making it difficult to compare the polarizations of different sources if the initial energies of the positrons are markedly different. Hence, the effect observed for Ga^{66} is invariably smaller than for Cu^{64}, unless positrons of approximately the same initial energies are compared in the two cases. When this is done (Table III) the evidence supports the assumption of full polarization $(+v/c)$ for Ga^{66} (if that is the value for Cu^{64}) and hence is in agreement with the results of Deutsch *et al.*[2] and of Frankel *et al.*[3]

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Radiative Capture of Alpha Particles to States of O^{18} and F^{18}†

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The radiative capture of alpha particles in N^{14} and C^{14} has been studied for bombarding energies between 1.3 and 3.0 Mev. Four narrow resonances were observed in the reaction $N^{14}(\alpha,\gamma)F^{18}$, corresponding to levels in F^{18} at 5.60, 5.67, 6.24, and 6.65 Mev. Two narrow resonances were observed in the reaction $C^{14}(\alpha,\gamma)O^{18}$, corresponding to levels in O^{18} at 7.63 and 8.05 Mev. These two are 1^- states.

The decay schemes of some of these levels were partly elucidated, and several partial radiative widths were measured. The decays studied gave information on the low-lying levels in F^{18} and O^{18}.

INTRODUCTION

THE radiative capture of alpha particles can be a very useful means of obtaining information on the low-lying levels in the light nuclei. It is a method which so far has been little exploited for bombarding energies greater than 1.5 Mev. The study of the decay scheme and of the angular properties of the gamma rays emitted at an isolated resonance will yield information on all of the levels involved in the compound nucleus. If the elastic alpha scattering data in the region of the resonance under examination can put limits on the spin of the level formed, then this can be of great help in interpreting what is seen in its radiative decay.

Much theoretical and experimental work has recently been done on the nuclei above O^{16} in the $1d$ shell. The positions of the positive-parity levels in F^{19} and many dynamic characteristics of the mass-19 nuclei agree very well with the prediction of the intermediate coupling shell-model theory,[1] and also with a rotational interpretation.[2] Similar success has been obtained with the first few O^{18} levels.[3] In the present work N^{14} and C^{14} were bombarded with alpha particles of energies between 1.3 and 3.0 Mev to try to find out more about the levels in F^{18} and O^{18}.

EXPERIMENTAL RESULTS

Cylindrical NaI crystals, 2 in. and $1\frac{1}{2}$ in. in diameter, 2 in. and 1 in. thick, were used as gamma-ray detectors, together with DuMont type 6292 phototubes. After amplification, pulses were fed into a multichannel pulse-height analyzer, and into conventional coincidence and gate circuitry as required. The gamma-ray energies were determined by comparison with six standard sources: annihilation radiation (0.511 Mev); Cs^{137} (0.661 Mev); Na^{22} (1.277 Mev); ThC″ (2.62 Mev); the $N^{15}(p,\alpha\gamma)$ reaction (4.43 Mev); and the $F^{19}(p,\alpha\gamma)$ reaction (6.14 Mev).

The investigation of (α,γ) reactions is rendered difficult by their low yield and by several sources of background, the most important being the neutrons formed in the reaction $C^{13}(\alpha,n)O^{16}$. The pulse-height spectrum produced in a NaI crystal by 3-4 Mev neutrons has a roughly exponential distribution. The upper "cutoff" moves up with increasing neutron energy. In addition the yield of the $C^{13}(\alpha,n)$ reaction increases rapidly above 2 Mev.[4] These two factors make the study of gamma rays of energies below 3-4 Mev increasingly difficult for bombarding energies greater than 2 Mev. To minimize this background stringent precautions were taken to make the buildup of natural carbon on the targets as slow as possible. The most effective experimental arrangement employed an activated charcoal pump maintained at liquid air temperature and surrounding the path of the beam. All gaskets used on the target side of this pump were of Teflon, and the target was kept at a temperature of

† Work supported by the U. S. Atomic Energy Commission and by the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

1 J. P. Elliott and B. H. Flowers, Proc. Roy. Soc. (London) **A229**, 526 (1955).

2 E. B. Paul, Phil. Mag. Ser. 8, **2**, 311 (1957).

3 O. M. Bilaniuk and P. V. C. Hough, Phys. Rev. **108**, 305 (1957).

4 Walton, Clement, and Boreli, Phys. Rev. **107**, 1065 (1957).

TABLE I. Data presently available on the levels in F^{18} from 5.6- to 6.8-Mev excitation energy.

