tritons. The polarization of the pickup alpha is positive (opposite to that of the proton), and the curve convex to the angle axis. This same behavior is noticed in the study of pickup deuterons from carbon[28] and in the study of neutron production from complex nuclei by protons.[29]

A more exact analysis will be made at a later date, by which time we hope to have completed some triple-scattering measurements, which will determine the relative phases of the spin-dependent and spin-independent scattering amplitudes.

[28] P. F. Cooper, thesis, Harvard University, 1958 (unpublished).
[29] S. G. Carpenter and R. Wilson, Phys. Rev. **113**, 650 (1959).

ACKNOWLEDGMENTS

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Angular Correlation Measurements in O^{15}†

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An accurate measurement of the energy of a gamma transition from the 7.56-Mev level in O^{15} discloses that the transition takes place to the 5.19-Mev level in O^{15} rather than to the 5.25-Mev level. Another transition takes place through the 6.15-Mev level. The third known transition occurs through the 6.79-Mev level rather than through the 6.86-Mev level. The angular correlations of cascades from the 7.56-Mev level through the levels at 6.79 Mev, 6.15 Mev, and 5.19 Mev are measured. These results, combined with previous results on these levels, are consistent only with $J^\pi=\frac{3}{2}^+$ and $\frac{3}{2}^-$, respectively, for the 6.79-Mev and 6.15-Mev levels. For the 5.19-Mev level, the present results indicate $J=\frac{1}{2}$, but are consistent also with $J=\frac{3}{2}$, if a suitable mixing ratio of $E2$ to $M1$ radiation is chosen. The preferred assignments are all consistent with the shell-model predictions and with comparisons with the N^{15} level scheme. It is noted that the doublets near 5.2 Mev in O^{15} and N^{15} are reversed in order.

INTRODUCTION

THE recent discovery of the 5.19-Mev and 5.25-Mev states in O^{15}, by means of the $O^{16}(He^3,\alpha)O^{15}$ reaction,[1–3] has opened the question of whether the observed γ transitions from higher levels in O^{15} occur to one or both of these states. The 7.56-Mev level is known to emit gamma rays[4,5] of energy 2.4 ± 0.1 Mev as well as gamma rays of energies 1.39 and 0.77 Mev, with relative intensities in the ratio 2:8:3. This level occurs as a resonance in the reaction $N^{14}(p,\gamma)$ at 277 kev.[1] The expected energies of the transitions to the 5.2-Mev doublet are 2.31 and 2.37 Mev. Because of this appreciable difference in gamma energies, an experiment was planned to measure accurately the transition energy. The 7.56-Mev level is known to be $\frac{1}{2}^+$ from proton elastic scattering measurements,[1,4] and the known isotropic gamma-ray distributions.[4,6] The doublet, on shell-model considerations,[7] is expected to be $\frac{1}{2}^+$ and $\frac{5}{2}^+$. These spin assignments would favor the $\frac{1}{2}^+\rightarrow\frac{1}{2}^+$ transition, rather than the $\frac{1}{2}\rightarrow\frac{5}{2}^+$ transition, leading to the hope that only one member of the 5.2-Mev doublet would be involved in the cascade.

Information on the spin of the intermediate state can be obtained by angular correlation measurements. Measurements have already been made by Gorodetzky *et al.*[8] on transitions from the 8.28-Mev $\frac{3}{2}^+$ level to the 5.2-Mev doublet. Unfortunately, no distinction could be made between the members of the doublet, both of which should act as intermediate states. The measured

