broad group corresponding to the 2.90-MeV state in Be^8 superposed on the alpha continuum. The intensity of the group corresponding to the 2.9-MeV state in Be^8 is 20 times that of the ground state group in the spectrum observed at $\theta_l=90°$. The alpha continuum is quite prominent indicating that the neutron pickup by He^3 may also lead to a simultaneous breakup into three alphas.

The simultaneous breakup of the Be^8 core can also be visualized in the following manner.[24] When picking up a neutron, Li^6 comes so close to the Be^8 core that the Coulomb repulsion between Li^6 and the Be^8 core becomes strong enough so that Be^8 is effectively excited to a very highly excited state, i.e., it breaks up into two α particles. The large Coulomb repulsion must affect the Be^8 core. It is possible that the first excited state in Be^8 is also formed. Since so many highly excited states in B^{11} contribute Li^7 particles to the continuum, it might be possible for the latter to mask the Li^7 group corresponding to the broad first excited state of Be^8.

[24] F. C. Khanna (private communication).

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Professor S. K. Allison for his sponsorship and guidance throughout this work. The assistance given by John Erwood, Walter Edwards, and Larry Palmer in operating the Van de Graaff and maintenance of the equipment are gratefully acknowledged. Walter Tomasek built a great deal of the equipment which facilitated this experiment. Dr. John Honsaker provided many helpful suggestions and stimulating discussions. Thanks are due to Dr. David Inglis and Dr. George Morrison of the Argonne National Laboratory for discussions which greatly aided the interpretation of the results of this work.

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$Ca^{46}(d,p)Ca^{47}$ Reaction at 7-MeV Bombarding Energy*

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The $Ca^{46}(d,p)Ca^{47}$ reaction has been investigated using the MIT-ONR electrostatic generator. The broad-range, multiple-gap spectrograph was used in the detection of the reaction protons. Twenty-seven excited levels were identified in Ca^{47} below an excitation energy of 6.1 MeV, and a Q value of 5.047 ± 0.010 MeV was measured for the ground-state transition. The angular distributions to the corresponding levels were measured and analyzed by means of the distorted-wave Born approximation. Unperturbed single-particle energies were extracted from the strengths and energies of the levels using the shell-model sum rules. An $l_n=2$ and an $l_n=0$ transition were observed to the 2.580- and 2.600-MeV levels, respectively. The Ca^{46} ground-state configuration is discussed in terms of these results.

I. INTRODUCTION

THE level structure of Ca^{47} has been investigated by using the $Ca^{46}(d,p)Ca^{47}$ reaction at an incident deuteron energy of 7.00 MeV. The scope and the techniques of the present experiment are similar to those used by Bjerregaard *et al.*[1] who studied the $Ca^{46}(d,p)Ca^{47}$ reaction at 10-MeV bombarding energy. In the present case, 28 levels were observed in Ca^{47} below 6.1 MeV of excitation. Compared with Ref. 1, we have identified four new levels at $E_x=3.425$, 4.103, 5.220, and 5.254 MeV. Generally, the two sets of data are in excellent agreement, although in two cases the values of the transferred orbital angular momentum (l_n values) derived from the present data differ from the assignments made in Ref. 1.

The Ca^{46} target nucleus has two neutron holes relative to the doubly magic $N=28$, $Z=20$ Ca^{48} core. In principle, the transition strength to the ground state of Ca^{47} should give a measure of the degree of configuration admixing in the Ca^{46} ground state.[2] However, since the

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[1] J. H. Bjerregaard, Ole Hansen, and G. Sidenius, Phys. Rev. **138**, B1097 (1965).

[2] M. H. Macfarlane and J. B. French, Rev. Mod. Phys. **32**, 567 (1960).

effect of such admixtures on the ground-state spectroscopic factor generally is smaller than the uncertainty with which the spectroscopic factor can be determined experimentally (about 20 to 30%),[3] the measurement of the transition strengths to low-lying ($1d_{3/2}^{-1}$) and ($2s_{1/2}^{-1}$) states is a more sensitive method for obtaining information on the target configuration. The observed strengths for exciting these states in nucleon-transfer reactions indicate the transition from the somewhat admixed Ca^{40} core[4–6] to the more inert Ca^{48} core.[7,8] The experimental procedures and the results of the present experiment are given in Sec. II; in Sec. III, the distorted-wave Born-approximation (DWBA) analysis is described. Section IV contains a detailed comparison with the work of Ref. 1, concluding in a proposed level scheme for Ca^{47}. The discussion of Sec. V contains a description of the Ca^{46} ground-state configuration, taking into account the observed low-lying $l_n=2$ and 0 transitions.

II. EXPERIMENTAL PROCEDURES AND RESULTS

A. Target

The Ca^{46} target was prepared in the Copenhagen Isotope Separator, as described in Ref. 1. The isotopic purity is better than 99.5%.

B. Elastic Scattering and the Cross-Section Scale

Elastic deuteron scattering from Ca^{46} was measured at 7.00 MeV at the Copenhagen Tandem Van de Graaff.[9] The data are shown in Fig. 1 in comparison with optical-model predictions.

Elastic deuteron scattering at 3 MeV has normally been used in this Laboratory for determining the target thickness.[4,10] However, since the present target is very inhomogeneous and covers only a small area ($\approx 0.5\times 1$ mm^2), the target thickness is dependent upon the beam geometry; hence, the thickness seen in the 7-MeV reaction measurement may be very different from the thickness seen in the 3-MeV (d,d) scattering (see the discussion in Ref. 9).

The yield normalization was performed in a separate experiment, where the (d,p) yields at forward angles from the 2.017-MeV transition (see Table I) and the elastic-scattering yields at back angles were determined.

