the dominant $(f_{7/2})^3$ proton configuration of V^{51} have been analyzed and discussed by Vervier.[9]

The decay of the $\frac{3}{2}^{(-)}$ level at 1.357 MeV to the 165- and 518-keV levels by $M1$ transitions should be hindered since the 1.357-MeV state is of the $(f_{7/2})^2(p_{3/2})$ configuration. The 100-psec lifetime limit for this state does not allow any interpretation of the states involved in terms of transition probabilities. The gamma branching from the 1.357-MeV level can be understood roughly on the basis of energy considerations.

The 80% $E2$ branch from the 518-keV state to the ground state is interesting in that the measured lifetime implies an $E2$ transition probability that is enhanced by a factor of about 5 relative to single-particle estimates. The reduced transiton probability for this $(\frac{3}{2}^{(-)}\rightarrow\frac{7}{2}^{(-)})$ transition is $B(E2)=3.7\times10^{-51}\,e^2\text{cm}^4$. This $E2$ strength is consistent with $(f_{7/2})^3$ configurations provided an effective neutron charge of $2.3e$ is assumed. $E2$ enhancements such as this add to the evidence which favors a collective aspect of the $f_{7/2}$ shell.

To summarize the discussion for the low-lying levels in Ar^{41}, the $M1$ hindrances of 100 and 3000 implied by the present lifetime measurements for the $(\frac{5}{2}^{(-)}\rightarrow\frac{7}{2}^{(-)})$ and $(\frac{3}{2}^{(-)}\rightarrow\frac{5}{2}^{(-)})$ transitions, respectively, are consistent with dominant $(f_{7/2})^3$ configurations within which $M1$ transitions are forbidden. A 2% $(f_{7/2})^2(f_{5/2})$ admixture into the $\frac{5}{2}^-$ first excited state can explain the smaller $M1$ hindrance for the $(\frac{5}{2}^{(-)}\rightarrow\frac{7}{2}^{(-)})$ transition. The $(\frac{3}{2}^{(-)}\rightarrow\frac{7}{2}^{(-)})$ $E2$ transition is enhanced over single-particle estimates by a factor of 5. For pure $(f_{7/2})^3$ configurations, this $E2$ strength requires an effective neutron charge of $2.3e$.

ACKNOWLEDGMENTS

We are indebted to Dr. E. K. Warburton for his participation in the initial phase of this experiment and for numerous suggestions and discussions. One of us (D.B.F.) wishes to thank Dr. D. E. Alburger for the hospitality extended by the Brookhaven Van de Graaff group.

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Study of the Reaction $Al^{27}(d,\alpha)Mg^{25}$ at 20.9 MeV

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The differential cross sections corresponding to the excitation of seven states of the residual nucleus in the reaction $Al^{27}(d,\alpha)Mg^{25}$ have been measured from 20° to 170° for a deuteron energy of 20.9 MeV (lab). The states resolved correspond to the first three members (ground, third, and eighth states) of the $K=\frac{5}{2}$ rotational band, the first three members (first, second, and fourth states) of the $K=\frac{1}{2}$ rotational band, and a state at 5.47 ± 0.03 MeV. The angular distributions are all peaked in the forward direction with very little enhancement of the differential cross sections at large angles. The integrated differential cross sections for the first three $K=\frac{5}{2}$ states are 459, 475, and 417 μb, respectively, as compared to 38, 38, and 95 μb for the first three $K=\frac{1}{2}$ states. The angular distributions corresponding to a given rotational band in Mg^{25} are strikingly similar both in magnitude and shape. Analysis of the energy level structure in terms of the rotational model indicates that the state in Mg^{25} at 5.47 ± 0.03 MeV is the 11/2 member of the $K=\frac{5}{2}$ rotational band.

INTRODUCTION

RECENTLY, Yanabu *et al.*[1] studied the $Al^{27}(d,\alpha)$-Mg^{25} reaction using 14.7-MeV deuterons. Data were obtained for the first three states of both the $K=\frac{1}{2}$ and $K=\frac{5}{2}$ rotational bands of Mg^{25}. They found that the transitions to the $K=\frac{5}{2}$ states are greatly enhanced over the transitions to the $K=\frac{1}{2}$ states. The integrated differential cross sections for the $K=\frac{5}{2}$ transitions are nearly identical (1.02 ± 0.06 mb), while those for the $K=\frac{1}{2}$ transitions are 0.14, 0.22, and 0.61 mb for the first three states, respectively. They interpret the enhancement of the $K=\frac{5}{2}$ transitions to be a consequence of a large overlap between the initial Al^{27} state and the final $K=\frac{5}{2}$ states of Mg^{25}. Cosper *et al.*[2,3] and Hinds *et al.*,[4] who investigated this reaction for deuteron energies of 9.2 and 10.1 MeV, did not observe these pronounced effects. For these energies the integrated cross sections are approximately proportional to $2I+1$ (I is the spin of the final state) irrespective of the rotational band in question. Cosper *et al.*[3] observed a