E_α(res) (Mev) Earlier[a–c]	Present	Γ_{lab} (kev) Earlier	Present	$J\pi l$	E_{exc}[d] (Mev)
1.530	1.530±0.004	<1.5	<2.0	1,−,1	5.602±0.027
1.617	1.618±0.004	<1.0	<2.0		5.670±0.027
2.351	2.350±0.003	<2.5	<1.0	{(2,+,2)[e] (3,2,−,3)[e]	6.240±0.027
2.370		<4.0		(1,+,0)[e]	6.255±0.027
2.767		<1.0		(5,4,3,+,4)[e]	6.564±0.027
2.868	2.876±0.006	<4.0	<2.0		6.650±0.028
2.870		120±7		1,−,1	6.644±0.027
3.080		130±7		2,−,1	6.807±0.027

[a] See reference 6.
[b] See reference 7.
[c] See reference 8.
[d] The excitation energy in F^{18} corresponding to the E_α(res) were calculated by using the table of mass defects in F. Ajzenberg and T. Lauritsen [Revs. Modern Phys. **27**, 77 (1955)]. The error quoted is mainly due to errors quoted there.
[e] Parenthesis signifies uncertainty in the assignment.

~100°C by blowing hot air onto it. With this arrangement the rate of carbon buildup was reduced to the extent that in 10 hours running the thickness of the deposit was ~2-4 kev for 2-Mev alpha particles. In the experiments background runs were interlaced with "target" runs in order to make sensible corrections.

Both gaseous and solid nitrogen targets were used. Absolute yield measurements on the $N^{14}(\alpha,\gamma)$ reaction were made with a gas target of natural nitrogen, bombarded behind a 2500 A thick nickel foil. Solid nitrogen targets were made by heating tantalum disks, 0.015 in. thick, to red heat in an atmosphere of dry ammonia. The gamma-ray yields estimated using these two targets were in good agreement if it was assumed that one nitrogen atom was absorbed on the surface for every tantalum atom.

The C^{14} targets used were made by cracking acetylene in a discharge tube onto tungsten disks, 0.010 in. thick.[5] The acetylene contained 38.6% C^{14}, 0.6% C^{13}, and 60.8% C^{12}. It was assumed that the targets were of carbon with this isotopic constitution.

The total yield of a gamma ray integrated over a narrow resonance is proportional to $(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$, where J is the spin of the level; Γ_γ, Γ_α, and Γ are the partial widths for alpha emission and for the radiative transitions considered, and the total width, respectively. A measurement of the intensity of a gamma ray, with a target thicker than the total width, thus enables one to calculate this quantity. The interpretations of pulse-height spectra were made using the shapes of single gamma-ray lines determined from the calibration sources. Absolute yield measurements were made by calculating the detection efficiency of the crystal, knowing the absorption coefficient for the gamma ray in question.

$N^{14}+\alpha$

For bombarding energies between 1.3 and 3.0 Mev four narrow resonances were observed in the reaction $N^{14}(\alpha,\gamma)$. These were at 1.530±0.004, 1.618 ±0.004, 2.350±0.003, and 2.876±0.006 Mev. Table I summarizes data presently available on the levels in F^{18} in our region of interest. Figure 1 shows the decay schemes observed.

[5] Douglas, Gasten, and Mukerji, Can. J. Phys. **34**, 1097 (1956).

