Decay of Ne^{18}

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The radioactive nuclide Ne^{18} has been produced in the $O^{16}(He^3,n)Ne^{18}$ reaction by 5.2-Mev He^3 particles from the NRL 5-Mv Van de Graaff accelerator. The target, CaO on a Pt backing, was about 300 kev thick to the incident beam. The gamma rays following the decay of Ne^{18} were detected by a 3-in. diam by 3-in. NaI(Tl) crystal and a 256-channel pulse-height analyzer. Only one nuclear gamma ray was observed. Its energy, measured with respect to the Na^{22} gamma ray at 1.2736 ± 0.0016 Mev, is 1.041 ± 0.005 Mev. Therefore, this gamma ray is assigned to the 1.04-Mev state of F^{18}. This state is considered to be the isobaric spin analog state of the Ne^{18} ground state, and therefore has quantum parameters 0^+, $T=1$. The branching to this excited state was measured to be 0.07 ± 0.02 (including a calculated contribution of 0.00006 from orbital electron capture), and that to the ground state of F^{18} was measured to be 0.93 ± 0.02 (including a calculated contribution of 0.0002 from orbital electron capture). The *ft* values are, respectively, 3030 ± 880 and 1120 ± 70 sec. The half-life of Ne^{18} was measured to be 1.46 ± 0.07 sec.

INTRODUCTION

THE energy-level structure of the nuclide F^{18} has only recently received much attention from physicists. Prior to 1951, not one excited state was known below an excitation of about 6 Mev. However, theoretical work by Redlich[1] and Elliott and Flowers[2] on the application of shell-model theory to the nuclides in the mass 18–19 region has stimulated a great deal of interest in the experimental study of the low-lying excited states and their quantum parameters for such nuclides as F^{18}.

Prior to 1955, the only investigation of the low-lying energy levels in F^{18} was that of Middleton and Tai,[3] who used photographic emulsions to obtain the energy spectrum of alpha particles from the $Ne^{20}(d,\alpha)F^{18}$ reaction. They found levels at 1.05 ± 0.02 Mev and 1.83 ± 0.02 Mev and at several higher energies. Price,[4] using the $N^{14}(\alpha,\gamma)F^{18}$ reaction and scintillation spectrometry methods, found a level at 1.075 ± 0.010 Mev and deduced that it is involved in a gamma-ray cascade from two alpha-particle-capture resonances. They associated this state with the 1.05-Mev state of Middleton and Tai. Butler *et al.*,[5] using the $O^{16}(He^3,p\gamma)F^{18}$ reaction and a scintillation spectrometer, found two gamma rays in the vicinity of 1 Mev (0.94 and 1.06 Mev), another gamma ray of 1.69 Mev, and several higher energy gamma rays. They also used the $O^{18}(p,n\gamma)F^{18}$ reaction and the gamma-ray threshold technique to ascertain that there were two states in F^{18} at energies corresponding to the two gamma rays at about 1 Mev.[6] They identified their 0.94-Mev level with the 1.05-Mev level of Middleton and Tai and their 1.69-Mev level with the 1.83-Mev level of Middleton and Tai, because all of the higher levels also showed a difference of about 0.1 Mev in the same direction. It was assumed that the 1.06-Mev state was a new state and that it was the $T=1$ analog of the ground state of O^{18}. It was also assumed that the 0.94-Mev state was a $T=0$ state since it was probably the one observed by Middleton and Tai using the $Ne^{20}(d,\alpha)F^{18}$ reaction, which, according to the simple application of isobaric spin selection rules, could not excite a $T=1$ state. These assumptions were supported by a detailed consideration of all available evidence, including the angular distributions and cascade schemes observed by Price in the $N^{14}(\alpha,\gamma)F^{18}$ reaction.