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[1] T. Yanabu, S. Yamashita, T. Nakamura, K. Takamatsu, A. Masaike, S. Kakigi, Dai Ca Nguyen, and K. Takimoto, J. Phys. Soc. Japan 17, 914 (1962).

[2] S. W. Cosper and O. E. Johnson, Phys. Rev. 138, B610 (1965).

[3] S. W. Cosper, B. T. Lucas, and O. E. Johnson, Phys. Rev. 139, B763 (1965).

[4] S. Hinds, R. Middleton, and A. E. Litherland, in *Proceedings of the Rutherford Jubilee International Conference, Manchester, 1961* (Heywood and Company, Ltd., London, 1961), p. 305.

noticeable similarity in the forward-angle (<90°) portion of the angular distributions of the α_0 and α_3 alpha-particle groups which correspond to $(\frac{5}{2})_{5/2}{}^+$ and $(\frac{7}{2})_{5/2}{}^+$ states of Mg^{25}. [The notation $(I)_K{}^\pi$ is used, where I is the nuclear-spin quantum number, π is the parity of the state, and K is the rotational-band quantum number.] Conversely, a noticeable dissimilarity exists in the forward-angle portion of the angular distributions of the α_1, α_2, and α_4 alpha-particle groups that correspond to $(\frac{1}{2})_{1/2}{}^+$, $(\frac{3}{2})_{1/2}{}^+$, and $(\frac{5}{2})_{1/2}{}^+$ states of Mg^{25}. Theoretical interpretations[5,6] of Mg^{25} based on the unified model of Nilsson[7] indicate that the $K=\frac{1}{2}$ states are admixtures of various Nilsson orbitals. This indication tempted Cosper *et al.* to speculate that these theoretical interpretations might have some bearing on the forward-angular dissimilarities.

The preferential excitation of certain well-defined rotational states has been observed in other types of reactions. For example, in a study of the reactions $Al^{27}(p,\alpha)Mg^{24}$ and $Mg^{25}(p,d)Mg^{24}$, Nolen and Sherr[8] reported that the angular distributions corresponding to six states in Mg^{24} have features that appear to depend on whether the transition is to the $K=0$ or $K=2$ rotational bands of Mg^{24}.

Because of the importance of the energy dependence of these effects, the $Al^{27}(d,\alpha)Mg^{25}$ reaction was investigated for a deuteron energy of 20.9 MeV (lab). The reaction features outlined in the previous paragraphs have emerged even more strongly for this reaction at this energy. The results and some possible implications are reported herein.

PROCEDURE

A pure aluminum target (0.520 mg/cm²) was bombarded with the 21.0±0.1 MeV deuteron beam from the Lewis Research Center cyclotron. The alpha particles from the $Al^{27}+d$ reaction were detected in four Nucleon Diode 5000 Ω-cm surface barrier silicon detectors, the defining apertures of which were accurately spaced 5° apart. Each aperture subtended a solid angle of 2.78×10^{-4} sr. A block diagram of the electronics associated with a detector is shown in Fig. 1. The final output pulse from a given detector was routed into a particular 512-channel subsection of the 4096-channel pulse-height analyzer. The alpha particles were discriminated from charge-1 ($Z=1$) reaction products (protons, deuterons, and tritons) by setting the reverse bias on the detectors until the depletion region was just sufficient to absorb the full energy of the most energetic alpha particle. A $Z=1$ particle of the same energy would then deposit only a fraction of its energy within the sensitive region of the detector. The Q value of $+6.702$ MeV for the $Al^{27}(d,\alpha)Mg^{25}$ reaction as compared with -2.756 MeV for $Al^{27}(d,He^3)Mg^{26}$, for example, easily allows the separation of the alpha-particle groups of interest from $Z=2$ reaction products. The over-all energy resolution of the system was about 300 keV (full width at half-maximum). A typical histogram spectrum is shown in Fig. 2.

