in Fig. 6 is from a $d_{5/2}$ stripping calculation. This does not match the data as well as the $f_{7/2}$ calculation shown as the solid curve.

A $5^-;0$ level is found at 7.548 MeV in ^{26}Al in Ref. 11,

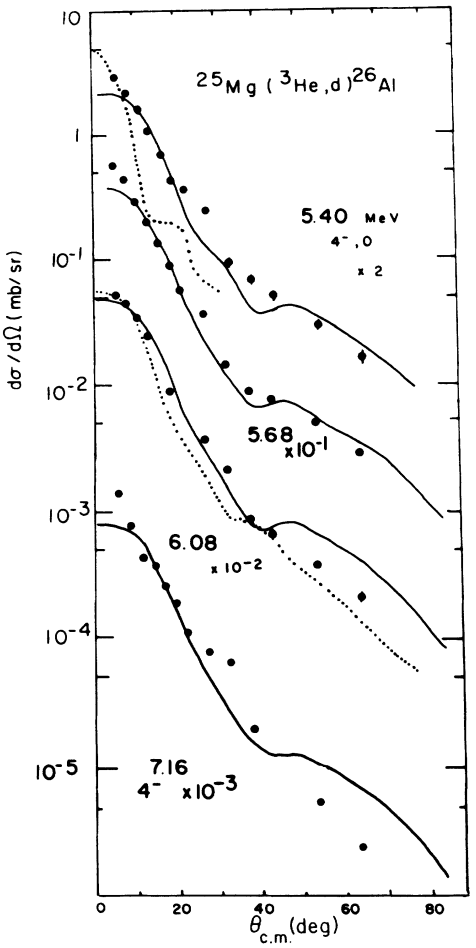

FIG. 6. Cross sections for the (^{3}He,d) reaction to two known 4^- states of ^{26}Al and to the two prominent peaks known from the (α,t) study are compared to EFR $f_{7/2}$ stripping calculations as the solid curves. The dotted curve compared to the 5.40 MeV results is for $p_{3/2}$ stripping, as permitted by the low spin, while a $d_{5/2}$ EFR prediction is compared to the 6.08 MeV data by the dotted curve.

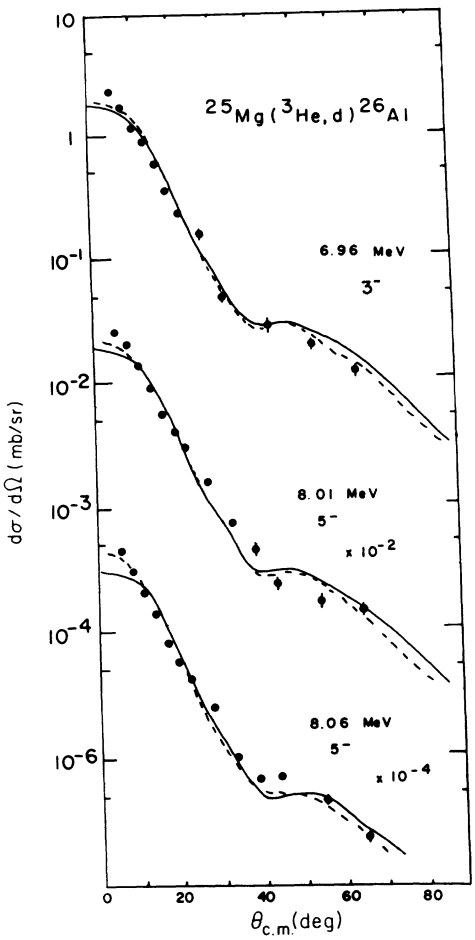

FIG. 7. Data for proton stripping to known 5^- states and one 3^- state of ^{26}Al are compared to $f_{7/2}$ EFR calculations shown by the solid curves. These calculations assume a slightly bound final state. Zero-range calculations with unbound wave functions are shown by the dashed curves.