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* On leave from The "J. Stefan" Institute, Ljubljana, Yugoslavia.
[1] F. Ajzenberg-Selove and T. Lauritsen, Nuclear Phys. (to be published).
[2] Allen, Middleton, and Hinds (private communication).
[3] B. Povh, Phys. Rev. **114**, 1114 (1959).
[4] R. E. Pixley, Ph.D. thesis, California Institute of Technology, 1957 (unpublished).
[5] Johnson, Robinson, and Moak, Phys. Rev. **85**, 931 (1952).
[6] The angular distributions of the three low-energy gamma rays have been recently remeasured at the Kellogg Radiation Laboratory, and are found to be isotropic within 2%. The high-energy gamma-ray distributions are also consistent with isotropy. S. Bashkin (private communication) reports that his latest results are also in agreement with isotropy, superseding the earlier report of anisotropy [Bashkin, Carlson, and Nelson, Phys. Rev. **99**, 107 (1955)].
[7] E. Halbert and J. B. French, Phys. Rev. **105**, 1563 (1957).
[8] Gorodetzky, Gallmann, Croissiaux, and Armbruster, Nuclear Phys. **6**, 517 (1958).

average angular correlation was found to be consistent with $\frac{3}{2}$ or $\frac{5}{2}$, assuming that only one level contributed.

The choice of the 7.56-Mev level as the initial level has the advantage that the angular correlations with $\frac{1}{2}^+$ as the initial state are stronger than they would be with $\frac{3}{2}^+$ as the initial state. On the other hand, the yield of radiation from the 7.56-Mev level is low. In spite of the latter disadvantage, it was decided to measure the anisotropy of the known cascades from the 7.56-Mev level.

In addition to the cascade through the 5.2-Mev doublet, there is a cascade through a state at 6.15 Mev, thought to have negative parity and with a spin[9] $\leqslant \frac{5}{2}$. There is also a third cascade through one or both of the levels at 6.79 and 6.86 Mev. These are known, from $N^{14}(d,n)$[9,10] to be of positive parity with spin $\frac{1}{2}$ or $\frac{3}{2}$. The experiment has been planned to investigate all these cascades simultaneously. Estimates of the lifetime of the intermediate states show that they should be $<10^{-11}$ sec, and this is sufficiently short that no weakening of the expected angular correlations can be expected from this source.

METHOD

The target used was thick tantalum nitride, formed by heating 0.005-inch tantalum sheet to a bright red heat in an atmosphere of commercial ammonia. The target has been stable under bombardment with a proton beam sufficient to make it red hot, and a decrease of only 20% in the yield of gamma rays has been found after a total bombardment of 2.5 coulomb. The rate of contamination of the target by decomposed oil vapor is decreased by keeping the target red hot. The gamma spectra at the beginning and the end of the experiment were identical, and inspection of the target surface disclosed no visible contamination. Beam currents during the experiment were between 20 and 35 microampere of protons at an energy of 287 kev, just above the resonance energy. The proton beam was supplied by the 600-kv electrostatic accelerator in the Kellogg Radiation Laboratory, and was stabilized with electrostatic and magnetic analysis.

The initial aim of measuring accurately the energy of the 2.4-Mev transition was accomplished by a coincidence experiment. This was necessary because the 2.4-Mev radiation is weak, and does not stand out clearly from the background of 5.2-, 6.2-, and 6.8-Mev radiation. A 4×4-inch NaI crystal mounted on a Dumont 6364 photomultiplier was used, and a single-channel analyzer selected pulses corresponding to loss in the crystal of energies between 3.5 and 8 Mev. A 1.5×1.5-inch NaI crystal, mounted on a Dumont 6292 photomultiplier, detected lower energy gamma rays from the target. A 100-channel analyzer was used to display the

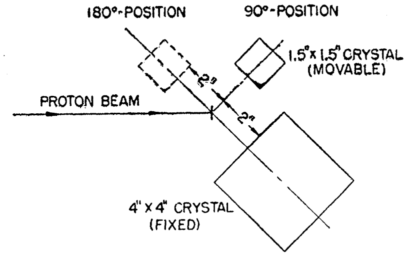

FIG. 1. The target and counter geometry with the two alternative positions of the 1.5×1.5-inch NaI crystal used in the angular correlation experiment.

