given by Edwards *et al.*[9] With these values, the mean lifetimes for the levels are

$$\tau_{265} = (1.71 \pm 0.10) \times 10^{-11} \text{ sec},$$
$$\tau_{280} = (4.02 \pm 0.30) \times 10^{-10} \text{ sec}.$$

DISCUSSION

The results for the 265-keV transition are in agreement with the previous values, $A_2 = (0.15 \pm 0.02)$ and $\tau_{265} = (1.57 \pm 0.10) \times 10^{-11}$ sec, obtained by Metzger[1,3] who used a branching ratio of $\Gamma_0/\Gamma = 0.96$.

Our result on the lifetime of the 280-keV level differs considerably from the direct lifetime measurement of Varma *et al.*,[4] while the agreement with the approximate value given by Shipley *et al.*[5] of $(4 \pm 2) \times 10^{-10}$ sec is good. The mixing ratio δ_{280} obtained in the present experiment agrees with the δ deduced from previous $\gamma\gamma$-angular correlation experiments[9] using Se^{75} sources in the form of metal and selenic acid. This seems to indicate that perturbation of the angular distribution is unlikely. Also compatible with these values are the δ_{280}'s resulting from conversion electron measurements[9] and from the angular distribution of the 280-keV γ quanta emitted after Coulomb excitation.[7,8] A weighted average of all these results yields $\delta_{280} = -(0.45 \pm 0.02)$.

Further information on the mixing ratio $|\delta_{280}|$ is obtainable by comparing the cross sections for Coulomb excitation[7,8] and resonance fluorescence. The reduced $E2$ transition probability obtained by Ritter *et al.*[7] with Ne ions as bombarding particles leads to $|\delta_{280}| = (0.65 \pm 0.06)$, while Kamitsubo's result[8] using α particles leads to $|\delta_{280}| = (0.37 \pm 0.05)$. No explanation can be offered for the discrepancy between the values from cross-section measurements and the averaged δ_{280} from angular distribution and conversion electron measurements.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to Dr. F. R. Metzger for his encouraging interest in this work and for many valuable suggestions and discussions.

PHYSICAL REVIEW VOLUMF 155, NUMBER 4 20 MARCH 1967

Single-Neutron-Hole States in Zr^{89} from the $Zr^{90}(He^3,\alpha)Zr^{89}$ Reaction at 18 MeV*

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The (He^3,α) single-neutron pickup reaction was studied in Zr^{90} at 18 MeV using solid-state detectors. The reaction Q value was determined to be 8.58 ± 0.05 MeV. Levels observed in this reaction are the ground state, the 0.59-, 1.07-, 1.44-, 1.72-, 1.84-, 2.06-, and 8.10-MeV states. Angular distributions of all these states except the 8.10-MeV state were measured from 10° to 100° in 5° steps. Distorted-wave Born-approximation analysis (DWBA) yielded the following l-value assignments: ground state, $l=4$; 0.59-, 1.07-, and 1.84-MeV states, $l=1$; 1.44- and 2.06-MeV states, $l=3$; 1.72-MeV state, possibly $l=3$. Relative spectroscopic factors were extracted. The 8.10-MeV state was identified as the analog state of the ground state of Y^{89}. Its angular distribution was measured from 10° to 50° and was in agreement with a $\frac{1}{2}^-$ spin assignment. The Coulomb displacement energy was calculated to be 11.70 ± 0.05 MeV. The ratio of the spectroscopic factors of the $T_>$ and the $T_<$ states is discussed in connection with the DWBA predictions. The locations of the single-neutron-hole states are investigated.