Naggiar *et al.*,[7,8] using the $O^{18}(p,n\gamma)F^{18}$ reaction and a scintillation spectrometer, confirmed the existence of two states in F^{18} at about 1 Mev, their measured gamma-ray energies being 0.94 ± 0.02 and 1.04 ± 0.02 Mev. From a measurement of the Doppler shift of the 1.04-Mev gamma ray, they concluded that the 1.04-Mev state probably is the $T=1$ analog of the O^{18} ground state. Almqvist *et al.*,[9] using the $N^{14}(\alpha,\gamma)F^{18}$ reaction and scintillation spectrometry techniques, including time-coincidence requirements, measured angular distributions of the gamma rays and their branching ratios. They observed gamma rays of 0.94 and 1.08 Mev and several higher energy gamma rays and assumed that the two lower energy gamma rays were the same as those observed in the $O^{16}(He^3,p\gamma)F^{18}$ reaction. Kuehner *et al.*,[10] using the $O^{16}(He^3,p\gamma)F^{18}$ reaction and the same techniques as Almqvist *et al.*, measured angular distributions of these gamma rays and their branching ratios. Their analysis indicated

[1] M. G. Redlich, Phys. Rev. **95**, 448 (1954); **110**, 468 (1958).
[2] J. P. Elliott and B. H. Flowers, Proc. Roy. Soc. (London) **A229**, 536 (1955).
[3] R. Middleton and C. T. Tai, Proc. Phys. Soc. (London) **A64**, 801 (1951).
[4] P. C. Price, Proc. Phys. Soc. (London) **A68**, 553 (1955).
[5] J. W. Butler, H. D. Holmgren, and W. E. Kunz, Bull. Am. Phys. Soc. **1**, 29 (1956).
[6] J. W. Butler, Oral Report, New York American Physical Society Meeting, 1956; quoted in Nuclear Sci. Abstr. **10**, No. 24 B, 28 (1956).
[7] V. Naggiar, M. Roclawski-Conjeaud, D. Szteinsznaider, and J. Thirion, J. phys. radium **17**, 561 (1956).
[8] D. Szteinsznaider, M. Roclawski-Conjeaud, and V. Naggiar, Compt. rend. **244**, 445 (1957).
[9] E. Almqvist, D. A. Bromley, and J. A. Kuehner, Bull. Am. Phys. Soc. **3**, 27 (1958).
[10] J. A. Kuehner, E. Almqvist, and D. A. Bromley, Bull. Am. Phys. Soc. **3**, 27 (1958).

that the 1.08-Mev state was probably the 0^+, $T=1$ analog state of the O^{18} ground state.

More recently, Phillips[11] and Middleton,[12] employing magnetic analysis of the protons from the $O^{16}(He^3,p)F^{18}$ reaction, found three groups of protons corresponding to excited states in the vicinity of 1 Mev in F^{18}, their values being 0.940, 1.045, and 1.125 Mev and 0.935, 1.040, and 1.120 Mev, respectively. Kuehner *et al.* re-examined the 1.08-Mev gamma ray from the $N^{14}(\alpha,\gamma)F^{18}$ reaction, obtaining 1.075 ± 0.010 Mev, which was incompatible with any of the three levels obtained from the magnetic analysis of protons. Therefore, using magnetic analysis, they made careful measurements of the proton groups from the $O^{16}(He^3,p)F^{18}$ reaction for several different bombarding energies and at several different angles of observation, assuming that resonance effects might influence the relative intensities and angular distributions of the different proton groups. Their results indicated that there were actually four excited states near 1 Mev, their energies being 0.940, 1.045, 1.080, and 1.125 Mev. These results were published by Kuehner *et al.*,[13] and further work by Hinds and Middleton[14] confirmed the existence of four levels at essentially the same energies. Thus, the situation concerning the region of excitation in F^{18} below a few Mev seemed to be well understood. However, recent work by Hinds and Middleton[15] indicates that the lowest $T=1$ state in F^{18} might be the 1.04-Mev state instead of the 1.08-Mev state. An independent check of the identity of the lowest $T=1$ state is therefore highly desirable.

One rather direct way of checking the $T=1$ assignment of the 1.08-Mev state is by observation of the decay of Ne^{18}. Since Ne^{18} is an even, even nucleus, it is very probable that it has a 0^+ ground state. Therefore, it should decay very strongly to its $T=1$ analog state in F^{18} since this would be a superallowed transition, and sufficient energy is available from the decay to populate all excited states below about 3 Mev. Gow and Alvarez[16] produced Ne^{18} with the $F^{19}(p,2n)Ne^{18}$ reaction and measured its positron end point as 3.2 ± 0.2 Mev and its half-life to be 1.6 ± 0.2 sec. They did not attempt to observe any gamma rays associated with the decay of Ne^{18}, nor did they obtain the beta spectrum at beta energies less than about 2 Mev. Thus, their work provided no evidence for a conclusion as to whether or not positrons were populating states in F^{18} other than the ground state.