spectrum of pulses in coincidence with those from the 4-inch crystal that were counted in the single-channel analyzer. This 1.5-inch crystal was chosen for good energy resolution. Because of the low counting rate in both crystals, the nominal 2-μsec resolving time of the 100-channel analyzer was adequate. For maximum counting rates, both crystals were mounted with their front surfaces less than 1 inch from the target spot. Approximately 8 hours of bombardment was needed to accumulate good statistics in the total absorption peak of the 2.4-Mev gamma ray, but this was broken up into half-hour runs, with an energy calibration before and after each run. This energy calibration used a ThC″ source at a low count rate, so that the gain of the photomultiplier would not be disturbed. None of the runs showed a change of gain greater than 0.5%. Other calibration points used in the final energy measurement were the Co^{60} radiation and the annihilation radiation observed in the coincidence spectrum.

For the angular correlation measurement, it was necessary to improve the angular resolution of the counters. This was done at a sacrifice in counting rate by moving the crystals so that their front surfaces were each 2 inches distant from the target. Figure 1 shows the target-counter geometry. Since the initial 7.56-Mev state in O^{15} has $J^\pi = \frac{1}{2}^+$, the magnetic substates are uniformly populated, and the correlation function is independent of the direction in space of the plane containing the target and the two counters. The correlation is also independent of the direction of the counter detecting the first radiation. For convenience, a horizontal plane containing the beam was chosen, and the counter detecting the high-energy radiation was at a fixed angle of 45° to the beam.

The coincidence counting rate was such that a bombardment of 18 hours was needed at each angle measured. For this reason, only two angles were measured, with the two counters 180° or 90° apart. Runs, each of approximately one-hour duration, were made alternately at the two angles. Each run lasted until 10^5 counts had accumulated in the single-channel analyzer measuring the high-energy radiation. This method of monitoring the reaction is preferable to integrating the beam current because it is unaffected by loss of nitrogen. The beam current was sufficiently steady that the

[9] Evans, Green, and Middleton, Proc. Phys. Soc. (London) **A66**, 108 (1953).
[10] Marion, Brugger, and Bonner, Phys. Rev. **100**, 46 (1955).

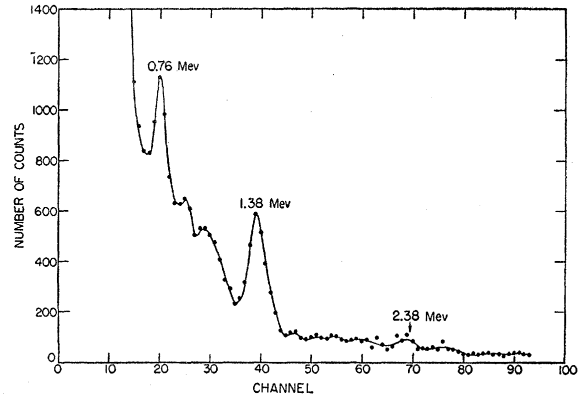

FIG. 2. A spectrum of low-energy radiation from $N^{14}(p,\gamma)$. The detector was a 1.5×1.5-inch NaI crystal 2 inches from the target and at 135° to the beam. The total charge on the target was of the order of 40 000 microcoulombs.

time-dependent background in the single-channel analyzer [about 1% of the count due to $N^{14}(p,\gamma)$] did not change appreciably from run to run.

The target spot was limited to an area 4 mm wide by 8 mm high. The vertical axis of this rectangle coincides within 0.2 mm with the axis about which the 1.5-inch crystal rotated. A shift of the beam spot laterally by 0.3 mm would be expected to change the ratio of counts in the monitor to counts in the movable counter by 1%. Before starting the coincidence measurements, a check was made to ensure that the count rate in the movable counter was the same at the two positions where it was intended to count coincidences. The target was normal to the beam. The target absorption correction for radiation to the counter when it was at 45° to the beam was only 1%. By integrating the beam current and alternating angles every 9000 microcoulomb up to a total of 36 000 microcoulomb at each angle it was found that the singles spectra recorded at the two angles were indistinguishable to better than 1%. At the same time, the single-channel analyzer recorded about 54 000 counts for each of the two runs. These also agreed to better than 1%, showing that the single-channel analyzer was a satisfactory yield monitor, and was not affected appreciably by differing amounts of radiation scattered from the movable counter at its two positions. By limiting the current to 20 microampere, loss of nitrogen was prevented during this run.