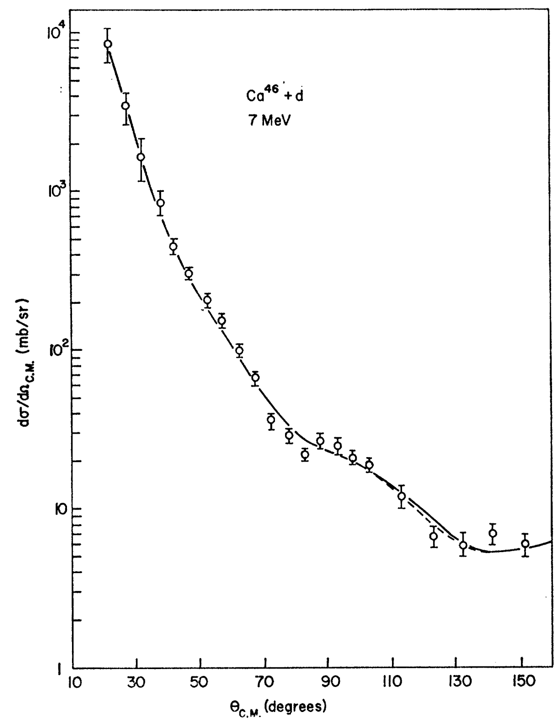

FIG. 1. Elastic deuteron scattering from Ca^{46}. The 7.0-MeV elastic deuteron-scattering cross section versus center-of-mass angle for Ca^{46} is shown in comparison with calculated cross sections. The full curve represents the angular distributions predicted from the parameter set 46*B* of Table II, whereas the dashed curve shows the scattering generated by potential 46*A*.

The experiment was performed at 7.00 MeV using the MIT multiple-gap spectrograph. Thus, the reaction protons and the elastically scattered deuterons were observed simultaneously, and the normalization is therefore independent of target thickness. Using the absolute cross-section scale established by the elastic-scattering results from the Copenhagen Tandem, we arrive at a (d,p) 2.017-MeV state maximum cross section of 32 mb/sr, which corresponds to a spectroscopic strength in good agreement with that of Ref. 1. The cross-section scales of the present work and of the Bjerregaard *et al.* work[1] are related through a (d,d) excitation function measured at the Copenhagen Tandem.[9] The two scales should agree internally to better than 20%. The error in the absolute cross-section scale established in this way is estimated to be $\pm 25\%$ for the present work.

C. The (d,p) Experiment

The experimental procedure and data reduction used in this experiment were similar to those used in other $Ca(d,p)$ experiments performed in this Laboratory.[4,8,10] The Ca^{46} target was bombarded by 7-MeV deuterons from the MIT-ONR electrostatic generator; the reaction products were momentum analyzed at 24 angles in the

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[3] L. L. Lee, Jr., J. P. Schiffer, B. Zeidman, G. R. Satchler, R. M. Drisko, and R. H. Bassel, Phys. Rev. **136**, B971 (1964).

[4] T. A. Belote, A. Sperduto, and W. W. Buechner, Phys. Rev. **139**, B80 (1965).

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[6] R. Bock, H. H. Duhm, and R. Stock, Phys. Letters **18**, 61 (1965).

[7] B. F. Bayman, T. W. Conlon, and E. Kashy (to be published).

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[9] T. A. Belote, J. H. Bjerregaard, Ole Hansen, and G. R. Satchler, Phys. Rev. **138**, B1067 (1965).

[10] W. E. Dorenbusch, T. A. Belote, and Ole Hansen (to be published).

TABLE I. Results.

	Present work				Bjerregaard *et al.*[a]			
Level No.	Q (MeV)	E_x (MeV) (±5 keV)	l_n	$(2j+1)S_{lj}$	E_x (MeV)	l_n	$(2j+1)S_{lj}$	Shell-model assignment
0	5.047	0.0	3	2.1	0.0	3	2.20	$1f_{7/2}$
1	3.030	2.017	1	3.9	2.013	1	3.30	$2p_{3/2}$
2	2.467	2.580	2	0.08	2.579			$1d_{3/2}$
3	2.447	2.600	0	0.05	2.606	0	0.04	$2s_{1/2}$
4	2.198	2.849	1	0.10	2.857	1	0.08	$2p_{1/2}$
5	2.173	2.874	1	0.53	2.878	1	0.49	$2p_{1/2}$
6	1.751	3.296	1	0.07	3.301			$2p_{1/2}$, $2p_{3/2}$
7	1.622	3.425	b		...			
8	1.028	4.019	1	0.06	4.012	1	0.05[c]	$2p_{3/2}$
9	0.990	4.057	1	1.2	4.049	1	0.99	$2p_{1/2}$
10	0.944	4.103	b		...			
11	0.645	4.402	1	0.07	4.403	1	0.05	$2p_{3/2}$, $2p_{1/2}$
12	0.262	4.785	3	0.81	4.782	3	0.79	$1f_{5/2}$
13	0.240	4.807	1	0.30	4.804	1	0.26	$2p_{1/2}$, $2p_{3/2}$
14	−0.142	5.189	1	0.24	5.192	1	0.22	$2p_{1/2}$, $2p_{3/2}$
15	−0.173	5.220	b		...			
16	−0.207	5.254	d		...			
17	−0.258	5.305	2 (3)	0.06 0.40	5.311	(2) 3	0.04 0.18	$2d_{5/2}$, $(1f_{5/2})$
18	−0.278	5.325	4	1.7	5.328	4	0.93	$1g_{9/2}$
19	−0.380	5.427	3 (2)	0.47 0.08	5.428	3 (2)	0.29 0.06	$1f_{5/2}$, $(2d_{5/2})$
20	−0.412	5.459	3 (2)	0.74 0.12	5.453	...	...	$1f_{5/2}$, $(2d_{5/2})$
21	−0.441	5.488	1	0.09	5.478	1	0.08	$2p_{3/2}$, $2p_{1/2}$
22	−0.592	5.639	3 (2)	0.54 0.07	5.636	3 (2)	0.36 0.11	$1f_{5/2}$, $(2d_{5/2})$
23	−0.713	5.760	(1)	0.08	5.761	1	0.08	$2p_{3/2}$, $2p_{1/2}$
24	−0.762	5.809	3 (2)	0.68 0.10	5.807	3 (2)	0.59 0.12	$1f_{5/2}$, $(2d_{5/2})$
25	−0.795	5.842	3 (2)	0.76 0.11	5.842	4	1.02	e
26	−0.819	5.866	d		5.874	1	0.04	$2p_{3/2}$, $2p_{1/2}$
27	−1.015	6.062	3 (2)	1.0 0.13	6.066	3 (2)	0.58 0.12	$1f_{5/2}$, $(2d_{5/2})$
28					6.191			
29					6.270			
30					6.366			
31					6.555			