Dunning and Butler[17] measured the threshold energy for the $O^{16}(He^3,n)Ne^{18}$ reaction to be 3.811 ± 0.015 Mev. From this value and the table of masses of Everling *et al.*,[18] the end point of positrons populating the ground state of F^{18} is calculated to be 3.423 ± 0.013 Mev. Dunning and Butler also measured the half-life of Ne^{18}, obtaining a value of 1.25 ± 0.20 sec.

The present experiment is an effort to check the $T=1$ assignment of the 1.08-Mev state of F^{18} by means of the detection and measurement of the gamma rays from excited states of F^{18} resulting from the positron decay of Ne^{18}. A further purpose is to determine the complete decay scheme of Ne^{18}: gamma-ray energies, branching ratios, and half-life.

EXPERIMENTAL PROCEDURE FOR GAMMA-RAY ENERGY MEASUREMENTS

The Ne^{18} was produced by 5.2-Mev He^3 particles impinging on a target of CaO at a resonance in the $O^{16}(He^3,n)Ne^{18}$ reaction. The singly charged He^3 particles were supplied by the NRL 5-Mv Van de Graaff Accelerator. The target was prepared by the electrodeposition of Ca onto a Pt disk, 15/32-in. diam$\times$0.010 in. thick. The Ca was then oxidized and purged of impurities by being heated in an atmosphere of oxygen at 2500°F for 6 hr. The resulting CaO layer was about 300 kev thick to the incident He^3 beam. The target was protected from vacuum system contaminants by being enclosed in a surface at liquid-nitrogen temperature.[19]

The gamma rays were detected by a 3-in.$\times$3-in. NaI(Tl) crystal and associated electronic equipment, including a 256-channel pulse-height analyzer. The spectrometer was calibrated with a Na^{22} source.

A graded attenuator was placed between the target (Ne^{18} source) and the crystal, whose axis was in the horizontal plane containing the beam and was perpendicular to the axis of the target holder. The target holder itself has 0.020-in. stainless steel walls. Outside the cylindrical target holder was a cylindrical sleeve of paraffin, 0.125 in. thick, for the purpose of stopping the positrons in a reasonably small volume and with a minimum of bremsstrahlung. Between the paraffin sleeve and the NaI crystal was the graded attenuator for the purpose of reducing the very high intensity of the annihilation radiation with respect to higher energy (but lower intensity) nuclear gamma rays. The attenuator consisted of 0.3 in. of lead, 0.016 in. of tantalum, 0.012 in. of cadmium, 0.010 in. of zinc, 0.032 in. of aluminum (the crystal container), and 0.2 in. of MgO (the crystal reflector).

Since Ne^{18} has a short half-life, 1.5 sec, and since the $O^{16}(He^3,n)Ne^{18}$ cross sections at bombarding energies below 5.5 Mev were observed to be very small compared with the competing $O^{16}(He^3,p)F^{18}$ and $O^{16}(He^3,\alpha)O^{15}$

[11] G. C. Phillips (private communication).
[12] R. Middleton (private communication to J. A. Kuehner).
[13] J. A. Kuehner, E. Almqvist, and D. A. Bromley, Phys. Rev. Letters **1**, 260 (1958).
[14] S. Hinds and R. Middleton, Proc. Phys. Soc. (London) **73**, 721 (1959).
[15] S. Hinds and R. Middleton, Proc. Phys. Soc. (London) **74**, 762 (1959).
[16] J. D. Gow and L. W. Alvarez, Phys. Rev. **94**, 365 (1954).
[17] K. L. Dunning and J. W. Butler, Bull. Am. Phys. Soc. **4**, 444 (1959).
[18] F. Everling, L. A. König, J. H. E. Mattauch, and A. H. Wapstra, Nuclear Phys. **15**, 342 (1960).
[19] K. L. Dunning, J. W. Butler, and R. O. Bondelid, Phys. Rev. **110**, 1076 (1958).

reactions, it was necessary to use a special procedure to obtain the decay spectrum of Ne^{18}. F^{18} has a half-life of approximately 2 hr and is a positron emitter. O^{15} has a half-life of approximately 2 min and is also a positron emitter. There was also very intense prompt gamma radiation leading to the ground states of F^{18} and O^{15}, necessitating a procedure for removing the high voltage from the phototube during the time the beam was on target to avoid significant shifts in phototube gain due to the radically different counting rates.