At the end of the experiment, singles spectra were again recorded with the 1.5-inch crystal at angles of 135° and 45° to the beam. The spectra were of the same shape as the initial spectra, and the yields at 135° and 45° were still identical. Figure 2 shows a singles spectrum with the 1.5-inch crystal at an angle of 135° to the beam. This figure also illustrates the difficulty of precise energy measurement of the 2.4-Mev gamma ray in the presence of the higher energy radiation.

During the experiment, the beam alignment on the target, the gain of the monitor counter, and the gain of the movable counter were all checked periodically and found to be satisfactory. In addition, a 60-cycle pulser was used to insert pulses into the preamplifier for the movable counter. Thus, a continuous record of the amplifier gain for the movable counter was obtained, as there were approximately 30 accidental coincidences per hour due to the pulser, and these formed a peak in an unused portion of the spectrum.

In order to compare the measured angular correlations with the theoretical ones, the latter must be modified to take into account the finite solid angles subtended at the target. The method used was that described by Rose,[11] and the coefficients obtained are shown in Table I, using Rose's notation. These coefficients are almost independent of the assumed absorption coefficient, so that only an average value is presented.

RESULTS

Figure 3 shows the coincidence spectra obtained. The observed gamma-ray energies were 0.76±0.02 Mev, 1.38±0.02 Mev, and 2.38±0.02 Mev. For the 0.76-Mev gamma ray, the result clearly favors the transition from the level at 7.56±0.005 Mev to the level at 6.79±0.01 Mev rather than to the level at 6.86±0.01 Mev. An upper limit to the intensity of the transition to the 6.86-Mev level is 25% of the intensity of the 0.76-Mev gamma ray. Any larger percentage would have shifted the peak energy and noticeably distorted the total absorption peak in the coincidence spectrum. The 1.38-Mev gamma ray is associated with the transition to the level at 6.15±0.03 Mev, and the spectrum indicates that only a single gamma ray is involved.

The 2.38-Mev gamma ray corresponds to the transition to the level at 5.19±0.01 Mev. To confirm the energy calibration and check the expected spectrum shape, a spectrum of $C^{12}(p,\gamma)$ was taken at a proton energy of 450 kev, using a semithin carbon target. This spectrum is also shown on Fig. 3(a). Most of the radiation from this target is expected to have an energy of 2.35 Mev.[1] The total absorption peak of this radiation was located one channel (0.03 Mev) below the peak in the coincidence spectrum from $N^{14}(p,\gamma)$, and the width at half height was 3.5 channels. This result confirms the energy calibration of the coincidence spectrum and shows that the coincidence spectrum is mainly due to one gamma ray. The transition to the 5.25-Mev level

TABLE I. Resolution correction factors.[a]

Crystal	J_2/J_0	J_4/J_0
1.5-inch	0.935	0.797
4-inch	0.732	0.312

[a] The expected experimental angular correlations are obtained from the theoretical ones by multiplying the coefficient of $P_2(\cos\theta)$ in the theoretical correlation by the products of J_2/J_0 for each crystal, and similarly for the coefficient of $P_4(\cos\theta)$, using J_4/J_0.

[11] M. E. Rose, Phys. Rev. 91, 610 (1952).

must have a strength less than 25% of the strength of the 2.38-Mev transition.

In Figs. 3(a) and (b), the spectrum shape from channel 73 down to channel 43 is consistent with that expected from a single gamma ray. Above channel 73, a uniform background averaging 6 counts per channel was observed. Accidental coincidences and cosmic rays account for only 30% of this background. The remainder is thought to be due to true coincidences in which high-energy electrons from 6-Mev gamma rays lose just enough energy in the 4-inch crystal to open the coincidence gate. They then escape from the 4-inch crystal and enter the 1.5-inch crystal, losing 2 to 3 Mev in the latter. Another possibility is that one member of a pair, produced in either crystal or in the lead shielding, enters each crystal. An approximate calculation of the probability of a single electron activating both counters gave a result of the correct order of magnitude. The background, measured over the spectrum from channel 74 to channel 93, appeared to be the same for the two positions of the movable counter. This background is assumed to be constant in magnitude over the whole spectrum used.