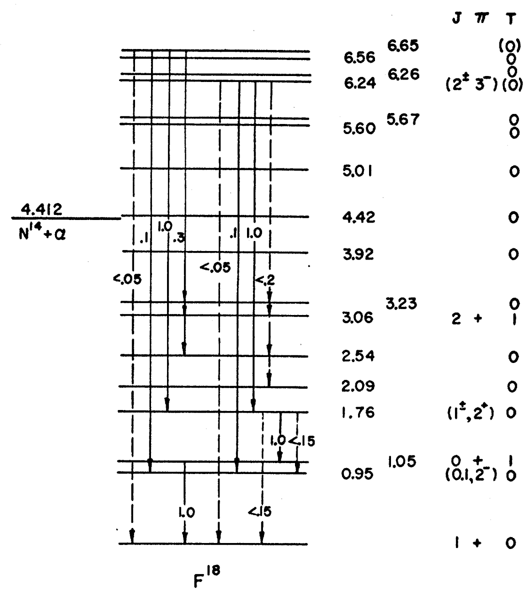

FIG. 1. Energy levels known in F^{18} up to 6.65 Mev and the decay schemes as determined in the present work. All of the levels in the figure except those at 3.06 and 1.05 Mev most probably have $T=0$, since they were observed in either the $Ne^{20}(d,\alpha)F^{18}$ [R. Middleton and C. T. Tai, Proc. Phys. Soc. (London) **A64**, 801 (1951)] reaction or in $N^{14}+\alpha$. This means that all of the levels in Fig. 7 except the ground and 1.99-Mev states in O^{18} have their $T=1$ counterparts in F^{18} which are not indicated above. Levels in F^{18} at 6.666 Mev and above have been observed in the reaction $O^{17}(p,\alpha)F^{18}$ [Katarina Ahnlund, Phys. Rev. **106**, 124 (1956)].

The radiative capture yield in between the four resonances is less than 10% of that at any resonance, and in particular the yield from the resonance at $E_\alpha=2.370$ Mev is less than 5% of that of the 2.350-Mev resonance.

The 5.60- and 5.67-Mev levels corresponding to the 1.53- and 1.62-Mev resonances, respectively, were not looked at further. They have both been studied in some detail by Price,[6] and the lower one by Bromley *et al.*[7]

The narrow level corresponding to $E_\alpha=2.876$ Mev is also observed in elastic alpha scattering, and is seen in the reaction $N^{14}(\alpha,p)$ leading to the ground state of O^{17}.[8] The large background at this energy makes the study of the decay of the 6.65-Mev level difficult. Gamma rays of energies 5.80±0.10 Mev and 4.90±0.05 Mev are present with $(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ equal to 0.25±0.1

[6] P. C. Price, Proc. Phys. Soc. (London) **A68**, 553 (1955).
[7] D. A. Bromley *et al.*, Bull. Am. Phys. Soc. Ser. II, **3**, 27 (1958).
[8] D. F. Herring, Bull. Am. Phys. Soc. Ser. II, **2**, 303 (1957); and University of Wisconsin thesis, 1957, University Microfilms, Ann Arbor, Michigan.

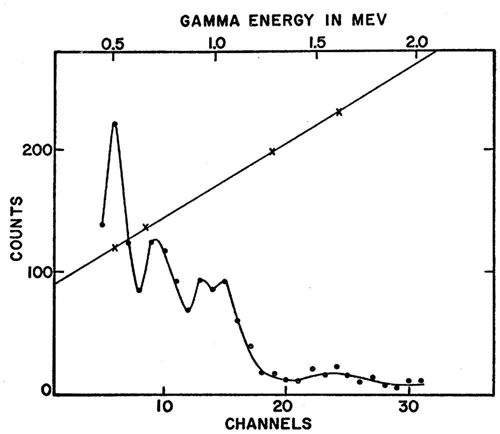

FIG. 2. Gamma rays observed in a 1 in. thick by $1\frac{1}{2}$ in. diameter NaI crystal which are in coincidence with radiation of energy greater than 3 Mev from the 6.24-Mev level in F^{18}. The upper limit shown in Fig. 1 on the ground-state transition from the 1.76-Mev level is based on the absence of a peak at 1.76 Mev in the above spectrum. The straight line through the crosses shows the energy scale as obtained with the calibration sources.

ev and 2.1±0.7 ev, respectively. An upper limit of 5% was put on the ground-state transition relative to that to the 1.76-Mev state. There are transitions to states in F^{18} around 3 Mev with about 30% of the intensity of the transition to the 1.76-Mev level.

*The 6.24-*Mev *Level*

This level decays mainly by emission of a gamma ray of energy 4.45±0.05 Mev to a state at 1.76±0.02 Mev. There is also a gamma ray of energy 5.30±0.10 Mev with about 10% of the intensity of the main transition. Upper limits of 5% and 20% of the 4.45-Mev gamma ray can be put on transitions to ground state and states around 3 Mev. The values measured of $(2J+1)\Gamma_\gamma$