The datum taking procedure was as follows. The target was bombarded for about 0.1 sec during which time the high voltage on the phototube was partially removed by the connecting of the first dynode to the cathode by means of a relay. Since the voltage was not removed from the phototube as a whole, the recovery period following removal of the short was very brief. About 10 milliseconds following the bombardment, the dynode was disconnected from the cathode, and about 100 milliseconds following the bombardment, the count switch of the 256-channel analyzer was turned on, and counts were stored in the left half of the memory of the analyzer. This counting period lasted 2 sec and was timed by a scaler recording the 60 cycles per second from the commercial power line. About 8 sec following the bombardment (by which time essentially all the Ne^{18} had decayed) counts were stored in the right half of the 256-channel analyzer, again for 2 sec, the precise time being recorded by another scaler counting 60 cycles per second.

After each of the bombard-count cycles described above, there was a waiting period of five to ten min during which time the 2-min activity (O^{15}) diminished in intensity. A single-channel analyzer, set for the annihilation radiation photopeak, was used to determine when the 2-min activity had almost disappeared. The usual criterion was that the annihilation radiation be less than about 5000 counts/min before a new bombard-count cycle was initiated. Immediately after the disappearance of the Ne^{18} activity, the background annihilation radiation was usually of the order of 20 000 counts/min.

The purpose of the counting period for the right half of the memory of the 256-channel analyzer was twofold: (1) to obtain a rough measure of the half-life of any nuclear gamma rays observed in the left-half spectrum, and (2) to obtain an accurate measure of the background spectrum associated with the left-half spectrum. The background was different for each bombard-count cycle because of (1) the buildup of O^{15} and F^{18}, and (2) unequal beam intensities from cycle to cycle. Thus the right half of the analyzer contained the background to be subtracted from the counts in the left half in order to obtain the net counts from the decay of Ne^{18}, and included counts due to the 2-min O^{15} activity, the 2-hr F^{18} activity, accelerator background, and room background.

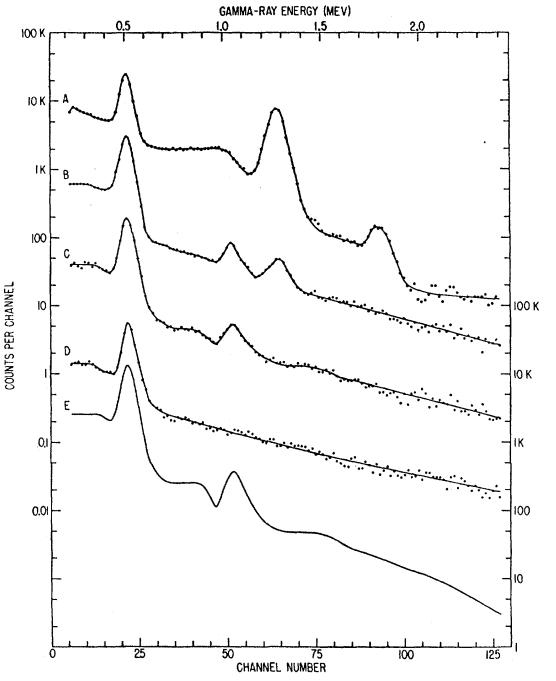

FIG. 1. Gamma-ray spectra measured in the present experiment. The five different spectra are shown on the same graph in order to conserve space and are placed on the graph in an order consistent with minimum space consumption. The curves are as follows: *A* (left scale), Na^{22} spectrum with same geometry and attenuation as Ne^{18} source (Curve *C*); *B* (left scale$\times 10$), combined simultaneous spectrum of Ne^{18} and Na^{22}; *C* (left scale$\times 10^2$), Ne^{18} spectrum including background; *D* (left scale$\times 10^3$), background spectrum for Curve *C*; and *E* (left scale$\times 10^4$ or right scale), net Ne^{18} spectrum (Curve *C* minus Curve *D*).