INTRODUCTION

In this experiment we have extended the study of the (He^3,α) single-neutron pickup reaction to $N=50$ nuclei. The choice of Zr^{90} is made because of its simple proton configuration which yields a simple level structure of Zr^{89}. The purpose of this study is threefold: First, the distorted-wave Born-approximation (DWBA) analysis is performed for an $l=4$ transition in the (He^3,α) reaction. Recently, an analysis of $l=4$ transitions in (α,He^3) reactions[1] has cast some doubt on the correctness of the extracted spectroscopic factors. It is, therefore, of interest to check this in the (He^3,α) reaction. Second, the location of the single-neutron-hole states in Zr^{89} is investigated. The splittings of these states are of interest although there has been no theoretical investigation concerning them. Third, the excitation of analog states of Y^{89} in Zr^{89} is investigated. Of particular interest is the ratio of the spectroscopic factors of the $T_>$ and $T_<$ states with the same spin and parity. Discrepancies between the theoretical predictions and the experimental values of these ratios extracted using the customary separation-energy prescription of the DWBA analysis were obtained in recent work with the (p,d) reaction.[2] It is, therefore, interesting

* Work supported by the U. S. National Science Foundation.
[1] C. R. Bingham, M. L. Halbert, and R. H. Bassel, Bull. Am. Phys. Soc. **11**, 118 (1966); Phys. Rev., this issue, **155**, 1248 (1967).

[2] R. Sherr *et al.*, Phys. Rev. **139**, B1272 (1965).

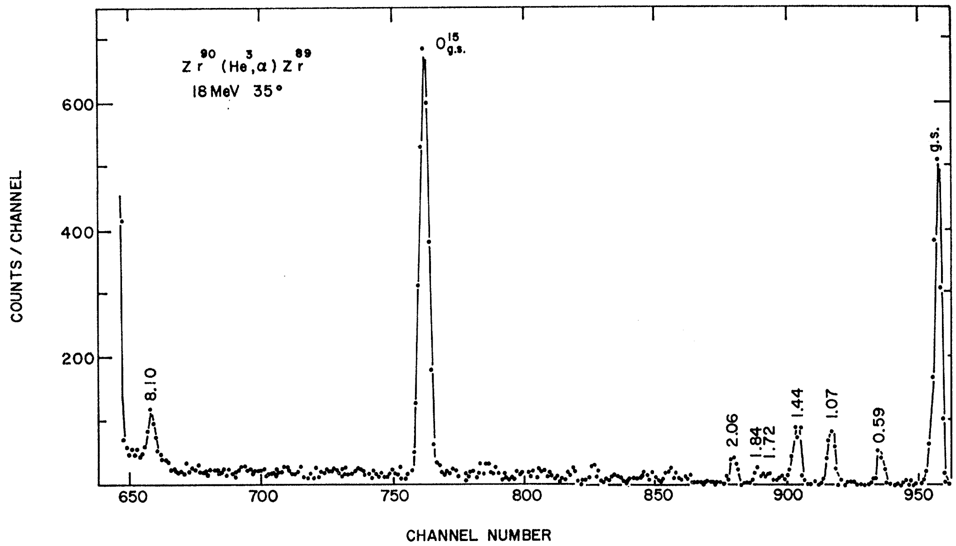

FIG. 1. α-particle spectrum from the reaction $Zr^{90}(He^3,\alpha)Zr^{89}$ at 18 MeV measured at 35°. The numbers above the identified peaks are the excitation energies in MeV. (g.s.≡ground state).

to find out whether the same discrepancies exist in the study of the (He^3,α) reaction.

EXPERIMENTAL DETAILS

At first, self-supporting ZrO foils of about 100–150 $\mu g/cm^2$ thickness were used as targets. These broke, however, after being bombarded by an 18-MeV He^3 beam of about 50 nA for several minutes. Therefore, ZrO with 90% enriched Zr^{90} was evaporated on a 20 $\mu g/cm^2$ carbon foil and used instead. The estimated thickness of the ZrO layer is about 100–150 $\mu g/cm^2$.