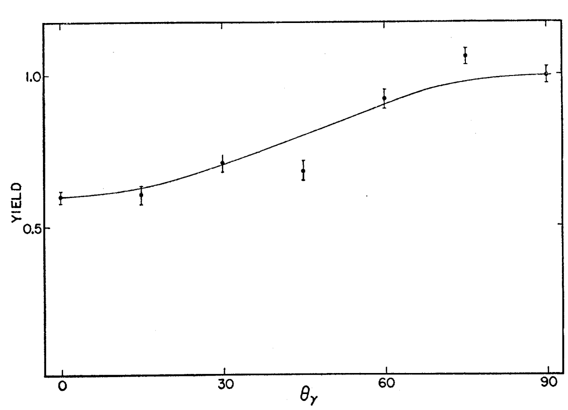

FIG. 3. The angular distribution of the 4.45-Mev gamma ray emitted by the 6.24-Mev level in F^{18}. The solid curve represents as angular distribution $W(\theta)=1-0.40\cos^2\theta$. A small geometry correction gives the point-to-point correlation $W(\theta)=1-0.41\cos^2\theta$.

for the two gamma rays are 7.9±1.0 ev and 0.8±0.15 ev, respectively.[9]

The low-energy gamma rays in coincidence with gamma rays of energy greater than 3 Mev are shown in Fig. 2. This spectrum shows gamma rays of energies 720, 950, and 1050 kev. The decay schemes shown in Fig. 1 were obtained with the aid of this and other coincidence spectra.

The (γ,γ) correlation between the 4.45-Mev gamma ray and the 1.05-Mev gamma ray was measured in the plane perpendicular to the beam by putting the "window" of a single-channel kicksorter on the total energy peak of the 1.05-Mev gamma and above the 950-kev peak, and putting these counts in coincidence with gamma rays of energy greater than 3 Mev in another crystal. The correlation was isotropic to within 10%. This isotropy is consistent with other evidence[7] that the 1.05-Mev level is 0^+, $T=1$. The ground state is then 1^+, $T=0$. To account for the gamma decay data the 1.76-Mev state is most likely to be 1^+, 1^-, or 2^+ and must have $T=0$ since it appears that no level exists in O^{18} below 2 Mev.

The angular distribution of the 4.45-Mev gamma ray, after geometry correction, is satisfactorily represented by $W(\theta)=1-(0.41\pm0.05)\cos^2\theta$. This is shown in Fig. 3. The alpha elastic scattering data exclude all but an $l=2$ or 3 wave formation of the level but are not conclusive.[8] The only possibilities which fit the angular distribution and the most likely spins of the 1.76-Mev state are:

$$\text{(i)}\quad 1^+ \xrightarrow{l=3} 3^- \xrightarrow{E1} 2^+:\quad A_2=-0.391,$$

$$\text{(ii)}\quad 1^+ \xrightarrow{l=3} 2^- \xrightarrow{E1\text{ or }M1} 1^\mp:\quad A_2=-0.500,$$

$$\text{(iii)}\quad 1^+ \xrightarrow{l=2} 2^+ \xrightarrow{E1\text{ or }M1} 1^\mp:\quad A_2=-0.334.$$

The A_2 quoted above are the theoretically expected values of the coefficient in the angular distributions $W(\theta)=1+A_2\cos^2\theta$ for the unmixed schemes quoted above.

(i) The measured value of $(2J+1)\Gamma_\gamma$ of 8 ev makes it unlikely that the transition is an $E1$, since the $|M|^2$ value of 0.017 would then be greater than that of any known isotopic-spin-forbidden $E1$ transition.[10]

(ii) The possibility is also unlikely since if $l=3$ wave alpha particles predominantly formed a state of spin 2, this would mean that the $l=3$ component in the reduced alpha-particle width would be a factor of ~50 times greater than the $l=1$ component. If we allow this, then a small amount of $l=1$ wave alphas interfering with $l=3$ waves will produce the observed correlation more accurately.[11] Figure 4 shows theoretically allowed

[9] This level is not seen in $N^{14}(\alpha,p)$ but is observed in $N^{14}(\alpha,\alpha)$. We therefore assume that $\Gamma_\alpha \gg \Gamma_p$, Γ_γ and that $\Gamma_\alpha \cong \Gamma$, and that the isotopic spin of the level is $T=0$.

[10] D. H. Wilkinson, Phil. Mag. Ser. 8, 1, 127 (1956).