Subtraction of the background was particularly important in the determination of the branching ratio because the net annihilation radiation photopeak gave the measure of the total number of decays of Ne^{18}.

The data in the two halves of the memory of the analyzer were allowed to accumulate for a series of bombard-count cycles. After 64 of these bombard-count cycles, the 2-hr activity was allowed to disappear by an overnight wait. The following day 85 bombard-count cycles were made, giving a total of 149 cycles for the two days.

Several times during the period of datum accumulation, the gain of the spectrometer was checked utilizing the right half of the memory. The accumulated background spectrum was obtained by the addition of all of the spectra erased for the gain check.

RESULTS OF GAMMA-RAY ENERGY MEASUREMENTS

The accumulated spectrum in the left half of the memory of the analyzer for 149 bombard-count cycles is shown in Fig. 1, Curve *C*. The left-hand scale, multiplied by 10^2, applies. Except for the annihilation radiation photopeak, only one other photopeak is

observable—at an energy slightly over 1 Mev. Curve *D* (left-hand scale times 10^3) shows the spectrum in the right half of the analyzer (background). The background contains a large amount of annihilation radiation, but no evidence for a gamma ray in the vicinity of 1 Mev (or any other energy). Thus, the half-life of the source of the 1-Mev gamma ray is short compared to 8 sec (the waiting period between the recording of the two different spectra) and is therefore consistent with the measured half-life of Ne^{18} (1.46 sec, discussed later).

The net spectrum due to the decay of Ne^{18} is shown as Curve *E* (right-hand scale) and was obtained as Curve *C* minus Curve *D*. There is evidence for a peak of low intensity at about 1.5 Mev in the difference spectrum. This is a sum peak and arises from the summing of nuclear gamma-ray pulses and annihilation radiation pulses, each being from the same Ne^{18} decay, and each having photopeak interactions. An upper limit of about 2% of the intensity of the 1-Mev gamma ray can be placed on any other gamma ray which might be present and which is above 1.2 Mev in energy.

The precise determination of the energy of the 1.04-Mev gamma ray was made by the simultaneous recording of the Ne^{18} and Na^{22} spectra. To a first approximation, this procedure eliminated spectrometer gain shifts between calibration and measurement. However, since the phototube gain was observed to be dependent on the counting rate, and since the counting rate was not constant because of the decay of Ne^{18}, a second-order shift in gain between the Na^{22} and Ne^{18} spectra did occur. That is, the majority of Ne^{18} counts appeared during the first half of the counting period, while the Na^{22} counts were statistically uniform throughout the period. Thus, if the phototube gain did shift during the counting period, the effective gain for the Ne^{18} counts would be slightly different from the effective gain for the Na^{22} counts, but this second-order effect should be extremely small.

Curve *B* (left-hand scale times 10) shows the combined Na^{22} and Ne^{18} spectrum (no background has been subtracted). The energy of the Ne^{18} gamma ray, based on the Na^{22} gamma ray as 1.2736 ± 0.0016 Mev,[20] is 1.041 ± 0.005 Mev. Therefore, the gamma ray is assigned to the 1.043-Mev state in F^{18}, the 0.940- and 1.085-Mev states being well outside the uncertainty. Since the only state in F^{18} observed to be populated in the decay of Ne^{18} is the 1.04-Mev state, it is considered to be the analog of the ground state in Ne^{18} and is therefore assigned the quantum parameters 0^+, $T=1$.