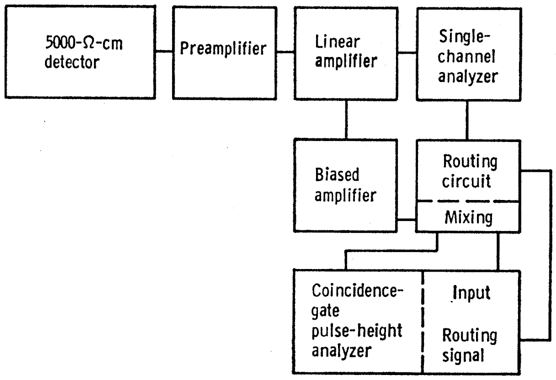

FIG. 1. Electronics associated with a single counter.

RESULTS

The over-all energy resolution was sufficient to allow the separation of six alpha-particle groups corresponding to the ground and five excited states of Mg^{25}. The energy level scheme of Mg^{25} and the levels resolved in this

Peak	Rotational quantum number, K	Total angular momentum quantum number, J	Excitation energy, W, MeV
1			5.47±0.03
2	5/2	9/2+	[a]3.399
3		3/2+, 5/2+	2.803
	1/2		2.736
	1/2	1/2+	2.565
4	1/2	5/2+	[a]1.962
5	5/2	7/2+	[a]1.611
6	1/2	3/2+	[a].976
7	1/2	1/2+	[a].584
8	5/2	5/2+	[a]0.

[a]Resolved energy levels.

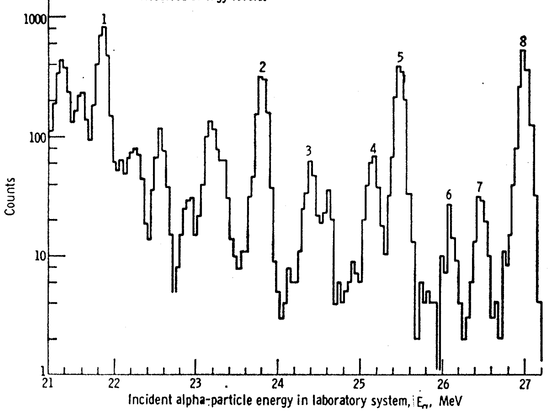

FIG. 2. Typical spectrum for $Al^{27}(d,\alpha)Mg^{25}$ reaction. Reaction energy $Q=6.702$ MeV; deuteron energy $E=20.9$ MeV (lab); laboratory scattering angle $\theta_{lab}=17.5°$.

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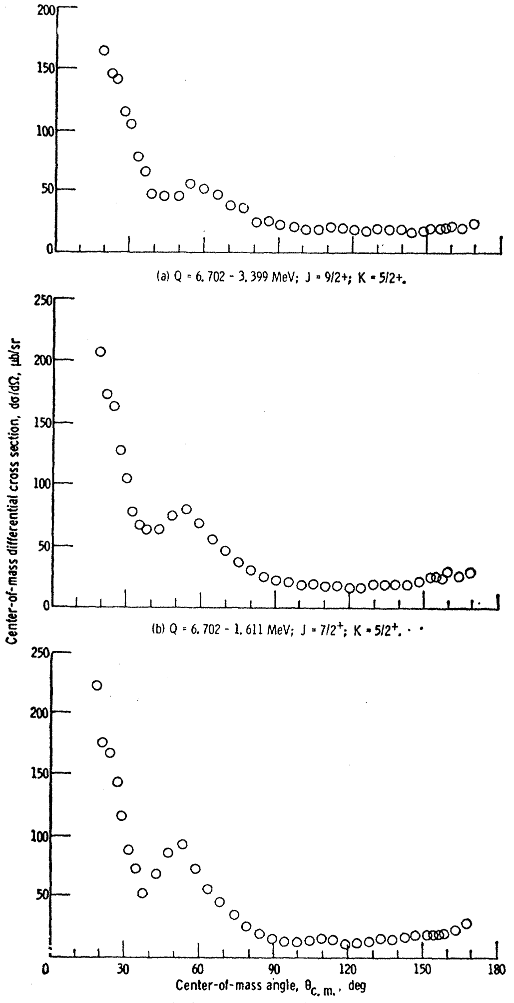
[5] A. E. Litherland, H. McManus, E. B. Paul, D. A. Bromley, and H. E. Gove, Can. J. Phys. **36**, 378 (1958).