[11] This can also be done by mixing in with the predominantly $M1$ transition an amount of $E2$ as big as or greater than the single-particle estimate of the strength of a 4.46-Mev $E2$ transition.

values of the angular distribution coefficient A_2 for various values of α_α, the ratio of the amplitudes of the $l=1$ and the $l=3$ alpha-particle waves. The shaded portion represents all allowed values of A_2 obtained when $\cos\beta_\alpha$ (where β_α is the phase difference between the $l=1$ and $l=3$ waves) varies from -1 to $+1$.

(iii) The sequence $1^+ \rightarrow 2^+ \xrightarrow{M1} 1^+$ would correspond to $|M|^2=0.9$ for the $M1$ transition, which is a reasonable figure. $1^+ \rightarrow 2^+ \xrightarrow{E1} 1^-$ would correspond to an even larger $|M|^2$ value of 0.024 for the isotopic-spin-forbidden $E1$ transition. This value could be explained on the basis of a large mixing in the predominantly 2^+, $T=0$ state of nearby 2^+, $T=1$ states. These states are expected to exist in this region from the configurations d^2, ds, and s^2. One has been found at 8.22 Mev in O^{18} from the $C^{14}(\alpha,\alpha)$ reaction,[12] and an additional one may have been identified at $\sim$17 Mev in O^{18} from the $C^{14}(\alpha,\gamma)$ reaction.[13] The same sort of argument might also apply in scheme (i), but $T=1$, $J=3^-$ levels are expected to lie somewhat higher than 6 Mev in F^{18}. There is also the possibility that the assumption of $T=0$ for the 6.24-Mev level is incorrect. Definite assignments to the 6.24- and 1.76-Mev states must await additional evidence.

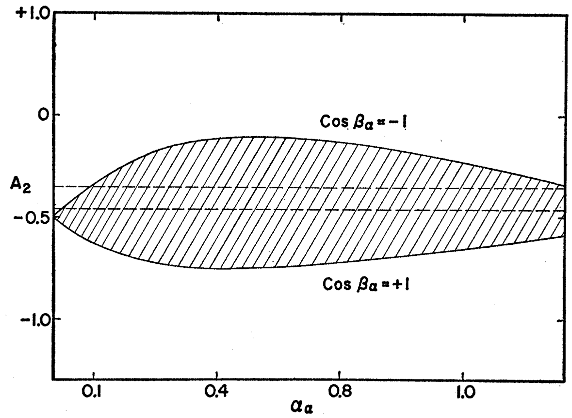

FIG. 4. The coefficient A_2 as a function of the parameters α_α and $\cos\beta_\alpha$. The shaded area represents all allowed values of A_2 calculated for the scheme $1^+(1,3)2^-(1)1^\pm$. The experimental value is shown as the area between the dotted lines.

An attempt was made to measure the anisotropy of the 5.3-Mev gamma ray but the relatively large background subtraction made the results inconclusive.

The situation regarding the low-lying levels in F^{18} is not in such good agreement with theory as in the case in F^{19}. The 1.76-Mev state is not the 3^+ or the 5^+