[a] Reference 1.
[b] Nonstripping level.
[c] The value given in Table I of Ref. 1 should read 0.052 instead of 0.52.
[d] Angular-distribution data forward of 90 deg uncertain.
[e] See discussion in text.

MIT multiple-gap spectrograph.[11] The protons were recorded in 50-μ Eastman Kodak NTA nuclear emulsions; the heavier charged particles were excluded from reaching the emulsions by employing thin aluminum foils of suitable thickness. The over-all energy resolution was 12 keV. Exposures of 4000 and 400 μC [μC stands for micro Coulomb] were taken, and the proton spectrum at 67.5-deg laboratory scattering angle is shown in Fig. 2. Impurity groups from Si^{28} and $Cl^{35,37}$ target contaminants are rather prominent and complicate the analysis of the spectra somewhat (see the discussion in Ref. 1). The proton groups corresponding to a residual mass of 47 were identified from their kinematic energy shift with angle.

The ground-state Q value for the $Ca^{46}(d,p)Ca^{47}$ reaction was measured to be 5.047±0.010 MeV, as compared with 5.052±0.006 MeV given by Bjerregaard *et al.*[1] The incident energy (7.000±0.008 MeV) was calculated from the position of the proton group corresponding to the 1.278-MeV excited state in Si^{29}, taking

[11] H. A. Enge and W. W. Buechner, Rev. Sci. Instr. 34, 155 (1963).