[6] K. H. Bhatt, Nucl. Phys. **39**, 375 (1962).

[7] S. G. Nilsson, Kgl. Danske Videnskab. Selskab, Mat.-Fys. Medd. **29**, No. 16 (1955).

[8] J. A. Nolen, Jr. and R. Sherr, Bull. Am. Phys. Soc. **9**, 440 (1964).

experiment are shown in Fig. 2.[9] The experimental data are tabulated in a laboratory report.[10] The experimental results plotted in the form of center-of-mass differential cross sections (μb/sr) against center-of-mass reaction angle (deg) are shown in Figs. 3 and 4. The errors shown are those due to statistical uncertainties and, if not specified, are less than the size of the point. The probable systematic error in the absolute differential cross section is assessed to be 10%. For purposes of illustration, the angular distributions corresponding to the $K=\frac{5}{2}$ and $K=\frac{1}{2}$ rotational bands of Mg^{25} as indicated in Fig. 2 are grouped together.

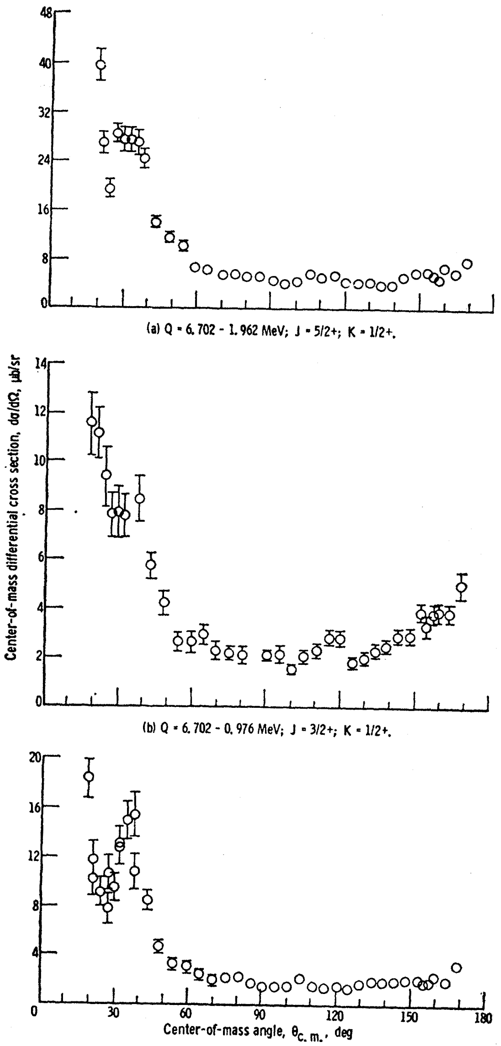


(a) Q = 6.702 - 3.399 MeV; J = 9/2+; K = 5/2+.

(b) Q = 6.702 - 1.611 MeV; J = 7/2+; K = 5/2+.

(c) Q = 6.702 MeV; J = 5/2+; K = 5/2+.

FIG. 3. Angular distributions corresponding to the $K=\frac{5}{2}$ states of magnesium 25.



(a) Q = 6.702 - 1.962 MeV; J = 5/2+; K = 1/2+.

(b) Q = 6.702 - 0.976 MeV; J = 3/2+; K = 1/2+.

FIG. 4. Angular distributions corresponding to the $K=\frac{1}{2}$ states of magnesium 25.

DISCUSSION

Effects of Rotational Structure on Differential Cross Sections

Several features of the preceding results and comparison with measurements at other energies are worthy of mention:

(1) All angular distributions are peaked in the forward direction with very little, if any, enhancement in the backward direction. This feature is in sharp contrast with the data at 9.2 MeV,[3] where a significant backward peaking was observed and in mild contrast to the data at 14.7 MeV,[1] where a slight backward peaking was observed.

(2) The angular distributions corresponding to the $K=\frac{5}{2}$ states are nearly one order of magnitude greater than those corresponding to the $K=\frac{1}{2}$ states. The

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[9] P. M. Endt and G. Van der Leun, Nucl. Phys. 34, 1 (1962).

[10] J. R. Priest and J. S. Vincent, NASA Technical Note D-3548, 1966 (unpublished).

TABLE I. Integrated differential cross sections.