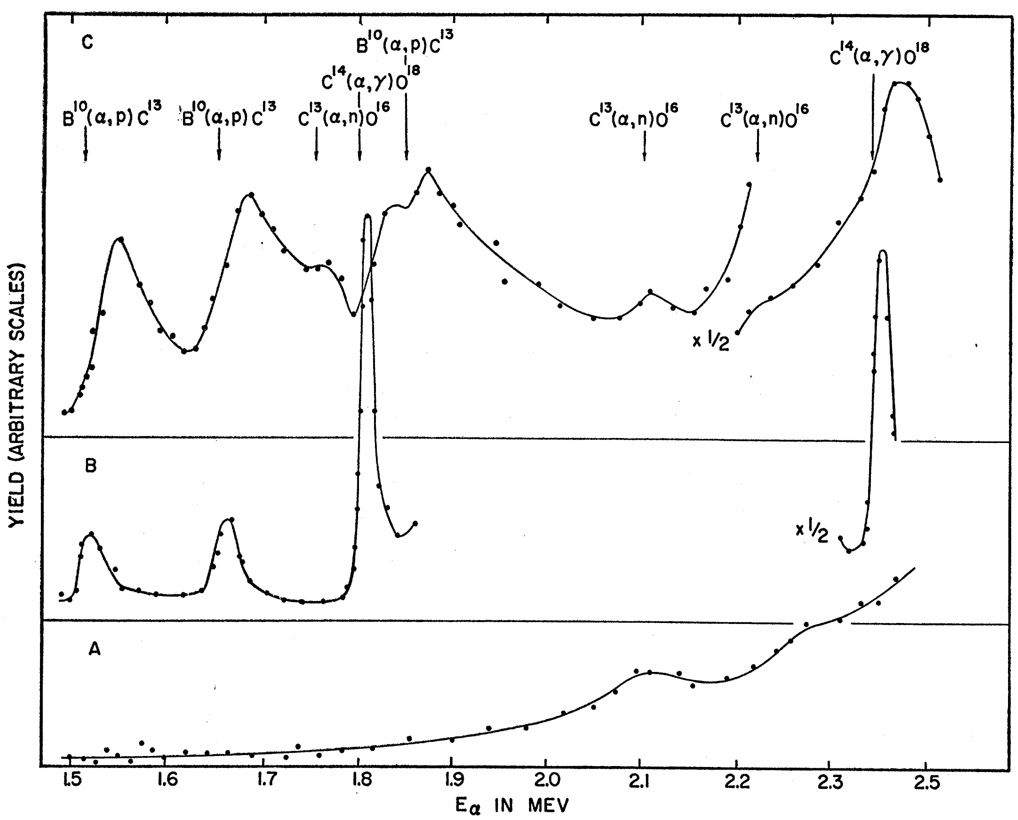

FIG. 5. Number of counts corresponding to an energy greater than 3.5 Mev *versus* energy for 38.6% C^{14} and natural carbon targets. Curve A is for a natural carbon target about 20 kev thick at 2 Mev. Curve B is for a C^{14} target about 16 kev thick at 2 Mev. Curve C is for a C^{14} target of thickness about 80 kev. This target was nonuniform and probably had deposits on its surface.

[12] J. A. Weinman and E. A. Silverstein, Phys. Rev. (to be published); and J. A. Weinman, University of Wisconsin thesis, 1957 (unpublished).
[13] A. E. Litherland and H. E. Gove (private communication, 1958).

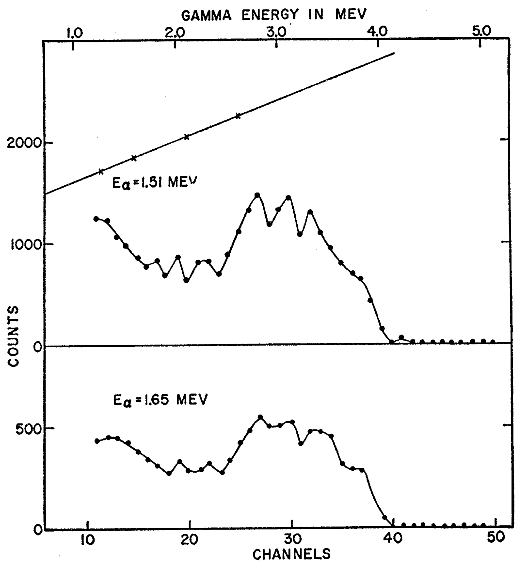

FIG. 6. Gamma rays observed in a 2 in. thick by 1.5 in. diameter NaI crystal at the resonances observed at bombarding energies of 1.51 and 1.65 Mev. Gamma rays from the first three excited states of C^{13} are observed at 3.85, ~3.6, and 3.05 Mev.

predicted by the shell-model calculations, and this provides further embarrassment if, as data from the $F^{19}(d,t)F^{18}$ and $N^{14}(\alpha,\gamma)F^{18}$ reactions[7,14] suggest, the 950-kev state has odd parity.