The experimental set-up and procedure were the same as those described in previous publications.[3] Because of the large differential cross section for elastic scattering at extreme forward angles, pile-up rejection[3] was applied for the cross-section measurement at angles smaller than or equal to 20°. In addition to this, to decrease the pile-up counts and the dead time of the analyzer the apertures defining the solid angles subtended by the detectors were reduced considerably and the beam intensity was kept below 5 nA. Detectors were systematically arranged on either side of the beam, e.g., 10°, 20°, 30°, to the left and 15°, 25° to the right, in order to measure the differential cross section at forward angles in 5° steps in one very long run. In order to gather enough statistics with an average current about 3–5 nA, data was accumulated for approximately 20 h. The reduced apertures of the detectors were calibrated with respect to a standard aperture using an Am^{241} α source placed at the target position. This ensures accurate normalization factors for the differential cross sections at all angles. The measurement of the angular distribution of the 8.10-MeV state was difficult at 10°, 15°, and 20° where it is somewhat covered by the very strong elastic scattering peak. Therefore, magnetic spectrograph exposures were made at these three angles using Ilford Nuclear Research $K-1$ plates of 50 μ thickness. The differential cross sections of the 8.10-MeV state at these three angles were obtained by comparison with the known cross section of the ground-state transition measured with solid-state detectors. Absolute cross sections were estimated by comparison with the elastic scattering cross section of He^3 by Zr^{90}, assuming that for angles less than 25° the scattering is purely Coulomb. The uncertainty of this estimation is roughly 20% due to the presence of carbon and oxygen in the target.

EXPERIMENTAL RESULTS

The 35° α-particle spectrum is shown in Fig. 1. States which are excited strongly enough for identification are the ground state, the 0.59-, 1.07-, 1.44-, and 8.10-MeV states. Angular distributions of these states except the 8.10-MeV state were measured from 10° to 100° in 5° steps.

For the 8.10-MeV state the angular distribution was measured at 10°, 15°, and 20° using the magnetic spectrograph and from 25° to 50° using solid-state detectors. Beyond 55° the cross section of the reaction leading to this state is too low to be measured with the single-gap magnetic spectrograph and the elastically scattered He^3 group is too close in energy for the solid-state detectors. Therefore, no measurement was made at these angles.

The angular distributions for the relatively weaker states at 1.72, 1.82, 2.06 MeV have poor statistics. l-value assignments were made by comparison to the

[3] C. M. Fou and R. W. Zurmühle, Phys. Rev. **140**, B1283 (1965); C. M. Fou, R. W. Zurmühle, and L. W. Swenson, *ibid.*, 144, 927 (1966).

TABLE I. Optical-potential parameters used. Group I was referred to as shallow-well, Group II deep-well. For the shallow well: He^3 well parameters were obtained from the 18-MeV data of elastic scattering on Ni^{58}, α well parameters obtained from 34.7-MeV data of elastic scattering on Zr^{90}. For the deep well: He^3 well parameters are a consistent set obtained by Bassel for medium-weight nuclei, α well parameters from 34.7-MeV data of elastic scattering on Zr^{90}.

		V (MeV)	W (MeV)	r_v (F)	r_c (F)	a_v (F)	$Vs.o.$ (MeV)	r_w (F)	a_w (F)	$4W_d$ (MeV)	Reference
I	He^3	31.3	16.1	1.67	1.4	0.58	0	1.67	0.58	0	3
	α	94.5	14.7	1.475	1.4	0.561	0	1.475	0.561	0	5
II	He^3	173.0	17.6	1.14	1.3	0.723	0	1.60	0.81	0	3,5
	α	228.0	23.3	1.366	1.4	0.557	0	1.242	0.557	0	5

stronger states. No other distinct α groups were observed between the 2.06-MeV and the 8.10-MeV states. The uncertainties of the excitation energies are ± 50 keV. The Q value of the reaction was determined to be 8.58 ± 0.05 MeV which is in agreement with the latest mass table by Mattauch *et al.*[4] within experimental uncertainties. The magnetic spectrograph exposures taken at 10°, 15°, and 20° showed that there is possibly a very weak state at 1.52 ± 0.08 MeV and a somewhat stronger state at 9.60 ± 0.08 MeV. The 1.52-MeV state becomes very weak at larger angles and was not identifiable in the solid-state-detector spectra. The 8.10- and the 9.60-MeV states were identified to be the analog states of the ground state and the 1.53-MeV state in Y^{89}, respectively. They will be discussed in a later section of this paper.