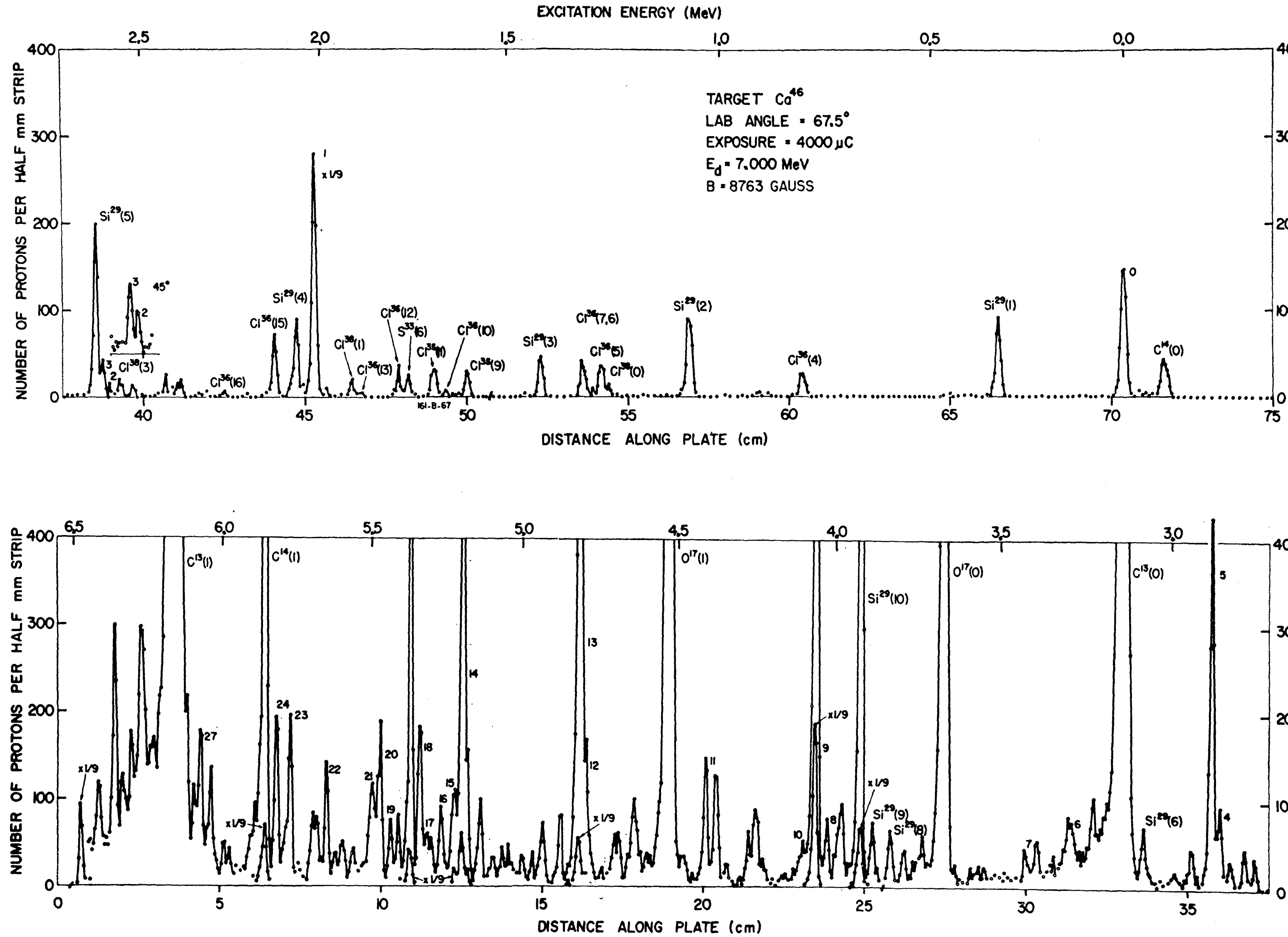


FIG. 2. Typical reaction proton spectrum. The measured proton spectrum at 67.5-deg laboratory angle is shown as the number of protons per 0.5-mm strip across the exposed zone versus distance along the plate. The groups corresponding to levels in Ca^{47} are identified by the number labeling these states in Table I. Proton groups from target impurities are also identified.

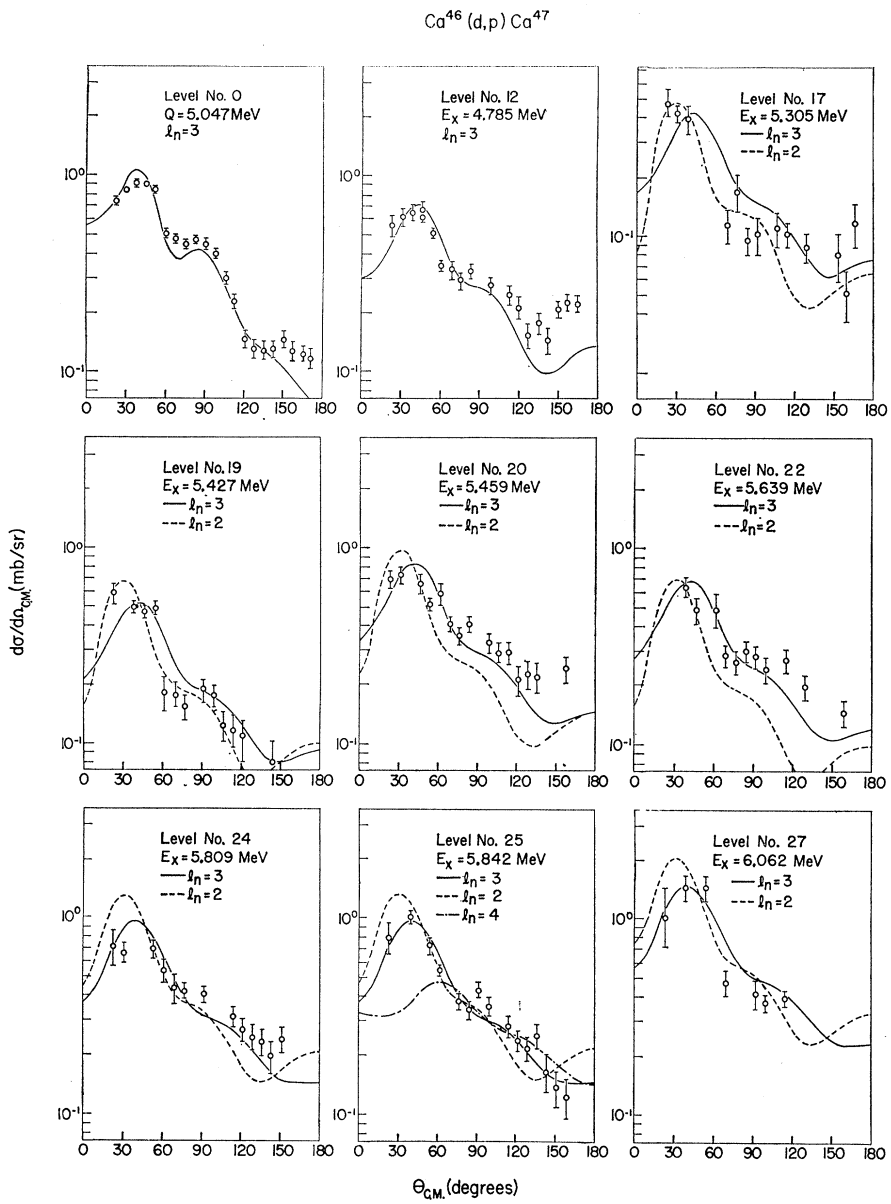


FIG. 3. Angular distributions of $l_n=3$ transitions from the $Ca^{46}(d,p)Ca^{47}$ reaction. The angular-distribution data (open circles) are compared with DW curves for the levels assigned $l_n=3$ or 3(2) in the present work. Also shown is the $l_n=2(3)$ transition to level No. 17.

the Q value for this transition to be 4.976 ± 0.007 MeV.[12]

The results obtained in the present experiment are given in Table I in comparison with the results of Bjerregaard *et al.*[1] Figures 3 through 7 show the observed angular distributions, compared with distorted-wave (DW) predictions.