$C^{14}+\alpha$

Two narrow resonances were found in this reaction for E_α between 1.3 Mev and the $C^{14}(\alpha,n)$ threshold at 2.34 Mev. These were at bombarding energies of 1.794±0.006, and 2.334±0.006 Mev. The resonances at 2.55,[12] 2.64, and 2.80 Mev observed in the $C^{14}(\alpha,n)$ reaction[15] and the $C^{14}(\alpha,\alpha)$ reaction were also seen in the NaI counter, but the large background due to the capture of the slow neutrons obscured any gamma rays present. Figure 5 shows yield curves for counts above 3.5 Mev in a NaI crystal for targets of 38.6% C^{14} and natural carbon, respectively. The absence of resonances in $C^{12}(\alpha,\gamma)$ implies that there are no 0^+, 1^-, 2^+, etc. states in O^{16} with radiative widths >0.03 ev in this region. This is in agreement with previous work.[16] The resonances observed at 1.51 and 1.65 Mev are most probably in the reaction $B^{10}(\alpha,p)C^{13}$.[17] They both have widths greater than 10 kev, and occur at the right alpha-particle energies.[18] The gamma-ray spectra at these two resonances are shown in Fig. 6. Both show gammas of energies 3.85, 3.05, and ~3.6 Mev, and an absence of higher energy gamma rays. This is also suggestive of $B^{10}(\alpha,p)$, the intensities agreeing with the previous work on $B^{10}+\alpha$ and the known modes of decay of the C^{13} levels at these energies. By comparing the intensities observed with the known cross sections it is found that the boron impurity in the targets must be of the order of 1%. This large amount of contamination might arise in the conversion of the $BaC^{14}O_3$ to acetylene (see reference 5) if the Pyrex (borosilicate glass) reacts with the barium metal to form a gaseous boron hydride.

The yield from the C^{14} targets in between resonances can be accounted for by the $C^{13}(\alpha,n)$ reaction and there are no other $C^{14}(\alpha,\gamma)$ resonances in this region with yields greater than 15% of any of the others.

Table II shows data presently available on the levels in O^{18} in our region of interest.

Figure 7 shows the presently known levels in O^{18} O^{18} up to the 8.05-Mev level, and decay schemes as elucidated in the present work.

The 8.05-Mev *Level*

This level decays mainly by transitions to the ground state and first excited state at 1.99 Mev. The anisotropy (defined as the yield at 180° divided by the yield at 90°) of the ground-state gamma ray is 0.116±0.056. This value is consistent only with a 1^- assignment to the 8.05-Mev level.[19] The transition is thus an $E1$ and the angular distribution, corrected for geometry, is $W(\theta)=1-(0.92\pm0.06)\cos^2\theta$, compared with the expected $1-\cos^2\theta$. The anisotropy of the gamma ray to the 1.99-Mev state is 0.915±0.064. This is consistent only with a spin of 2 for this state, and we then assign 2^+ to the first excited level in view of the stripping results of Bilaniuk and Hough.[3] The corrected angular distribution is

$$W(\theta)=1-(0.09\pm0.067)\cos^2\theta,$$

compared with the expected $1-0.142\cos^2\theta$.

TABLE II. Data presently available on the levels in O^{18} from 7.6 to 8.5-Mev excitation energy.

E_α(res) (Mev) Earlier[a,b]	Present	Γ_{lab} (kev) Earlier	Present	$J\pi l$	E_{exc}[c] (Mev)
	1.798±0.006		<3	1,−,1	7.634±0.029
2.331±0.005	2.334±0.006	<6±3	<3	1,−,1	8.051±0.029
2.553±0.004		1.6±1		2,+,2	8.222±0.029
2.642±0.005		10±1		3,−,3	8.293±0.029
2.798±0.011		22±10			8.412±0.030

[a] See reference 12.
[b] See reference 15.
[c] The excitation energy in O^{18} corresponding to the E_α(res) were calculated by using the table of mass defects in F. Ajzenberg and T. Lauritsen [Revs. Modern Phys. **27**, 77 (1955)]. The error quoted is mainly due to errors quoted there.

[14] F. A. El Bedewi and I. Husseim, Proc. Phys. Soc. (London) **A70**, 233 (1957).
[15] R. M. Sanders, Phys. Rev. **104**, 1434 (1956).
[16] G. A. Jones and D. H. Wilkinson, Proc. Phys. Soc. (London) **A66**, 1176 (1953).
[17] We are indebted to Dr. A. E. Litherland and Dr. H. E. Gove for drawing attention to this possibility.[13]
[18] Shire, Wormald, Lindsay-Jones, Lundén, and Stanley, Phil. Mag. **44**, 1197 (1953).
[19] Since the alpha particle and the C^{14} nucleus both have zero spin, this reaction is more easily amenable to analysis. Conservation of angular momentum and parity make it impossible for the $C^{14}+\alpha$ combination to form an excited state of O^{18} that has odd angular momentum and even parity or vice versa. It also prohibits the mixing of l values in the reaction.