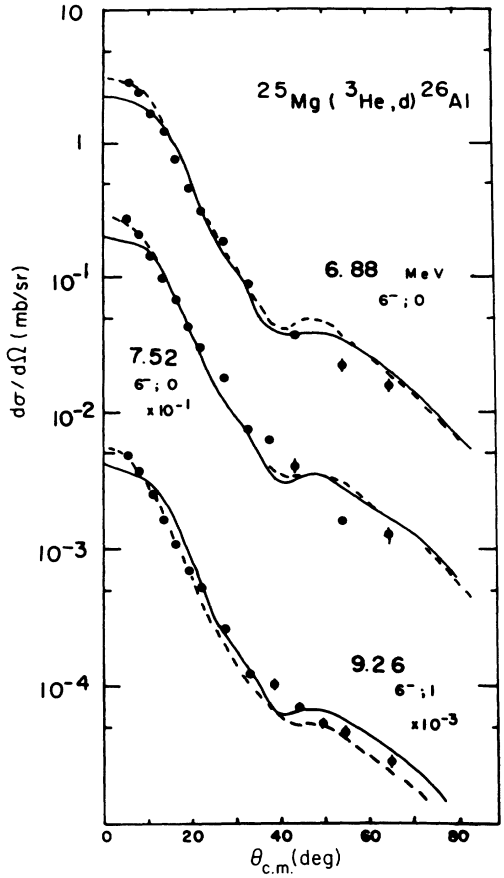

FIG. 8. Cross sections for the lowest 6^- states of ^{26}Al are compared to DWBA predictions for $f_{7/2}$ stripping, with the solid curves from an EFR model and dashed curves for a zero-range model with unbound wave functions. These curves are normalized to the data in the overall region near 20°.

TABLE III. Proton stripping spectroscopic factors for high spin states in ^{26}Al are compared to Nilsson calculations for an empty $f_{7/2}$ shell.

E_x (MeV)	$J^\pi;T$	$S(^3\text{He},d)$[a]	$S(\alpha,t)$[b]	$S(\alpha,^3\text{He})$[c] analog	K Ω	S_{calc}
6.88	$6^-;0$	0.13	0.16		$6\ \frac{7}{2}$	0.21
7.52	$6^-;0$	0.11	0.15		$5\ \frac{5}{2}$	0.10
8.01	$5^-;(0)$	0.10	0.14			
8.06	$5^-;(1)$	0.18	0.19	0.21	$5\ \frac{5}{2}$	0.12
9.26	$6^-;1$	0.17	0.20	0.13	$6\ \frac{7}{2}$	0.21
11.97	$6^-;1$	0.046	0.080	0.029	$5\ \frac{5}{2}$	0.10
12.40	$6^-;1$	0.029	0.065	0.056	$4\ \frac{3}{2}$	0.030
12.55	$6^-;1$	0.017	0.058	0.013	$3\ \frac{1}{2}$	0.016
13.25	$6^-;1$	0.015		0.005	$2\ \frac{1}{2}$	0.007
14.05	$6^-;1$	0.012		0.017	$1\ \frac{3}{2}$	0.003
14.74	$6^-;1$	0.018		0.012	$0\ \frac{5}{2}$	0.001
15.37	$6^-;1$	0.0095			$1\ \frac{7}{2}$	0.0003
16.55	$6^-;1$	0.012			?	
$\sum 6^-;0$		0.24	0.31			0.31
$\sum 6^-;1$		0.33	0.44	0.26		0.37

[a]This work.
[b]Reference 1.
[c]Reference 4.

but is not seen in the (^{3}He,d) spectra, and we identify the 7.524 MeV peak with the 7.529 MeV 6^-;0 level in Ref. 11. Two 5^- states are found very near 8.0 MeV in both (^{3}He,d) and (α,t) (Ref. 1) stripping and in (p,γ) studies.[11] Only one at 7.453 MeV is seen in the ($\alpha,^3$He) reaction to $T_z=1$ ^{26}Mg, so one of those in ^{26}Al must have $T=0$.

In the (α,t) reaction, the 6.96 MeV peak was not associated with a known spin,[1] but a 3^-;1 assignment comes from Ref. 11. This is used to obtain the spectroscopic factor for the (α,t) work in Table II.

The previous study of the ^{25}Mg(α,t)^{26}Al stripping reaction to 6^- states also populated strong peaks at 5.674±0.005 and 6.080±0.005 MeV.[1] Newly analyzed data and EFR(q) DWBA fits for $f_{7/2}$ stripping are shown in Fig. 5. The good fits give $(2J_f+1)S=3.19$ and 3.52, respectively. These compare very well with the (^{3}He,d) results to these same states, as compared in Table II. No spin assignments are available for these strongly excited states.

The sums of $f_{7/2}$ stripping spectroscopic factors are also listed for (^{3}He,d) and (α,t) results. Both are far short of the expected total of unity for both $T=0$ and $T=1$, 5^- and 6^- states. The problems pointed out in Ref. 1 are thus confirmed.

In the present analysis of the splitting of the stretched states in mass 26, only the simple Nilsson scheme will be used. The best account of the $f_{7/2}$ single-particle states seen in mass 25 by stripping reactions is obtained for negative deformations, even though the positive-parity ground state band gives evidence of positive deformations. The ^{24}Mg($\alpha,^3$He)^{25}Mg reaction,[3] when analyzed as in all our studies, gave a spectroscopic factor of 0.23 for the 3.97 MeV lowest $\frac{7}{2}^-$ state. If this is the (303) $K=\frac{7}{2}^-$ band head at $\beta=-0.3$, a spectroscopic factor of 0.25 is expected.