THE DWBA ANALYSIS

Determination of l Values

Because of the presence of oxygen and carbon in the target the elastic scattering angular distribution could not be measured. However, this angular distribution is expected to be rather structureless, and therefore, no effort was made to measure it separately. The optical parameters were taken from the analysis of He^3 elastic scattering by Ni^{58} at the same energy. Parameters for the α channel were taken from the analysis of α-particle elastic scattering by Zr^{90} at 34.4 MeV[5] and 24.7 MeV.[6] Two sets of parameters were used which represent deep and shallow He^3 potential wells (Table I). The shallow He^3 well parameters were obtained by the authors.[3] They resemble those of a well used by Blair and Wegner.[7] The parameters of the deep He^3 well were obtained from the analysis[5] of ORNL data of elastic He^3 scattering and are consistent for a wide range of medium-weight nuclei. However, the $l=4$ prediction of the DWBA using the deep He^3 well does not reproduce the slope of the ground-state experimental angular distribution whose spin is known to be $\frac{9}{2}^+$. It is interesting to note that a change in r_w of $+10\%$ brings the slope into agreement (see Fig. 2). This indicates that absorption of higher partial waves is needed for the deep He^3 well. r_w is known to be an insensitive parameter in fitting a rather structureless elastic scattering angular distribution. It is, therefore, not impossible that r_w is slightly mass-dependent in the deep well making it larger for Zr^{90} than for Ni^{58} at 18-MeV incident energy. As long as there is no evidence for this effect from optical-model fits of elastic scattering data we see no justification for assuming it. Therefore, the shallow-well parameters were used in all following calculations. The use of optical potentials with different well depths in the DWBA analysis of (He^3,α) angular distributions could yield different relative spectroscopic factors. An unpublished analysis of the $Ni^{58}(He^3,\alpha)Ni^{57}$ and $Ca^{40}(He^3,\alpha)Ca^{39}$ reactions by the authors has shown that up to an excitation of 3 MeV the difference in the relative spectroscopic factors extracted from the deep and shallow wells is less than 10% between states with the same l and less than 30% between states of different l. It is not known what the difference would be in the present case because no reasonable fit could be obtained from the DWBA calculation using the deep well. The difference is, however, expected to be about the same.

The DWBA predictions, using the Oak Ridge National Laboratory Computer Code JULIE,[8] are plotted together with the experimental data points in Fig. 3(a)

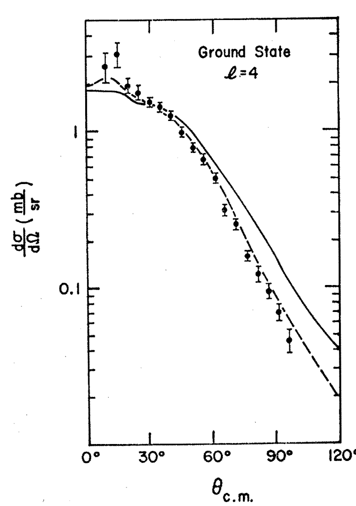

FIG. 2. DWBA predictions for the angular distribution of the α particles leading to the ground state of Zr^{89}. Both curves assumed an $l=4$ transition using the deep-well parameters. The dashed curve is the prediction with r_w increased by 10%.

[4] J. H. E. Mattauch *et al.*, Nucl. Phys. **67**, 1 (1965).

[5] R. H. Bassel (private communication).

[6] L. McFadden and G. R. Satchler, Nucl. Phys. **84**, 177 (1966).

[7] A. G. Blair and H. E. Wegner, Phys. Rev. **127**, 1233 (1962).

[8] R. H. Bassel, R. M. Drisko, and G. R. Satchler, Oak Ridge National Laboratory Report No. ORNL-3240, 1962 (unpublished); and (private communication).