The measured radiative widths are $\Gamma_\gamma=0.09\pm0.02$ ev and 0.23 ± 0.04 ev for the ground and first excited state transitions, respectively. These correspond to $|M|^2$ values of 2.3×10^{-4} and 1.4×10^{-3} for the $E1$ transitions. These are smaller than the average value of 0.032 which Wilkinson[10] obtains for $E1$ transitions, but as pointed out, lower intensity transitions may be missed in his survey for that reason.

An upper limit of 20% of that to the 1.99-Mev state is put on gamma transitions to either the 3.55- or 3.93-Mev states.

*The 7.63-*Mev *Level*

This level we assign 1^- for the same reasons as for the 8.05-Mev state. The ground-state gamma has angular distribution $W(\theta)=1-(0.993\pm0.027)\cos^2\theta$ and $\Gamma_\gamma=0.12\pm0.02$ ev. The 5.64-Mev gamma has angular distribution $W(\theta)=1-(0.13\pm0.07)\cos^2(\theta)$ and $\Gamma_\gamma=0.24\pm0.04$ ev. These correspond to $|M|^2$ values of 3.6×10^{-4} and 1.8×10^{-3} for the ground and first excited state $E1$ transitions, respectively.

From a study of the high-energy gamma spectrum and the spectrum of gammas in coincidence with gamma rays of energy greater than 700 kev, an upper limit of 10% of the intensity of the 5.64-Mev gamma can be put on transitions to the states at 3.55 and 3.93 Mev. This limit and the corresponding limit of 20% from the 8.05-Mev level support the assignment[3] of 4^+ to the 3.55-Mev state in agreement with shell-model calculations, but do not rule out other possibilities.

In view of the success of the unified model in describing many properties of some nuclei in the $1d$ shell[2,20] it is interesting to see how well the 0^+ and 2^+ ground and first excited states of O^{18} can be described as members of a $\Omega=K=0$ rotational band. If the 1^- states are both members of different $\Omega=K=1$ bands then the ratios of the reduced matrix elements for the $E1$ transitions to the 0^+ and 2^+ states should both be equal[21] to 2 : 1. In fact the ratios are 1 : 5 and 1 : 6 for the decays from the 7.63- and 8.05-Mev levels, respectively. This suggests that the rotational description is not a good one, at least without invoking large perturbing effects.

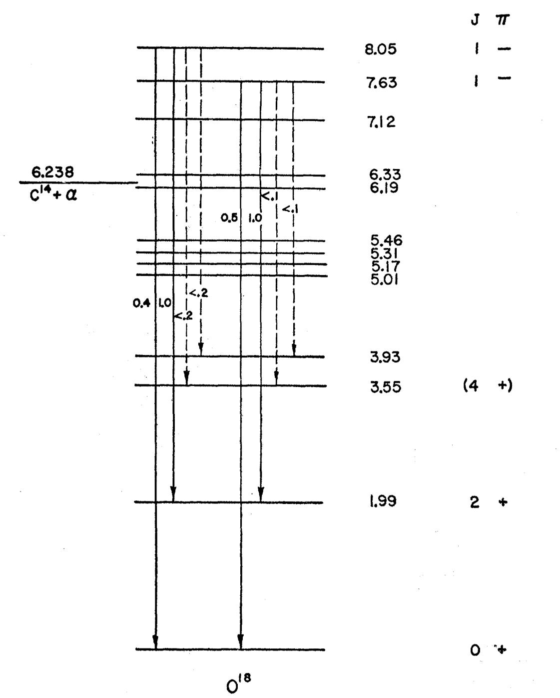

FIG. 7. Energy levels known in O^{18} up to 8.05 Mev and the decay schemes as determined in the present experiment. Levels up to 6.33 Mev were seen in the reaction $F^{19}(t,\alpha)F^{18}$ [Nelson Jarmie, Phys. Rev. **104**, 1683 (1956)]; others in $C^{14}+\alpha$.

The shell-model description of the states must account for the small matrix elements for the $E1$ transitions from the 7.63- and 8.05-Mev levels. The size of these matrix elements argues against the description of the negative-parity levels as states of single-particle excitation within the configurations df, dp, sf, and sp.

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[20] Litherland, McManus, Paul, Bromely, and Gove, Chalk River Report PD-289, 1957 (unpublished).

[21] Alaga, Alder, Bohr, and Mottelson, Kgl. Danske Videnskab. Selskab, Mat.-fys. Medd. **29**, No. 9 (1955).