J	K	Integrated cross sections, microbarns
$\frac{1}{2}+$	$\frac{1}{2}$	38
$\frac{3}{2}+$	$\frac{1}{2}$	38
$\frac{5}{2}+$	$\frac{1}{2}$	95
$\frac{5}{2}+$	$\frac{5}{2}$	459
$\frac{7}{2}+$	$\frac{5}{2}$	475
$\frac{9}{2}+$	$\frac{5}{2}$	417

differential cross sections integrated from 20° to 170° are shown in Table I. Although the integrated cross sections are a factor of 2 lower than those obtained using 14.7-MeV deuterons, they are nearly identical. Each integrated cross section differs from the average value of 450 μb by less than 6%. These data and the data of Yanabu *et al.*[1] show clearly that the approximate proportionality between the integrated cross sections and $2I+1$ observed for the same reaction for 9.2- and 10.1- MeV deuterons[2,4] does not hold at all for 14.7- and 20.9-MeV deuterons.

(3) A striking similarity exists both in magnitude and shape between the angular distributions corresponding to the $K=\frac{5}{2}$ states. Cosper *et al.*[3] reported a partial similarity in these angular distributions at 9.2 MeV. Although it was not explicitly pointed out by Yanabu *et al.*, there is a decided similarity for the same angular distributions at 14.7 MeV. However, the effect is much more pronounced at 20.9 MeV.

(4) Some similarity is apparent in the shapes of the angular distributions corresponding to the $K=\frac{1}{2}$ states. The shallow minimum at about 27° and the maximum at about 38° appear in all three cases. The integrated differential cross sections, in contrast to those for the $K=\frac{5}{2}$ transitions, are not identical. This was also observed by Yanabu *et al.*[1] However, at 20.9 MeV, the cross sections for the first two $K=\frac{1}{2}$ transitions are the same (38 μb) and are nearly a factor of 3 smaller than that for the third $K=\frac{1}{2}$ transition (95 μb). Yanabu *et al.*[1] observed an approximate proportionality with $2I+1$ for the corresponding transitions. In regard to these observations, there is an interesting correlation with the results of inelastic scattering of 42-MeV alpha particles from Mg^{25}.[11] The excitation of the $(\frac{5}{2})_{1/2}{}^+$ state is substantially larger than the excitation of the $(\frac{1}{2})_{1/2}{}^+$ and $(\frac{3}{2})_{1/2}{}^+$ states. It is suggested[12] that this represents band mixing of the $(\frac{5}{2})_{1/2}{}^+$ state with the $K=\frac{5}{2}$ rotational band. The enhancement of the excitation of the $(\frac{5}{2})_{1/2}{}^+$ state over the two lower members of this $K=\frac{1}{2}$ rotational band in the $Al^{27}(d,\alpha)Mg^{25}$ reaction at 20.9 MeV may reflect this same supposition.

The systematics observed in these angular distributions at 14.7 and 20.9 MeV are more than just accidental. Clearly the transitions to the $K=\frac{1}{2}$ states are being inhibited. The systematics of the data suggest that this inhibition is associated with the rotational state characterized by the quantum number K.

Considerable evidence from other types of reactions supports this hypothesis. For example, the reactions $Mg^{24}(\alpha,\alpha')Mg^{24}$ and $Mg^{25}(\alpha,\alpha')Mg^{25}$ for $E_\alpha=40$ MeV, which leave the residual nuclei in known collective rotational states, have been analyzed successfully by Blair[13] in terms of his adiabatic theory. In the reaction $Mg^{25}(d,d')Mg^{25}$, Blair and Hamburger[14] observed that the ground, 1.611-, and 3.399-MeV $K=\frac{5}{2}$ states were preferentially excited. Their interpretation of this result is that the formation of the $K=\frac{5}{2}$ states only requires excitation of a rotational collective mode, while formation of a $K=\frac{1}{2}$ state requires the excitation of a single particle from Nilsson orbit 5 to orbits 9, 11, or 8. The experimental and theoretical interpretations of Blair and Hamburger[14] are consistent with the fact that collective states are easier to excite than single-particle states. Furthermore, the ratio of the differential cross sections for this scattering at 29.7° for the $(\frac{9}{2})_{5/2}{}^+$ and the $(\frac{7}{2})_{5/2}{}^+$ states is in good agreement with the theoretical expectation of the simple inelastic diffraction scattering model.[13] A similar interpretation seems appropriate for the results of the $Al^{27}(d,\alpha)Mg^{25}$ reaction. The ground states of both Al^{27} and Mg^{25} have a spin and parity of $\frac{5}{2}+$, and these states are the first members of a $K=\frac{5}{2}$ rotational band. Both nuclei are prolate spheroids and have very nearly the same ground-state quadrupole moment ($\approx$0.15 b[15]) and rotational moment