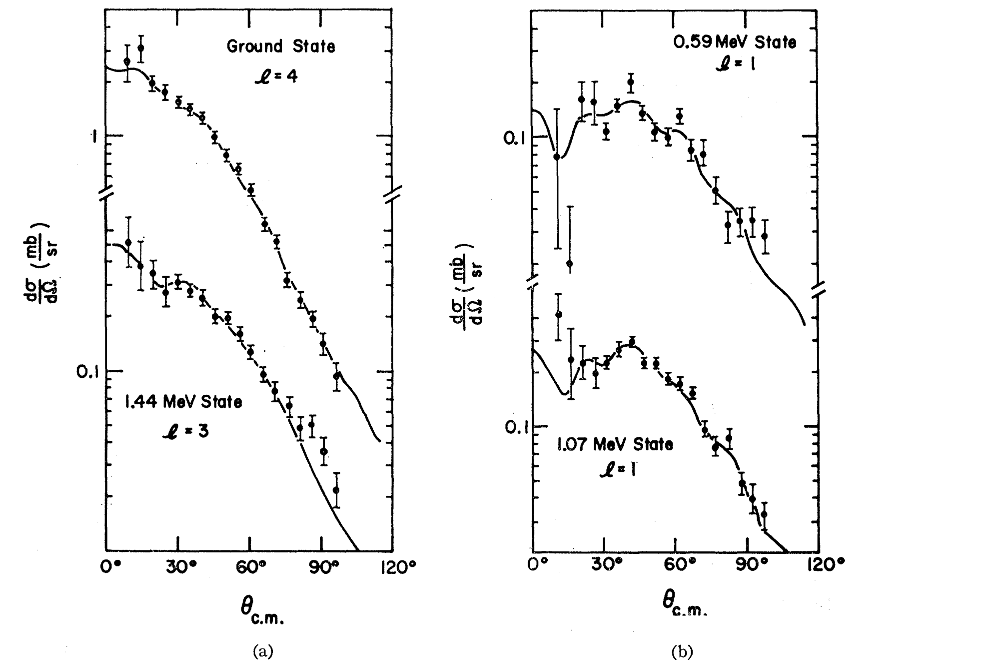

FIG. 3. (a) DWBA predictions for the ground state and the 1.44-MeV state using the Group I parameter set given in Table I. (b) DWBA predictions for the 0.59- and 1.07-MeV states using the Group I parameter set given in Table I.

and 3(b). The assumed angular momentum transfers are indicated.

The experimental angular distributions of the ground state and the 1.44-MeV state are both rather structureless and differ only in their slopes. This difference in slope is very well predicted by the DWBA calculation (assuming $l=4$ for the ground state and $l=3$ for the 1.44-MeV state). Agreement between the experimental angular distribution of the 0.59-MeV state and the prediction of DWBA calculation for $l=1$ is also very satisfactory. The DWBA prediction for $l=2$ has a shape which is steeper and smoother than the prediction for $l=1$ but not so steep and with more structure than the prediction for $l=3$. None of the experimental angular distributions agree with the $l=2$ DWBA prediction. This is reasonable (or not surprising) since no $l=2$ transitions at low excitation energy are expected according to the shell model.

EXTRACTION OF SPECTROSCOPIC FACTORS AND TENTATIVE SPIN ASSIGNMENTS

The relative spectroscopic factors are extracted according to the customary separation-energy prescription (SE); i.e., the binding energies of the neutrons to be picked up are set equal to their separation energies. Their wave functions are then calculated assuming a Saxon-Woods–type real well with $r=1.2$ F and $a=0.65$ F, where r is the radius parameter and a is the diffuseness parameter. The well depth is adjusted to yield the binding energy of the neutron in the assumed shell-model orbit. The prescription of setting the binding energy equal to the separation energy is generally accepted because it gives the proper asymptotic behavior of the wave function of the particle to be transferred. For the 8.10-MeV state the binding energy is very large because of its high excitation energy. The wave function calculated for the neutron in this state is more confined inside the nuclear potential than a wave function calculated for a lower lying state with the same J^π. Consequently, the DWBA predicts a smaller differential cross section. In other words, with the same experimental differential cross section, the extracted spectroscopic factor will be larger.