III. OPTICAL-MODEL AND DISTORTED-WAVE (DW) ANALYSIS

Optical-model parameters for the deuterons were sought by using the available elastic-scattering data (Fig. 1 and Ref. 9). The proton parameters were taken from the work of Perey.[13] The 7-MeV deuteron scattering (Fig. 1) was fitted by means of the search code ABACUS[14] employing a least-squares criterion. The resulting best fit is shown in Fig. 1, while the corresponding parameters are given in Table II, denoted 46*A*. Another deuteron parameter set (46*B* in Table II), somewhat closer to the 10-MeV set *X*, was also obtained. The elastic deuteron scattering generated by this set (46*B*) is practically the same as set 46*A*, and the least-squares criterion does not differ considerably. Moreover, since the 10-MeV (d,d) data show less scattering than do the 7-MeV data, we feel justified in using the 46*B*

[12] P. M. Endt and C. van der Leun, Nucl. Phys. **34**, 1 (1962).

[13] F. G. Perey, Phys. Rev. **131**, 745 (1963).

[14] E. H. Auerbach, Brookhaven National Laboratory Report No. BNL 6562 (ABACUS-2), 1962 (unpublished).

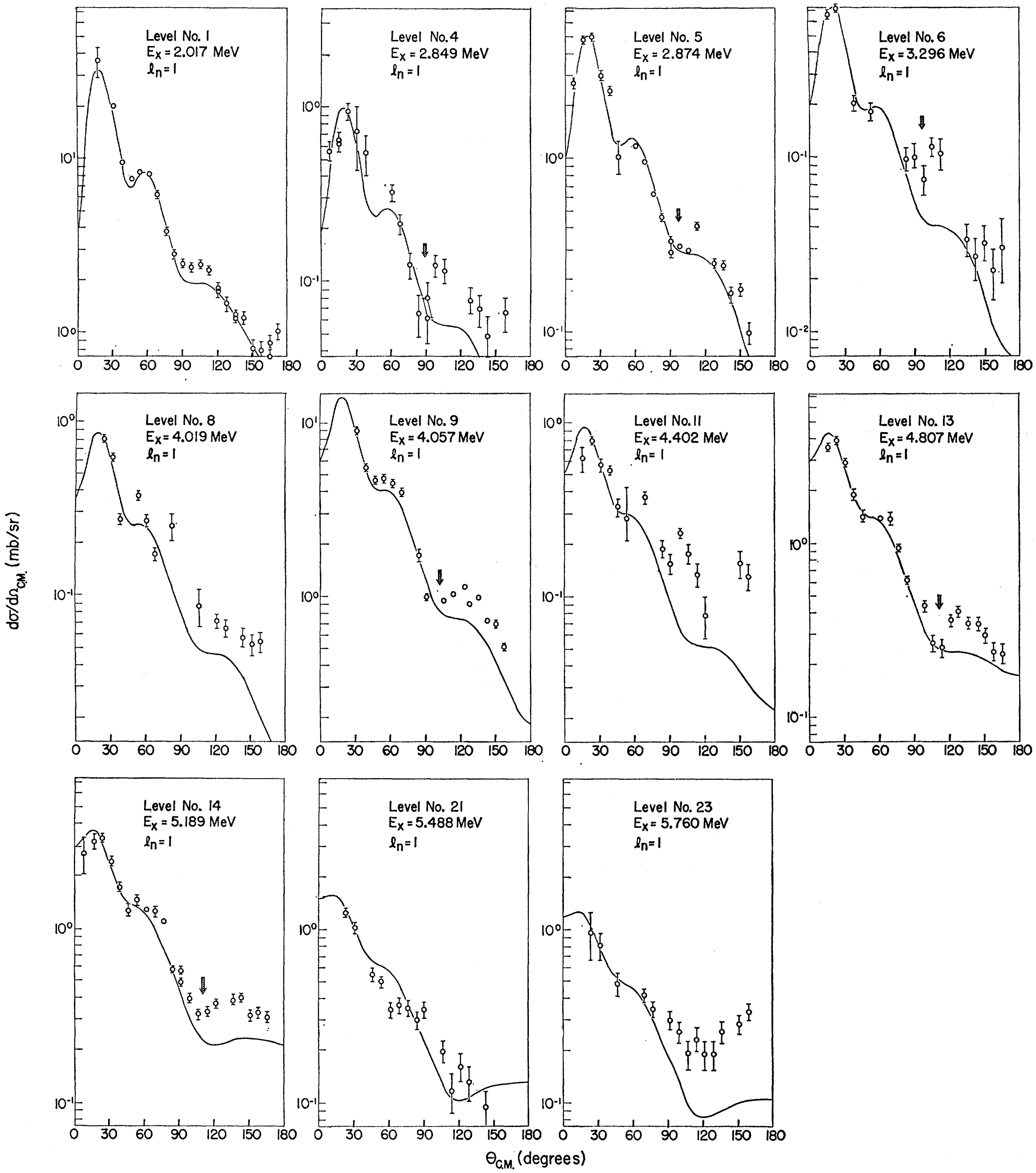


FIG. 4. The $l_n=1$ angular distribution from $Ca^{46}(d,p)Ca^{47}$. The data for the $l_n=1$ levels observed in the present work are shown in comparison with the DW curves. The arrow near 100 deg (level Nos. 4, 5, 6, 9, 13, and 14) indicates the position of the back-angle "dip" (see the discussion in Sec. IV).

set of optical-model parameters for the (d,p) DW calculations rather than the best-fit set (46A).