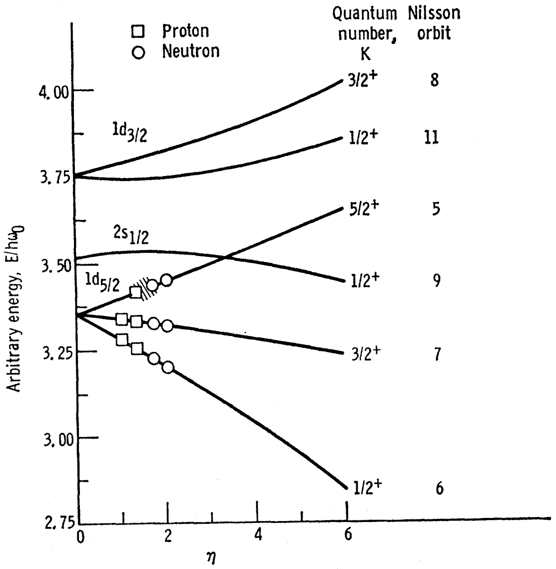

FIG. 5. Nilsson diagram for aluminum 27.

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[11] I. M. Naqib and G. W. Farwell, University of Washington (unpublished data).

[12] J. S. Blair, Argonne National Laboratory Report ANL-6878, 1964, p. 166 (unpublished).

[13] Reference 12, p. 156.

[14] A. G. Blair and E. W. Hamburger, Phys. Rev. **122**, 566 (1961).

[15] M. A. Preston, *Physics of the Nucleus* (Addison-Wesley Publishing Company, Reading, Massachusetts, 1962), p. 152.

of inertia.[6] The single-particle configurations for these nuclei are similar since Al^{27} has five $1d_{5/2}$ protons coupling to $I=\frac{5}{2}$ and Mg^{25} has five $1d_{5/2}$ neutrons coupling to $I=\frac{5}{2}$. In the collective rotational model scheme of the ground states of Al^{27} and Mg^{25}, the last $1d_{5/2}$ proton and the last two $1d_{5/2}$ neutrons of Al^{27} are in the fifth Nilsson orbit. For Mg^{25} the last two $1d_{5/2}$ protons are in the seventh Nilsson orbit and the last $1d_{5/2}$ neutron is in the fifth Nilsson orbit. To illustrate this, the Nilsson diagram[6,14] for Al^{27} is reproduced in Fig. 5. The corresponding diagram for Mg^{25} is the same except that a $1d_{5/2}$ proton and $1d_{5/2}$ neutron are removed. The validity of this model is strengthened by the careful study of the mirror nuclei Al^{25} and Mg^{25} by Litherland *et al.*[5] If the reaction $Al^{27}(d,\alpha)Mg^{25}$ proceeds by picking up a neutron and proton from Al^{27}, then the $K=\frac{5}{2}$ states could be formed simply by exciting rotational modes. The formation of the $K=\frac{1}{2}$ states, however, would require not only rotational excitation but also the promotion of the $1d_{5/2}$ neutron in the fifth Nilsson orbit to a $2s_{1/2}$ state in the ninth Nilsson orbit. In addition, the rotational moment of inertia of the $K=\frac{1}{2}$ states is substantially larger than that for the $K=\frac{5}{2}$ states,[6] and therefore considerable rearrangement of the nucleons would be required. Thus, the $K=\frac{1}{2}$ transitions should be inhibited.

The very nature of the forward peaking observed in all the angular distributions suggests an analysis using the distorted-wave Born approximation (DWBA), in terms of a direct interaction knockout or pickup mechanism. Limited experience with DWBA direct reaction calculations[16] using the FORTRAN code of Gibbs *et al.*[17] for the reactions $F^{19}(d,\alpha)O^{17}$ and $N^{15}(d,\alpha)C^{13}$ have shown that reasonable fits can often be obtained. Since more than one L value (L is determined from the relation $\mathbf{J}_f=\mathbf{J}_i+\mathbf{L}+\mathbf{S}_{\text{deuteron}}$) is permitted for these transitions, the resulting theoretical differential cross sections predicted for calculations with definite L values should be mixed. However, the best fits are obtained in those cases where a single L value is allowed or a single L value dominates. It is clear from an examination of the angular distributions that it is difficult to apply this simple DWBA formalism with any meaning. This could be because in these reactions at least two L values are allowed or because the angular distributions are reflecting some collective structural property of the nuclei involved which is not accounted for in the simple DWBA formalism. Because of these complications no attempt was made to apply the simple DWBA theory.