An alternative way of extracting spectroscopic factors is the effective binding-energy prescription (EB), in which the well depth for a certain shell-model orbital is fixed. The well depth is adjusted so that it gives a binding energy for this orbital which is equal to the weighted average of all the separation energies of the particles leaving the residual nucleus in the same J^π state. By comparison with the SE prescription, this method enlarges the spectroscopic factors of the lower states and reduces the spectroscopic factors of the higher states. We will return to discuss the spectroscopic factors of the 8.10-MeV analog state extracted using these two prescriptions in the following section.

The normalization of the extracted spectroscopic factors is accomplished by assuming that the ground state of Zr^{89} is the only $g_{9/2}$ state; consequently, its spectroscopic factor should be 10, the total number of $g_{9/2}$ neutrons in Zr^{90}. This requires the normalization of all spectroscopic factors by a factor of about 27. Similar factors have been found necessary in other (He^3,α) reactions.[3] The normalized spectroscopic factors are listed in Table II.

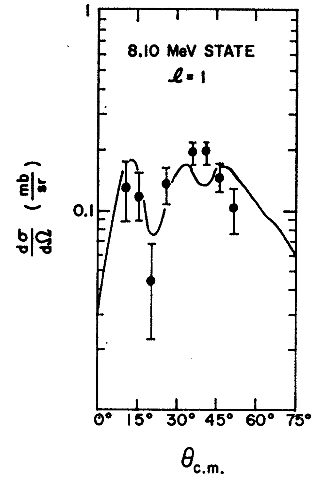

FIG. 4. DWBA prediction for the 8.10-MeV state, the analog state of the Y^{89} ground state, assuming an $l=1$ transition. The Group I parameter set was used.

SUM RULE FOR $T_>$ AND $T_<$ STATES

For the single-neutron pickup reaction, the summed spectroscopic factors of the $T_>$ and the $T_<$ states with the same J^π have been calculated by French and Macfarlane[9]:

$$\sum S_{T>}=\frac{1}{N-Z+1}\langle\text{proton}\rangle_j,$$

$$\sum S_{T<}+\sum S_{T>}=\langle\text{neutron}\rangle_j,$$

where $\langle\text{proton}\rangle_j$ is the number of protons and $\langle\text{neutron}\rangle_j$ the number of neutrons in the target nucleus occupying the l_j shell from which the neutron is picked up. According to this sum rule our assumption that the ground state is the only $\frac{9}{2}^+$ state implies that there is no proton in the $g_{9/2}$ shell. The $g_{9/2}$ neutron hole state, consequently has no $T_>$ component. The twelve protons in Zr^{90} outside the closed $f_{7/2}$ major shell fully occupy all three subshells: $p_{3/2}$, $p_{1/2}$, $f_{5/2}$. The sum of the spectroscopic factors of the $T_>$ and $T_<$ states observed in the $Zr^{90}(He^3,\alpha)Zr^{89}$ reaction can then be predicted. They are shown in Table III. For the $p_{1/2}$ neutron pickup the predicted sum for $T_<$ states is 1.8. Therefore, the 0.59-MeV state is very likely the only $\frac{1}{2}^-$ state.[10] The spectroscopic factor of the 1.07-MeV state exceeds 1.8 by 45% so it probably is a $\frac{3}{2}^-$ state rather than a $\frac{1}{2}^-$ state. Pickup from the 1.44-MeV state shows an $l=3$ angular distribution. Its low excitation energy favors a $\frac{5}{2}^-$ spin assignment. The 1.72- and 2.06-MeV states are also believed to be $\frac{5}{2}^-$ states because of their low excitation energies. Because the 0.59-MeV state takes up the full strength of the $\frac{1}{2}^-$ state, the 1.84-MeV state is tentatively assigned to be $\frac{3}{2}^-$. The spin assignment of the 8.10- and 9.60-MeV states will be discussed in the following section concerning analog states.

TABLE II. Spectroscopic factor extracted from DWBA analysis using the JULIE computer code. Group I parameter set and separation-energy prescription were used. All tentative spin assignments in the parentheses were made using the shell-model argument that the $f_{7/2}$ level is separated by a few MeV from the $f_{5/2}$ level and that the summed spectroscopic factor of the $\frac{1}{2}^-$ state should be less than two. The assignment of the 8.10-MeV state is made under the assumption that it is the analog state of the Y^{89} ground state.