The DW cross sections were calculated with the code JULIE.[15] No lower cutoffs were used on the radial integrals; the calculations employed the zero-range approximation; finite-range, nonlocality, and spin-orbit effects were not investigated. The neglecting of these effects has been previously discussed [Ref. 3, $Ca^{40}(d,p)$ at 11 MeV and Ref. 10, $Ca^{42}(d,p)$ at 7 MeV]. In these references it is pointed out that the spectroscopic strengths for $1f_{7/2}$, $2p_{3/2}$, $2p_{1/2}$, $2d_{5/2}$, and $1g_{9/2}$ transitions are not strongly affected (≈ 10 to 20%); whereas $1f_{5/2}$ and $1d_{3/2}$ transitions may appear with strengths

[15] R. H. Bassel, R. M. Drisko, and G. R. Satchler, Oak Ridge National Laboratory Report No. 3240 (Office of Technical Services, Washington, D. C., 1963).

TABLE II. Optical-model parameters.

Identification of parameter set	Reference	Particle (MeV)	V (MeV)	W_D (MeV)	Optical parameters[a] (fermis) r_0	a	r_0'	a'	r_c
X	[b]	d(10 MeV)	115	13.0	1.0	0.804	1.419	0.660	1.3
46A	present	d(7 MeV)	117.3	13.0	1.0	0.793	1.49	0.676	1.3
46B	present	d(7 MeV)	116.2	13.2	1.0	0.782	1.47	0.662	1.3
	present	p	52.4	10.35	1.25	0.65	1.25	0.47	1.25
	present	n	[c]	...	1.25	0.65	...	...	...

[a] For V_{opt}, see, e.g., Ref. 4.
[b] Reference 1.
[c] Adjusted to give a binding equal to $Q_{(d,p)}+2.23$ MeV.

low by as much as 50% for $1f_{5/2}$ and about 25% for $1d_{3/2}$. The strengths given in Table I were obtained by normalizing the summed experimental cross sections at angles forward of 90 deg to the correspondingly summed DW cross sections.

IV. COMPARISON WITH OTHER DATA

The general agreement between the present data and those of Ref. 1 is excellent (see Table I). The maximum deviation in excitation energy is 10 keV, and the average deviation is 4.0 keV. The four new levels identified here are all weak and of nonstripping character. The spectroscopic strengths are also generally in good agreement.

However, with regard to l_n assignments, it should be noted that there are a few disagreements. Level No. 6 at 3.296 MeV is assigned $l_n=1$ here and "nonstripping" in Ref. 1. In fact, no yield data were extracted for this transition in Ref. 1 because of background difficulties. We feel that our assignment is correct and that no real discrepancy exists. Level No. 20 at 5.459 MeV is assigned $l_n=3$ here; no assignment was made in Ref. 1. The data of Ref. 1 are consistent with $l_n=3$, except for the two most forward angles. The discrepancy may come from an undetected impurity that increases the yield at forward angles in the 10-MeV experiment; in the 7-MeV experiment this impurity may be shifted sufficiently so as not to interfere. Level No. 25 at 5.842 MeV is assigned $l_n=3$ here and $l_n=4$ in Ref. 1. This discrepancy may also be due to an impurity that contributes to the yield for one set of the data and thus results in an erroneous assignment. It is not possible to ascertain which assignment is correct.

The similarity between $l_n=3$ and $l_n=2$ distributions observed in Ref. 1 above level No. 12 is still evident, although to a lesser extent, in the 7-MeV DW predictions. For level No. 17, the present data suggest an $l_n=2$ assignment in preference to $l_n=3$. Otherwise, we agree with the trend of Ref. 1 and favor $l_n=3$ for level Nos. 19, 20, 22, and 24, and 27. Level No. 2 at 2.580 MeV is recognized as a weak $l_n=2$ transition here. Again, the 10-MeV data disagree only at the two forward angles; no l_n assignment was given in Ref. 1. The sharp minima at back angles observed at 10 MeV,

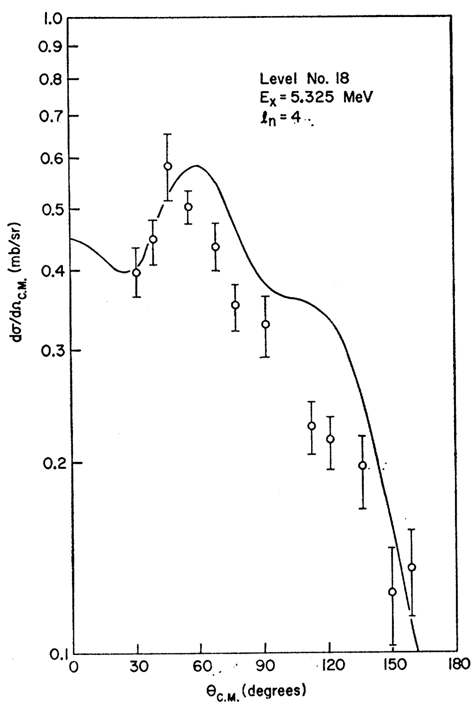


FIG. 5. The $l_n=4$ transition data from $Ca^{46}(d,p)Ca^{47}$. The data corresponding to the $l_n=4$ transition to the 5.325-MeV level are shown in comparison with the predicted $l_n=4$ curve.