The anisotropy A is defined as $I(180°)/I(90°)-1$. To calculate the anisotropy observed for the 2.38-Mev gamma ray, the number of coincidence pulses between channels 45 and 75 was determined at each angle. From this total, an equal amount of background at each angle was subtracted. This background, accurate to 10%, amounted to less than 20% of the total count. The anisotropy had the value $A(2.38)=+0.01\pm0.03$. The error given is the probable error due to the counting statistics, and includes the background subtraction.

The anisotropy of the 1.38-Mev gamma ray was calculated in two ways. In the first calculation only the pulses in the total absorption peak were counted (between channels 35 and 43). From this was subtracted an equal number of pulses at each angle, corresponding to the background and the pulses due to the 2.38-Mev gamma ray. In the second calculation, pulses in the Compton peak (channels 26 to 35) were also included. As before, an equal number of pulses was subtracted at each angle. In both calculations, the number of pulses subtracted was about 10% of the total number. An anisotropy of 0.18 ± 0.03 was obtained for the first calculation and the second calculation gave 0.15 ± 0.02, so that an average value of $+0.165\pm0.03$ was taken for $A(1.38)$.

For the 0.76-Mev gamma ray, the number of pulses to be subtracted is substantial and less certain. An initial calculation was made of the number of pulses between channels 17 and 23. From these were subtracted (1) an equal contribution at each angle (about 5% of the total) due to the 2.38-Mev gamma ray and the background, and (2) a number of pulses (about 35% of the total) due to the 1.38-Mev gamma ray. The ratio of the number of pulses, due to this gamma ray, subtracted at each angle, was determined from the mean experimental value of the anisotropy of the 1.38-Mev gamma ray. The actual number of pulses subtracted was determined by a knowledge of the shape of the 1.38-Mev and 0.76-Mev gamma spectra. The anisotropy with no subtraction due to the 1.38-Mev gamma ray was 0.19 ± 0.02, and the anisotropy with an excessive subtraction was 0.21 ± 0.03. An intermediate value of $+0.20\pm0.03$ was taken for $A(0.76)$.

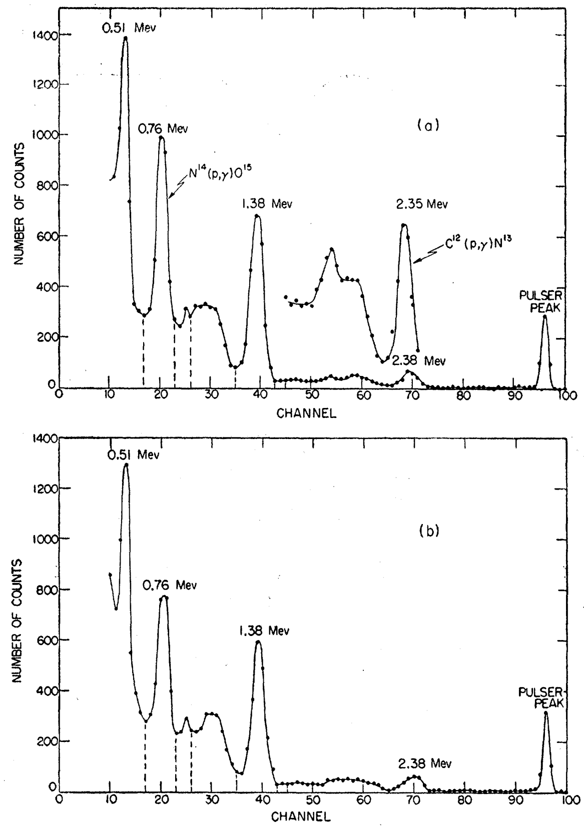

FIG. 3. (a) The coincidence spectrum with the two counters 180° apart. Also shown is the spectrum of 2.35-Mev radiation from $C^{12}(p,\gamma)$. (b) The coincidence spectrum with the two counters 90° apart. For (a) and (b), the monitor counter registered 1.65×10^6 counts. The peak at channel 96 is due to accidental coincidences between a 60-cycle pulser and the coincidence gate opened at an average rate of 30 times per second.