Excitation energy (MeV)	l_n	J^π	Spectroscopic factor
Ground state	4	$\frac{9}{2}^+$	10.0[a]
0.59±0.05	1	$(\frac{1}{2}^-)$	1.7
1.07±0.05	1	$(\frac{3}{2}^-)$	2.6
1.44±0.05	3	$(\frac{5}{2}^-)$	2.7
(1.52±0.08)			
1.72±0.05	(3)	$(\frac{5}{2}^-)$	(0.4)
1.84±0.05	1	$(\frac{3}{2}^-)$	0.9
2.06±0.05	3	$(\frac{5}{2}^-)$	0.9
8.10±0.05	1	$\frac{1}{2}^-$	0.7
(9.60±0.08)	(1)	$(\frac{3}{2}^-)$	(1.3)

[a] Normalized value.

TABLE III. Summed spectroscopic factors for $T_>$ and $T_<$ states identified tentatively in the present experiment.

	$\sum S_{T>}$ Theoret.	Exptl. EB	Exptl. SE	$\sum S_{T<}$ Theoret.	Exptl.
$g_{9/2}$	0	0	0	10.0	10.0[a]
$p_{1/2}$	0.18	(0.09)	(0.65)	1.82	1.73
$f_{7/2}$	0.55	···	···	5.45	4.0
$p_{3/2}$	0.36	(0.2)	(1.3)	3.64	3.5

[a] Normalized value.

APPLICATION TO THE ANALOG STATES OF Y^{89}

The strong excitation of the 8.10-MeV state indicates that it is the analog state of the Y^{89} ground state. If this is true, the Coulomb displacement (ΔC_{Coul}) is calculated to be 11.70±0.05 MeV using the Y^{89}-Zr^{89} mass difference of 2.82 MeV, the hydrogen atom-neutron mass difference of 0.78 MeV and the 8.10-MeV excitation energy. This agrees very well with the value 11.55±0.15 MeV obtained by Anderson *et al.*[11] from the (p,n) reaction on Y^{89}. The experimental angular distribution is in agreement with the DWBA $l=1$ angular distribution (Fig. 4). This is consistent with the $\frac{1}{2}^-$ spin and parity of the ground state of Y^{89}. The sum of the spectroscopic factors of $T_>$ and $T_<$ was calculated using the sum rule described in the previous section.

Comparison between the theoretical predictions and the experimentally extracted spectroscopic factors is made in Table III.

The normalized spectroscopic factors of the analog state for the EB and SE methods differ by a factor of 7. The EB result is in better agreement with the theoretical prediction because it is less than the predicted sum, which is possible if the 8.10-MeV state is not the only $T_>$ $\frac{1}{2}^-$ state. Similar results have been obtained else-

[9] J. B. French and M. H. Macfarlane, Nucl. Phys. **26**, 168 (1961).

[10] C. D. Goodman, Phys. Rev. Letters **10**, 247 (1963).

[11] J. D. Anderson, C. Wong, and J. W. McClure, Phys. Rev. **138**, B615 (1965).

where. However, a more rigorous method (such as introducing an isobaric spin-dependent potential and solving the coupled equations[12] to obtain the bound-state neutron wave function) is necessary to obtain better results. Furthermore, the applicability of DWBA is rather doubtful for the 8.10-MeV state since it is unstable against particle decay. Hence the extracted spectroscopic factor is given in parentheses in Table III. It is interesting to point out that the cross section of the analog state (Fig. 1) is comparable to that of the 0.59-MeV state. However, the DWBA differential cross sections of these two states using the same bound-state wave function differ by a factor of 20. The analog state with a smaller Q value has the larger predicted cross section because the transition is kinematically favored. Consequently, the extracted spectroscopic factor for the analog state is much smaller (Table III).