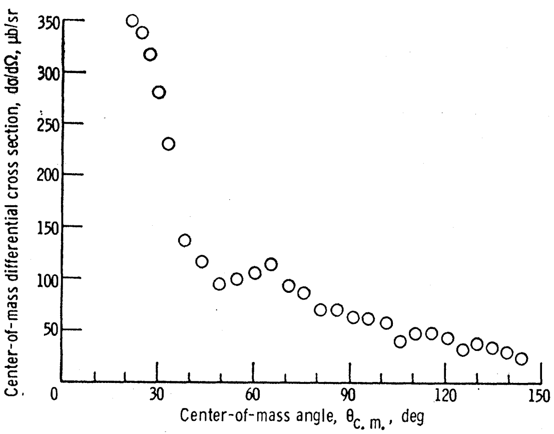

FIG. 6. Angular distribution of group corresponding to excitation of 5.47±0.03 MeV in magnesium 25; $Q=6.702-5.47$ MeV.

Analysis for 5.47-MeV State in Mg^{25}

The unusually high intensity of the group of alpha particles corresponding to an excitation of 5.47±0.03 MeV makes it possible to extract an approximate differential cross section and Q value. The over-all energy resolution (∼300 keV) and the number of levels at this excitation is such that certainly more than one level is excited. The width of the peak, however, indicates that perhaps a single level is preferentially excited. A reasonable estimate of the background contribution to this group was made, therefore, and the differential cross section calculated. The results are shown in Fig. 6. The shape of the angular distribution is very similar to those corresponding to the excitation of the $K=\frac{5}{2}$ states of Mg^{25}. The peak at about 65°, however, appears at a slightly larger angle. If the reaction leading to the $K=\frac{5}{2}$ states proceeds by picking up a neutron and a proton, the angular dependence of the differential cross sections, according to simple theory, should be characterized by the magnitude of the momentum transfer vector[18] $\mathbf{q}=(m_{Mg^{25}}/m_{Al^{27}})\mathbf{K}_d-\mathbf{K}_\alpha$. The peaks at about 55° and 65° for the ground and the 5.47-MeV states correspond to $|\mathbf{q}|=2.08\times10^{13}$ and 1.98×10^{13} cm^{-1}, respectively. Thus, the differential cross sections as a function of $|\mathbf{q}|$ are more nearly identical. It might be speculated that this level corresponds to the fourth member of the $K=\frac{5}{2}$ rotational band with spin $I=11/2$. Litherland *et al.*[5] analyzed the level structure and have indicated that such a state is possible within the framework of the rotational collective model. Their analysis shows that the energies of the first few levels can be fitted well by the rotational-model expression

$$E=A[I(I+1)+a(-1)^{I+1/2}(I+\tfrac{1}{2})]+B[I(I+1)+a(-1)^{I+1/2}(I+\tfrac{1}{2})]^2, \quad (1)$$

where A, a, and B are constants that depend on the rotational band in question. For the $K=\frac{5}{2}$ band, $a=0$, and Litherland *et al.* found that $A=272$ keV and $B=-1.69$ keV for Al^{25}. The expression yields excitation

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[16] J. R. Priest and J. S. Vincent, Bull. Am. Phys. Soc. **11**, 45 (1966).

[17] W. R. Gibbs, V. A. Madsen, J. A. Miller, W. Tobocman, E. C. Cox, and L. Mowry, NASA Technical Note D-2170, 1964 (unpublished).

[18] M. K. Banerjee, in *Nuclear Spectroscopy*, edited by Fay Ajzenberg-Selove (Academic Press Inc., New York, 1960), Part B, p. 695.

energies of 1.614 and 3.446 MeV for the known $(\frac{7}{2})_{5/2}{}^+$ and $(\frac{9}{2})_{5/2}{}^+$ states. These compare very well with the measured values of 1.611 and 3.399 MeV for Mg^{25}. Substitution of $I=11/2$ into this expression then gives an excitation energy of 5.313 MeV. This result is reasonably consistent with the measured value of 5.47 ± 0.03 MeV for the proposed $I=11/2$ state. The agreement, though, is less satisfying than that obtained for the 1.611- and 3.399-MeV states. The evaluation of the A and B coefficients were based on a limited number of known $K=\frac{5}{2}$ states, and Litherland *et al.* have indicated that these values should be treated with caution.