The decay scheme of Ne^{18} is depicted in Fig. 2, following the usual format of the Nuclear Data Group of the National Academy of Sciences—National Research Council. The values of the energy levels are the weighted averages given by Ajzenberg-Selove and Lauritsen.[21]

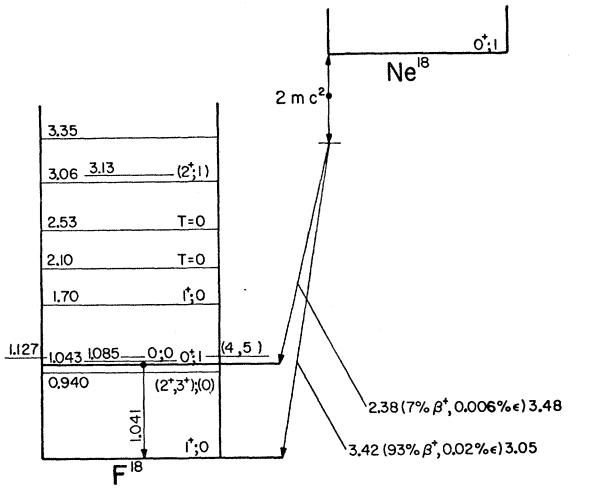

FIG. 2. Decay scheme of Ne^{18}. The labels on the transition lines give the end-point energies, branching ratios, and log*ft* values.

Beta-decay transitions to the 0.940- and 1.127-Mev states are not expected to be observable because they are "forbidden" by the selection rules, but if the 1.085-Mev state has a spin and parity of 0^+ as indicated by Kuehner *et al.*, one would expect it to be populated in the decay of Ne^{18}. Since such population is not observed, a reasonable conclusion is that the 1.085-Mev state probably has negative parity.

HALF-LIFE MEASUREMENT

Two previous measurements of the half-life of Ne^{18} have been made. Gow and Alvarez[16] obtained the value 1.6 ± 0.2 sec, and Dunning and Butler[17] obtained the value 1.25 ± 0.20 sec. These values are in nominal agreement, but both contain relatively large uncertainties, so a third measurement is considered desirable.

The experimental procedure was somewhat similar to the bombard-count cycles previously described, but instead of the gamma-ray energy spectrum being recorded on the 256-channel analyzer, the counts from a single-channel analyzer, set for the annihilation radiation photopeak, were recorded in the analyzer which was used as a sequencing scaler. That is, the channel, or address, was advanced at a uniform rate, and the counts were stored in each channel as that channel was activated.

The address-advance pulses came from a binary scaler which was modified in such a way that the output pulses from any binary stage could be shaped and fed to the small two-tube input amplifier which already existed on the scaler chassis, and then sent to the address scaler of the 256-channel analyzer. The input

[20] P. P. Singh, H. W. Dosso, and G. M. Griffiths, Can. J. Phys. **37**, 1055 (1959).

[21] F. Ajzenberg-Selove and T. Lauritsen, Nuclear Phys. **11**, 1 (1959).

to the address-advance scaler was the 60 cycles/sec from the commercial power line, and this was scaled down by 4 binary stages, so the input to the address scaler was 60/16 cycles/sec. The input circuits of the 256-channel analyzer were modified so that pulse analysis time was about 5 microseconds instead of the usually much longer time.

Fifteen of these bombard-count cycles were recorded, each one being recorded independently before the memory of the analyzer was cleared for the next cycle. The background for each cycle was determined by the counts in the channels corresponding to times after the essentially complete decay of the Ne^{18}, and subtracted from the total counts in the channels of interest before the various runs were added together for a combined decay curve. The dead-time correction was also made to each channel before the adding process.

The result of the half-life measurement is 1.46 ± 0.07 sec. This value is in satisfactory agreement with both previous values, and results in an appreciably reduced uncertainty.

BRANCHING RATIO MEASUREMENT

The branching ratio measurements are based on the photopeak areas for annihilation radiation and the nuclear gamma ray of Curve *E*, Fig. 1. The ratio of the gamma-ray photopeak area to the annihilation photopeak area gives the percentage branching to the excited state of F^{18} if the appropriate corrections are made for geometry, attenuation, efficiency, and the fact that each decay involves two annihilation quanta. Two further small corrections arise from the occasional summing of a gamma-ray photon and an annihilation photon, and from a small fraction of the positrons annihilating in flight.