The theoretical anisotropies were calculated for intermediate state assignments of $\frac{3}{2}\pm$ and $\frac{5}{2}\pm$. For $\frac{1}{2}\pm$, the angular correlation must be isotropic. The initial state was known to be $\frac{1}{2}+$ and the final state assumed to be $\frac{1}{2}-$. The latter assignment is supported by a comparison with the N^{15} ground state. It was assumed that $M2$ transitions would not compete with $E1$ in the $\frac{1}{2}+\rightarrow\frac{3}{2}\pm\rightarrow\frac{1}{2}-$ cascade. A mixing ratio δ was allowed for the amplitudes $E2/M1$. Similarly, it was assumed in the $\frac{1}{2}+\rightarrow\frac{5}{2}\pm\rightarrow\frac{1}{2}-$ cascade that $M3$ transitions would not compete with $E2$, but a mixing ratio δ was allowed for $E3/M2$.

Figures 4 and 5 present the theoretical anisotropies corrected for the geometry of the experiment by means

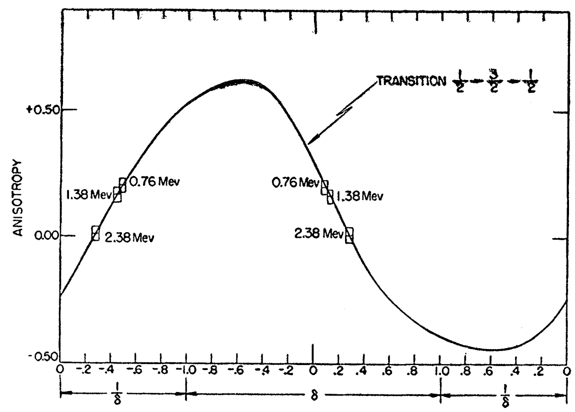

FIG. 4. The expected anisotropy for the transition $\frac{1}{2}\rightarrow\frac{3}{2}\rightarrow\frac{1}{2}$, modified by the experimental geometry. The anisotropy is plotted as a function of the mixing ratio $\delta=$ (amplitude of $E2$ radiation)/(amplitude of $M1$ radiation). The function $1/\delta$ is used when $|\delta|$ exceeds unity. The experimental results are included.

of the factors in Table I. The anisotropy is plotted for each assignment of the spin of the intermediate level as a function of the mixing ratio δ or $1/\delta$. Included in Figs. 4 and 5 are the experimental results just described.

DISCUSSION

1. 6.79-Mev level.—The spin assignment of this level is already known, from $N^{14}(d,n)$ stripping[9] measurements, to be $\frac{1}{2}^+$ or $\frac{3}{2}^+$. The 6.79-Mev and 6.86-Mev levels are not resolved in the stripping measurements, but both should be present. At the neutron threshold, the 6.79-Mev level is populated more strongly,[10] showing that it has a relatively large proton reduced width.

The observed anisotropy of $+0.20\pm0.03$ is definitely inconsistent with spin $\frac{1}{2}^\pm$ for the 6.79-Mev level. In addition, the minimum anisotropy expected for a $\frac{5}{2}^\pm$ assignment is $+0.27$, which is outside the probable error. The experimental evidence is consistent only with a spin assignment of $\frac{3}{2}$ and with a mixing ratio $\delta=0.08\pm0.03$ or -2.1 ± 0.2. The most likely mixing is an intensity (δ^2) of 0.6% of $E2$ compared with $M1$, occurring in the 0.76-Mev transition since the 6.79-Mev level has positive parity.