Other evidence exists that supports this speculation for the $I=11/2$ state. In a very careful study of the reaction $Mg^{24}(d,p)Mg^{25}$ at 10 MeV, Middleton and Hinds[19] report a level doublet corresponding to an excitation of 5.454 and 5.465 MeV in Mg^{25}. The 5.465-MeV state is assigned a spin and parity of $\frac{1}{2}^+$ as a result of an analysis using the Butler stripping theory. The 5.454-MeV level is very weakly excited and no spin and parity assignment was possible. The 1.611 $[(\frac{7}{2})_{5/2}{}^+]$ and 3.399 $[(\frac{9}{2})_{5/2}{}^+]$ MeV states are also weakly excited. The angular distribution for the 1.611-MeV state shows little resemblance to the stripping pattern, which for this transition would require a transfer of four units of angular momentum. Sheline and Harlan[20] studied the reaction $Al^{27}(d,\alpha)Mg^{25}$ at 7.5 to 8.5 MeV and, although they were not able to resolve the 5.454- and 5.465-MeV doublet, they were able to estimate from the intensity of the group and the barrier penetrability for alpha particles that the possible spins would lie between $\frac{5}{2}$ and 13/2. Since the 5.465-MeV state has been found to have spin $I=\frac{1}{2}$, the major contribution to this group must come from excitation of the 5.454-MeV state. The assignment of $I=11/2$ to this state would then be consistent with the estimates of Sheline and Harlan.

TABLE II. Comparison of calculated and experimental values of energy levels of the $K=\frac{5}{2}^+$ rotational band in Mg^{25}.

Experimental excitation energy W_{expt}(MeV)[a]	Calculated excitation energy W_{cal} (MeV)	Difference between calculated and experimental excitation energy W_{cal}-W_{expt}(keV)
0	0.014	+14
1.609	1.575	−34
3.398	3.425	+27
5.454	5.447	−7

[a] Experimental data (Ref. 19).

With the assumption that the 5.454-MeV state is the $I=11/2$ member of the $K=\frac{5}{2}$ rotational band, the constants A and B in Eq. (1) were re-evaluated. The procedure was the following:

Equation (1) for the energy of the $K=\frac{5}{2}$ states can be written

$$E=Ax+Bx^2, \tag{2}$$

where

$$x=I(I+1) \tag{3}$$

and I is the spin quantum number of the state in Mg^{25}. The excitation energy W is then

$$W=E-E_0=Ax+Bx^2-E_0, \tag{4}$$

where E_0 is the energy of the ground state. A least-squares fit to Eq. (4) was performed. The results are $A=250$ keV, $B=-1.08$ keV. A comparison of the experimental results with those calculated from Eq. (4) is shown in Table II. As can be seen, the results are quite satisfactory. Thus the excitation energy also suggests that the 5.454-MeV state is the fourth member of the $K=\frac{5}{2}$ rotational band having $I=11/2$.

Although this assignment cannot be made with absolute certainty, it is consistent with the above analysis.

CONCLUDING REMARKS

The distinct forward peaking observed in all seven angular distributions indicate that the reactions proceed by a direct-interaction mechanism. The structure of Al^{27} and Mg^{25} suggests that this mechanism is the pickup of a neutron and proton from Al^{27}. The transitions to the $K=\frac{5}{2}$ states are envisaged as a pickup of a $1d_{5/2}$ neutron and proton and an excitation of a rotational collective mode. The excitation of the $K=\frac{1}{2}$ states in this scheme would be a pickup of a $1d_{5/2}$ neutron and proton but with an excitation of a $1d_{5/2}$ neutron to a $2s_{1/2}$ $K=\frac{1}{2}$ state. The inhibition of the transitions to the $K=\frac{1}{2}$ rotational states is analogous to the corresponding situation in the inelastic scattering of deuterons and alpha particles. The 5.454-MeV state in Mg^{25} has been tentatively identified as the $I=11/2$ member of the $K=\frac{5}{2}$ rotational band built on the ground state of Mg^{25}.

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