Since the ^{25}Mg target has $K_i=\frac{5}{2}^+$ and the most prominent single-particle state has $K_f=\frac{7}{2}^-$, we expect only

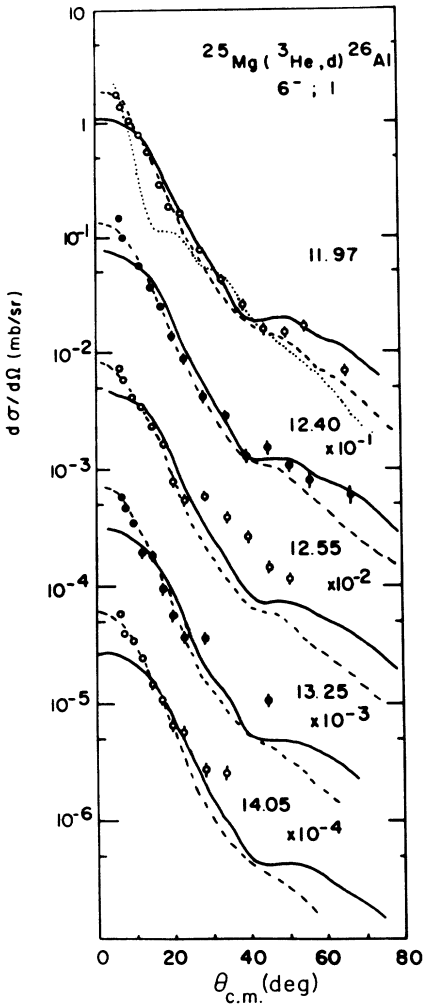

FIG. 9. Angular distributions for higher-lying states identified as having spins of 6^- by comparison to the $T=1$ levels of ^{26}Mg are compared to EFR calculations for $f_{7/2}$ stripping as the solid curves and zero-range (ZR) (unbound) calculations as the dashed curves. The ZR fits are used for the spectroscopic factors listed in Table II. A $d_{5/2}$ calculation is shown by the dotted curve compared to the 11.97 MeV data, but without agreement.

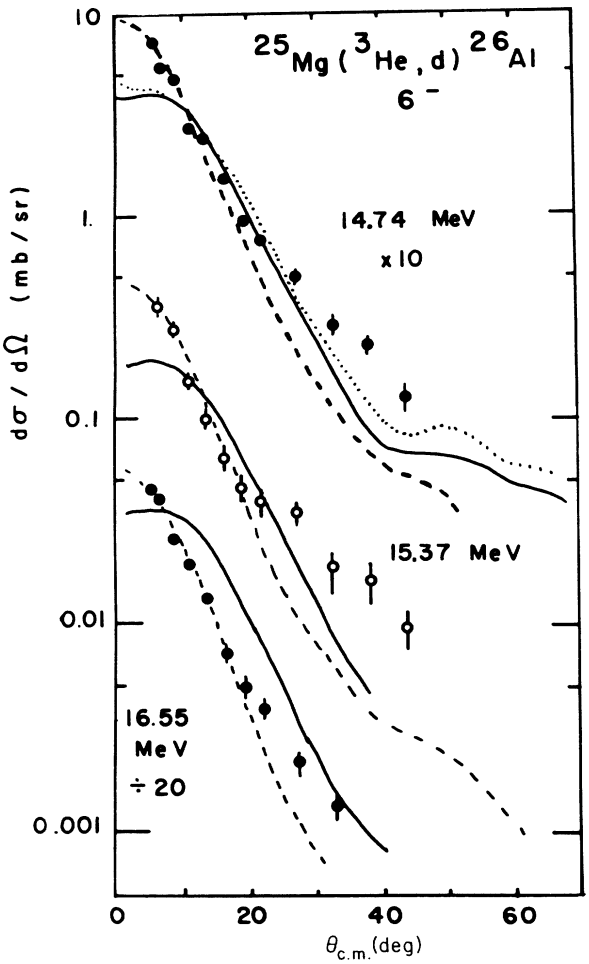

FIG. 10. Data for the three highest peaks of ^{26}Al identified as having spins 6^- are compared to $f_{7/2}$ stripping calculations, with the solid curves showing the EFR results and the dashed curves showing ZR (unbound) results giving the spectroscopic factors listed in Table II. The dotted curve for the 14.74 MeV data is for a zero-range calculation assuming a slightly bound proton, as must be assumed for the EFR solid curve.