2. 6.15-Mev level.—The previous experimental evidence on this level is less satisfactory. A stripping pattern has been observed[9] at high deuteron energies, and the theoretical fit to the experimental distribution, assuming $l_p=1$, is satisfactory for angles greater than 15°. Below this angle, the theoretical curve shows a slight rise, while the experimental curve drops. However, $l_p=1$ gives the best fit, and this indicates that the level is $\leqslant\frac{3}{2}^-$. A comparison with the N^{15} level scheme, and shell-model considerations, would give this level an assignment $\frac{3}{2}^-$. The anisotropy observed in this experiment is inconsistent with both $\frac{1}{2}$ and $\frac{5}{2}$ spin assignments. The probability of the anisotropy measured as $+0.165\pm0.03$ actually being as large as 0.27 (the minimum value expected for $\frac{5}{2}$) is less than 0.5%. Therefore, a firm spin assignment of $\frac{3}{2}$ can be made for this level, agreeing with N^{15} and the shell model. The possible mixing ratios are $\delta=0.12\pm0.03$ or -2.3 ± 0.2. The most probable mixing is an intensity (δ^2) of 1.4% of $E2$, occurring in the 6.15-Mev transition (assuming negative parity of the 6.15-Mev level).

3. 5.19-Mev level.—There is no previous experimental information on the spin and parity assignment of the 5.19-Mev level. The shell model[7] predicts that the first two levels above the ground state should be positive parity with spins of $\frac{1}{2}$ and $\frac{5}{2}$. The two levels in O^{15} at 5.19 and 5.25 Mev should correspond to the pair of levels in N^{15} at 5.28 and 5.31 Mev. Some of the experimental information on these levels in N^{15} comes from $N^{14}(d,p)$ stripping distributions[12] which show that the 5.28-Mev level has $l_n=2$ so that the spin and parity of the 5.28-Mev level is $\leqslant\frac{7}{2}^+$. It may be argued that the 5.28-Mev level is not $\frac{1}{2}^+$ or $\frac{3}{2}^+$ because it could then

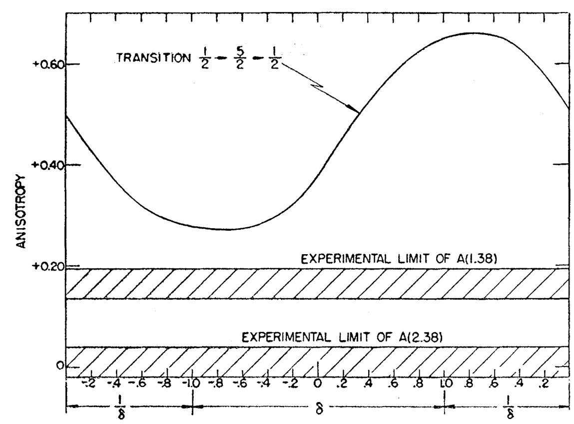

FIG. 5. The expected anisotropy for the transition $\frac{1}{2}\rightarrow\frac{5}{2}\rightarrow\frac{1}{2}$, modified by the experimental geometry. The anisotropy is plotted as a function of the mixing ratio $\delta=$ (amplitude of $E3$ radiation)/(amplitude of $M2$ radiation). The function $1/\delta$ is used when $|\delta|$ exceeds unity. The experimental results are included.

show an $l_n=0$ contribution through impurities in the wave functions. These $l_n=0$ contributions are not inhibited by the centrifugal barrier, and are visible in most cases where both $l_n=0$ and 2 are allowed by the angular momentum coupling, but not allowed by the shell model. No $l_n=0$ contribution is visible in the case of the 5.28-Mev level, so it is presumably not allowed by the angular momentum selection rules.