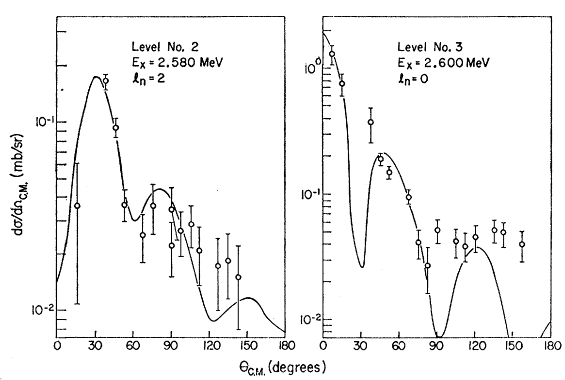
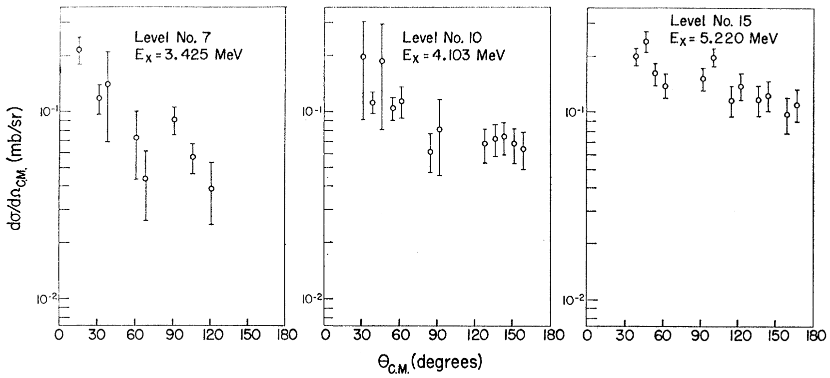


FIG. 6. Angular distributions to the 2.580- and 2.600-MeV levels. The angular distributions for the low-lying $l_n=2$ and $l_n=0$ levels are shown in comparison with the calculated curves (solid lines), assuming $1d$ and $2s$ transfers, respectively.

FIG. 7. Nonstripping data. The data to the 3.425-, 4.103-, and 5.220-MeV nonstripping levels are shown versus the center-of-mass angle.



and which are associated with $2p_{1/2}$ transitions,[16] are seen in the present work for transition No. 4 and tentatively for transition Nos. 5, 6, 9, 13, and 14, marked by arrows in Fig. 4. No dip is observed for transition No. 1, in agreement with the 10-MeV data. The dip effect at 7 MeV is rather weak, and no definite spin assignments have been made from the present $l_n=1$ data.

The summed strengths for the different shell-model transitions are given in Table III, and unperturbed

TABLE III. Sum-rule limits.

Transition	$\sum_k (2j+1)S_{lj}^k$ $1f_{7/2}$	$2p_{3/2}$	$2p_{1/2}$	$2p^c$	$1f_{5/2}$	$1g_{9/2}$	$2d_{5/2}$
Present work	2.1	3.96[a]	2.44[b]	6.64	5.00	1.7[f]	0.06
Bjerregaard *et al.*[d]	2.20	3.35	1.56	5.64	2.79	1.95	...
Theory[e]	2.0	4.0	2.0	6.0	6.0	10.0	6.0

[a] $l_n=1$ transition, Nos. 1 and 8.
[b] $l_n=1$ transitions marked with an arrow in Fig. 4. (Note that more transitions are included here than in Ref. 1.)
[c] All $l_n=1$ transitions.
[d] Reference 1. The $2p_{3/2}$ strength is corrected for the mistake quoted for level No. 8; the $1g_{9/2}$ strength includes transition No. 25, the l_n assignment of which disagrees with the present work.
[e] Assuming pure $1f_{7/2}^{-2}$ configuration relative to an inert Ca^{48} core (see, for example, Ref. 2).
[f] Includes only level No. 18.

single-particle energies, as derived from the energy-weighted sum rule,[17] are summarized in Table IV. Taking into account all the data available on Ca^{47} (Refs. 1, 7, 18), we propose the spin and parity assignments for the Ca^{47} levels given in the last column of Table I.

TABLE IV. Unperturbed single-particle excitation energies (MeV).[a]

	Transition $1f_{7/2}$	$2p_{3/2}$	$2p_{1/2}$	$1f_{5/2}$	$1g_{9/2}$	$2d_{5/2}$
Present work	0	2.14±0.09	4.00±0.07	5.6	≳5.3	>6.0
Bjerregaard *et al.*[b]	0	2.15±0.10	4.02±0.07	≳5.5	≳5.6	>6.0

[a] The unperturbed single-particle excitation energies given here were calculated using the definition of Yoshida (Ref. 17). The errors quoted on the $2p$ excitation reflect the uncertainty in assigning level Nos. 6, 11, 21, and 23 as $2p_{3/2}$ or $2p_{1/2}$. Again, we have corrected the $2p_{3/2}$ numbers of Ref. 1.
[b] Reference 1.

[16] L. L. Lee, Jr., and J. P. Schiffer, Phys. Rev. **136**, B405 (1964).
[17] S. Yoshida, Nucl. Phys. **38**, 380 (1962).
[18] T. Kuroyanagi, T. Tamura, K. Tanaka, and H. Morinaga, Nucl. Phys. **50**, 417 (1964).

V. DISCUSSION

Since the present data agree so well with the results of Ref. 1, we have no essential changes to suggest in the discussion given there. The recognition of the $l_n=2$ character of level No. 2 makes it possible to give a quantitative estimate of the $(1d_{3/2}^{-2})$ admixture in the Ca^{46} ground state.