TABLE IV. Excitation energies and transition strengths for mirror $6^-;1$ stretched states in mass 26 are compared. All strengths are expressed as percentages of the single-particle sum rule value.

^{26}Al			^{26}Mg		
E_x[a] (MeV)	$(^3He,d)$[a]	(α,t)[b]	E_x[c] (MeV)	$(\alpha,^3He)$[c]	(e,e')[d]
9.264	17	20	9.169	13	6.4
11.968	4.6	8	11.945	2.9	
12.403	2.9	6.5	12.512	5.6	10.2
12.552	1.7	5.8	12.865	1.3	4.6
13.250	1.5		12.958	0.5	3.1
14.050	1.2		13.958	1.7	4.4
14.744	1.8		14.542	1.2	6.9
15.371	0.95		(15.36)[e]		7.5
			(15.46)[e]		13.6
16.555	1.2		16.58	0.9	18.6
Σ	33	40		27	75
$\bar{E}$ (MeV)	11.14			11.9	14.4

[a]This work.
[b]Reference 1.
[c]Reference 3.
[d]Reference 5, data from Ref. 2.
[e]Reference 2.

the $K=1^-$ and 6^- bands to be strong for stripping to mass 26, but the K-coupling angular momentum coefficients are very small for the smaller K. In Table III are listed the observed and computed spectroscopic factors for 5^- and 6^- states, with an assumed steady sequence of K assignments. (Occupation numbers for $\beta=-0.3$ were used.)[12] Quite good agreement, both absolute and relative, is found up to about 13 MeV. The small spectroscopic factors for the higher states are seen to match the predictions only in the sense of being small.

This Nilsson scheme for stripping to 6^- states also provides a means to compare the incoherent one-nucleon stripping on a single-hole state with the coherent inelastic scattering reactions, based on all possible hole states. For stripping to the band heads, the single-nucleon strength relative to the single-particle value will always be three times the single-particle fraction for the scattering.[13] The data for the two classes of reactions, analyzed by a consistent method, have previously been compared,[1] with the stripping data now confirmed with much better energy resolution and at a completely different momentum transfer.

All measured results for mirror $6^-;1$ states are compared in Table IV. At low excitations the stripping strengths exceed those for the electron scattering, but the electron scattering strength is the greater at high excitations. The spectrum of Fig. 2 shows that no stripping strength comparable to that found by electron scattering can be present in this region of excitation. A $T=2$ state at 18.0 MeV is prominent in electron scattering,[2] but inaccessible to the stripping reaction. If some isovector strength from the $T=2$ transition enhanced the electron scattering for the high-lying states in ^{26}Mg, these relative strengths could be rectified.

The isovector 6^- strength in the $^{40}Ca(p,n)^{40}Sc$ region is observed to be strongly fragmented,[14] as is the electron (isovector) strength in ^{26}Mg.[2] For mass 40 this fragmentation was found to match that of the $d_{5/2}$ hole state, whereas for mass 26 the hole strength is found only in the single $T=\frac{1}{2}$ and a single $T=\frac{3}{2}$ peak.[4] For mass 26, the stripping results show a fragmentation of the particle strength to be responsible for the distribution of 6^- transition strength, as seen in Table IV.

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[1]R. J. Peterson *et al.*, Phys. Rev. C **33**, 31 (1986).
[2]M. A. Plum, Ph.D. thesis, University of Massachusetts, 1985.
[3]J. J. Kraushaar *et al.*, Phys. Rev. C **34**, 1530 (1986).
[4]R. J. Peterson *et al.*, Phys. Rev. C (to be published).
[5]B. L. Clausen, R. J. Peterson, and R. A. Lindgren, Phys. Rev. C **38**, 589 (1988).
[6]V. R. Pandharipande, C. N. Papanicolas, and J. Wambach, Phys. Rev. Lett. **53**, 1133 (1984).

[7]DWUCK5, an exact-finite-range nuclear reaction code written by P. D. Kunz, University of Colorado.
[8]K. Hatanaka *et al.*, Nucl. Phys. **A340**, 93 (1980).
[9]DWUCK4, an exact-finite-range nuclear code written by P. D. Kunz, University of Colorado.
[10]P. M. Endt, C. Alderliesten, and P. de Wit, Phys. Lett. B **173**, 225 (1986).
[11]P. M. Endt, P. de Wit, and C. Alderliesten, Nucl. Phys. **A459**, 61 (1986).
[12]J. P. Davidson, *Collective Models of the Nucleus* (Academic, New York, 1968).
[13]L. Zamick, Phys. Rev. C **29**, 667 (1984).
[14]T. Chittrakarn *et al.*, Phys. Rev. C **34**, 80 (1986).