The β decay of C^{15} has been studied by Alburger *et al.*,[13] who find that 68% of the β decays are allowed transitions from the $\frac{1}{2}^+$ ground state of C^{15} to the 5.31-Mev level of N^{15}. The ground state of C^{15} is now known to be $\frac{1}{2}^+$ from the $C^{14}(d,p)$ reaction,[14] so that the 5.31-

[12] R. D. Sharp and A. Sperduto, Massachusetts Institute of Technology Annual Progress Report No. 125, 1955 (unpublished).
[13] Alburger, Wilkinson, and Gallmann, Bull. Am. Phys. Soc. Ser. II, 4, 56 (1959).
[14] W. E. Moore and J. N. McGruer, Bull. Am. Phys. Soc. Ser. II, 4, 17 (1959).

Mev level of N^{15} is restricted to $\frac{1}{2}+$ or $\frac{3}{2}+$. The 5.31-Mev gamma ray to the ground state of N^{15} has an internal conversion coefficient which agrees best with an $E1$ transition,[13] confirming the spin assignment $\frac{1}{2}+$ or $\frac{3}{2}+$ for the 5.31-Mev level. No β decays were observed to the 5.28-Mev level of N^{15}, and this implies that this level has a spin $\geqslant\frac{5}{2}$, agreeing with the argument in the preceding paragraph.

If these spin assignments in N^{15} are transferred back to the O^{15} doublet, we have that one of the levels in O^{15} is expected to have spin $\frac{1}{2}+$ or $\frac{3}{2}+$, while the other is expected to have spin $\frac{5}{2}+$ or $\frac{7}{2}+$.

The experimental anisotropy of 0.01 ± 0.03 is definitely inconsistent with a $\frac{5}{2}$ spin assignment for the 5.19-Mev level in O^{15}. It is consistent with $J=\frac{1}{2}$, but is also consistent with $J=\frac{3}{2}$ if a mixing ratio $\delta=0.27\pm0.03$ or -3.7 ± 0.3 is chosen. [These correspond to an intensity (δ^2) of 7% of $E2$ radiation mixed with $M1$ radiation or vice-versa.] This means that the level order in this doublet is opposite to that found in N^{15}. Such a reversal is possible due to the Thomas shift.[15]

If it is assumed that the 5.19-Mev level has spin $\frac{1}{2}$ and the 5.25-Mev level has spin $\frac{5}{2}$, then the measured anisotropy places close limits on the contribution of the $\frac{5}{2}$ level to the cascade. A contribution of strength equal to 10% of the contribution through the $\frac{1}{2}$ level would change the isotropy measurably, even if the contribution of the $\frac{5}{2}$ state possesses its minimum anisotropy. This is a closer limit than can be obtained by inspection of the gamma spectrum.

CONCLUSION

Figure 6 is an energy level diagram of O^{15}, showing the present state of our knowledge. All the information derived from this experiment is consistent with the shell-model predictions. One of the outstanding gaps in our knowledge of O^{15} is the absence of a level, apparently a partner for the 7.16-Mev or 7.58-Mev level in N^{15}. This would be expected near 7 Mev in O^{15}, and would have been difficult to detect in the present experiment. In fact, no evidence was observed for any transitions other than those between known levels in O^{15}.

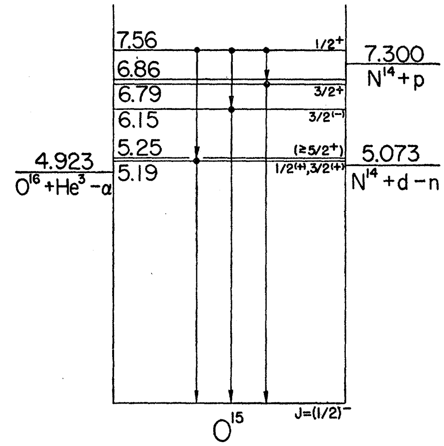

FIG. 6. Energy level diagram of O^{15}. The gamma transitions observed experimentally are shown.

ACKNOWLEDGMENTS

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[15] A. M. Lane and R. G. Thomas, Revs. Modern Phys. **30**, 257 (1958).