The 9.60±0.08 MeV state lies at the correct excitation energy to be the analog of the 1.53-MeV state in Y^{89}. The ratio of the differential cross sections of this state and of the 8.10-MeV state at all three angles (10°, 15°, and 20°) were constant within the experimental uncertainties. This suggests that the 9.60-MeV state is an $l=1$ state which agrees with the $\frac{3}{2}^-$ assignment of the 1.53-MeV state in Y^{89}. The spectroscopic factor of the 9.60-MeV state was estimated from this ratio and is given in Tables II and III in parentheses. No state analogous to the 0.915-MeV $\frac{9}{2}^+$ state in Y^{89} was observed. The upper limit on the differential cross section of the transition to this state is estimated to be 0.05 mb/sr. Therefore, the normalization of the spectroscopic factor of the ground state to 10 received further justification.

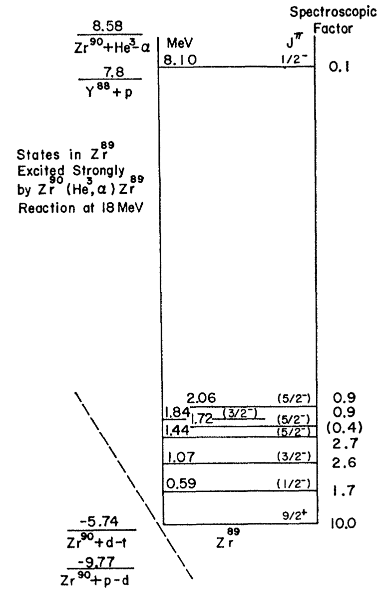

FIG. 5. Level scheme of Zr^{89} with summarized spectroscopic information.

CONCLUSION

The study of the $Zr^{90}(He^3,\alpha)Zr^{89}$ reaction at 18 MeV has shown the possible locations of strong single-neutron-hole states in Zr^{89}. The present tentative order of these states is $g_{9/2}$, $p_{1/2}$, $p_{3/2}$, $f_{5/2}$. The angular distribution of the $l=4$ transition to the ground state of Zr^{89} was in agreement with the DWBA prediction. It is found that the spectroscopic factor extracted for the $l=4$ transition requires approximately the same normalization constant as for transitions in previous experiments[3] with $l\leq 3$ using similar optical potential parameters. The analog state of the $\frac{1}{2}^-$ Y^{89} ground state is observed in Zr^{89} at 8.10±0.05 MeV excitation. The ratio of the spectroscopic factors of this state and the 0.59-MeV state (which is also $\frac{1}{2}^-$) compared to the theoretical prediction shows the need for a better extraction procedure than the customary separation energy prescription. The same conclusion has been pointed out previously in the analysis of the (p,d) reaction[2] and (He^3,α) reaction.[12] The spectroscopic information of Zr^{89} obtained in this experiment is summarized in Fig. 5.

Note added in proof. According to a theoretical calculation by B. F. Bayman, A. S. Reiner, and R. K. Sheline [Phys. Rev. **115**, 1627 (1959)], the proton configuration of the Zr^{90} ground state is (63±5%) $(2p_{1/2})^2$ (37±5%) $(1g_{9/2})^2$. Calculation by B. Goulard and D. DoDang [B. Goulard (private communication)] using pairing force reached the same conclusion. This prediction is further confirmed by experimental results obtained from $Zr^{90}(d,He^3)Y^{89}$ reaction [E. Newman (private communication)]. Consequently, the sum-rule prediction for the spectroscopic factor of the $T_<$ $\frac{9}{2}^+$ state in Zr^{89} is 9.93 instead of 10.0. This changes the normalization by only −0.7%. No conclusion or conjecture drawn in the text is affected. The authors are indebted to B. Goulard for bringing this to their attention.

ACKNOWLEDGMENTS

We are indebted to Dr. R. H. Bassel for his advice in the DWBA analysis and to W. Focht for his valuable assistance in performing the experiment.

[12] A. M. Lane, Nucl. Phys. **35**, 676 (1962); R. Stock and T. Tamura, Phys. Letters **22**, 304 (1966).