We shall treat the Ca^{48} ground state as a doubly closed shell structure of isospin $T=4$. This is consistent with our present knowledge of Ca^{48} (see, for example, Refs. 7, 8, and 12 and the discussions in Refs. 1 and 4). State (2) of Ca^{47} is excited in neutron pickup; therefore, this state may be written as[7]

$$|Ca^{47}(2)\tfrac{3}{2}^+;T=\tfrac{7}{2},T_z=\tfrac{7}{2}\rangle = \sum_{T_z'=1/2,-1/2} (4,\tfrac{7}{2}-T_z',\tfrac{1}{2},T_z'|\tfrac{7}{2},\tfrac{7}{2}) \times\{1d_{3/2}^{-1};T=\tfrac{1}{2},T_z'\}\{1f_{7/2}^{8};T=4,T_z=\tfrac{7}{2}-T_z'\}, \quad (1)$$

where $(T_1,T_{1z},T_2,T_{2z}|T_3,T_{3z})$ is a vector-coupling coefficient.[19] The fact that this state is excited in $Ca^{46}(d,p)Ca^{47}$ by a $1d_{3/2}$ transfer shows that the Ca^{46} ground-state wave function must contain $\{1f_{7/2}^8;T=4\}$ components.

Since, in Ca^{48}, the $1f_{7/2}$ neutron shell is completely filled, states involving the $(1f_{7/2})^8$ configuration with isospin lower than the maximum possible must contain neutrons in higher shell orbits as well as a breaking of the now closed proton s-d shell. Such complicated excitations are not likely to play a role in the Ca^{46} ground state; hence, we may write the wave function for this

[19] We shall use here the isospin formalism of Ref. 7 rather than the more usual model where only the neutron configurations are considered. In the latter notation, Eq. (2) would read:

$$|Ca^{46}(0)\rangle=\alpha_\nu(1f_{7/2}^6)+\beta_\nu(1f_{7/2}^8)(1d_{3/2}^{-2}).$$

In the case of Ca^{46}, α_ν^2 and β_ν^2 equal a^2 and b^2 of Eq. (2) within 4%, whereas the b^2 in the Ca^{40} case is approximately 50% larger than the corresponding β_ν^2.

We have not considered $(2d_{3/2})$ admixtures in the $3/2^+$ states. Such admixtures seem unlikely, since the $2d_{3/2}$ orbit is more than 7 MeV above the ground state of Ca^{47}.

state considering only the $1f_{7/2}$ and $1d_{3/2}$ degrees of freedom:

$$|Ca^{46}(0)0^+;T=3,\ T_z=3\rangle=a\{1f_{7/2}{}^6;\ T=3,\ T_z=3\}+b\sum_{T_z'=-1,0,1}(4,3-T_z',1,T_z'|3,3)\times\{1d_{3/2}{}^{-2};\ T=1,\ T_z'\}\{1f_{7/2}{}^8;\ T=4,\ 3-T_z'\}.\quad(2)$$

Assuming this wave function and that $|Ca^{47}(0)\rangle=\{1f_{7/2}{}^7;\ T=\frac{7}{2},\ T_z=\frac{7}{2}\}$, we find that the $Ca^{46}(d,p)Ca^{47}$ ground-state strength is

$$(2j+1)S_{lj}=8S_{3,7/2}=2a^2,\quad(3)$$

and the strength for the transition to the $Ca^{47}(2)$, $J^\pi=3/2^+$ state is

$$4S_{2,3/2}=2\times0.96b^2.\quad(4)$$

The data of Table I yield

$$a^2=1.0\pm0.25,\quad(5a)$$

$$b^2=0.04\pm0.01.\quad(5b)$$

If we include in Eq. (2) the term

$$c\sum_{T_z'=-1,0,1}(4,3-T_z',1,T_z'|3,3)\times\{2s_{1/2}{}^{-2};\ T=1,\ T_z'\}\{1f_{7/2}{}^8;\ T=4,\ 3-T_z'\},$$

we obtain for c^2 the value

$$c^2=0.01\pm25\%.\quad(5c)$$

This model still neglects the small admixtures of $(2p_{3/2})^2$ particles from the next shell. No measurements exist for Ca^{46}, but the data of Ref. 7 suggest that the total p strength in the Ca ground states amounts to less than ≈0.01 of a particle. In the two cases where pickup of $2p$ neutrons has been observed[7] (in Ca^{44} and Ca^{48}), the states excited were the strong (d,p) $3/2^-$ states, suggesting that the component to be added to Eq. (2) is

$$d\{2p^2{}_{3/2};\ T=1,\ T_z=1\}\{1f_{7/2}{}^4;\ T=2,\ T_z=2\},\quad(6)$$

with

$$d^2\approx0.01.\quad(5d)$$

In $Ca^{40}(d,p)Ca^{41}$, a $\frac{3}{2}^+$ state at 2.017 MeV is excited[4] with a strength of $(2j+1)S=0.8\pm0.25$. This state has recently been observed in neutron pickup[6] from Ca^{42}, thus suggesting the wave function:

$$|Ca^{41}(2)\tfrac{3}{2}^+;\ T=\tfrac{1}{2},\ T_z=\tfrac{1}{2}\rangle=\sum_{T_z'=-1/2,1/2}(1,\tfrac{1}{2}-T_z',\tfrac{1}{2},T_z'|\tfrac{1}{2},\tfrac{1}{2})\times\{1d_{3/2}{}^{-1};\ T=\tfrac{1}{2},\ T_z'\}\{1f_{7/2}{}^2;\ T=1,\ \tfrac{1}{2}-T_z'\}.$$

The corresponding terms in the Ca^{40} ground-state wave function,

$$b\sum_{T_z'=-1,0,1}(1,-T_z',1,T_z'|0,0)\times\{1d_{3/2}{}^{-2};\ T=1,\ T_z'\}\{1f_{7/2}{}^2;\ T=1,\ -T_z'\},$$

would then have

$$b^2=0.6\pm0.2,$$

which is an order of magnitude larger than for Ca^{46}.

It thus appears that a systematic study of the low-lying $l_n=2$ and 0 (d,p) and (p,d) transitions in this region can be utilized for a rather detailed study of the ground-state configurations.

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