An experimental check on this method was made with the use of the Na^{22} source. Since fundamentally, Na^{22} and Ne^{18} have similar decay schemes, a Na^{22} source was placed in the same relative position as that previously occupied by the target, with the same amount of attenuation shielding, and the spectrum recorded, as shown in Curve *A* (left-hand scale) of Fig. 1. Thus, the spectrometer was "calibrated" in terms of branching ratios since the branching ratio of Na^{22} is well known. A correction was made because of the fact that the two gamma-ray energies are not quite the same, and therefore, the efficiencies and attenuations were not identical.

Both methods agreed very well with each other, giving a branching ratio of $7\pm2\%$ (including 0.006% orbital electron capture) leading to the 1.04-Mev state, and $93\pm2\%$ (including 0.02% orbital electron capture) leading to the ground state. The fractions leading to orbital electron capture were calculated from the curves of Feenberg and Trigg.[22]

The most important uncertainty in the branching ratio measurement is the unknown fraction of the positrons from the Ne^{18} decay escaping down the vacuum tube through which the He^3 beam had passed to bombard the target. The effect of such escaping positrons would be to lower the annihilation photopeak, thus making the apparent branching ratio to the excited state appear to be somewhat higher than it really is. A reasonable estimate of this effect was made and included in the results given above. The experimental arrangement could have been improved somewhat in this respect by the placing of a baffle fairly close to the target to pass the collimated He^3 beam, but thick enough to stop the positrons.

Another effect having a remote possibility of influencing the results is the escape of Ne^{18}, in the form of gas, before decaying. This effect is in the opposite direction to the escape of positrons mentioned above, and hence would tend to compensate for the other one. However, since the nuclear reactions producing the Ne^{18} take place inside the surface of the CaO target, it appears very unlikely that the Ne^{18} would migrate out in less than 2 sec.

TABLE I. Summary of numerical results of the present experiment.

Ne^{18} half-life	1.46	±	0.07	sec
Gamma-ray energy	1.041	±	0.005	Mev
Branching ratio				
Ground state	0.93	±	0.02	β^+
	0.0002			ϵ
1.04-Mev state	0.07	±	0.02	β^+
	0.00006			ϵ
ft (ground state)	1120	±	70	sec
ft (excited state)	3030	±	880	sec

A summary of the numerical results of the present experiment is given in Table I. The *ft* values are based on the half-life and branching ratios from the present experiment and also on the threshold energy for the $O^{16}(He^3,n)Ne^{18}$ reaction,[17] the 1960 table of masses,[18] and the table of *f* values of Moszkowski and Jantzen.[23]

The first attempts to observe the decay of Ne^{18} in the course of the present experiment gave an indication for a gamma ray of about 1.65 Mev in addition to the 1.04-Mev gamma ray. A simple calculation indicated that the intensity of the 1.65-Mev peak could not be accounted for on the basis of the summing of the 1.04-Mev gamma-ray photopeak pulse and the pulse from one of the associated coincident annihilation quanta, nor could it be due to normal accidental coincidences between the nuclear gamma rays and annihilation quanta. These results were therefore reported in abstract form.[24] When the experiment was repeated with a completely different set of experimental equipment, there was no evidence for a 1.65-Mev peak, and this fact was reported orally.[24]

[22] E. Feenberg and G. Trigg, Revs. Modern Phys. **22**, 399 (1950).

[23] S. A. Moszkowski and K. M. Jantzen, University of California, Los Angeles, Technical Report No. 10-26-55, 1956 (unpublished).

[24] J. W. Butler and K. L. Dunning, Bull. Am. Phys. Soc. **5**, 101 (1960).

When no 1.65-Mev peak was observable in the later series of experiments, the following efforts were made to decide between the two series of experiments. The multichannel analyzers used were of the Argonne-Wilkinson type and therefore relatively slow and complicated. A different type of analyzer, the Oak Ridge type 20-channel analyzer, was then used to cover the region from 1.4–1.9 Mev. The spectrum obtained with it showed no evidence for a 1.65-Mev gamma ray, and we therefore conclude that no 1.65-Mev gamma ray is associated with the decay of Ne^{18}. The previously observed 1.65-Mev peak was apparently a type of electronic "ghost" peak of the 1.04-Mev peak.

DISCUSSION

The mode of decay of Ne^{18} populating the ground state of F^{18} is very similar to the decay of He^6. In both cases, there are two identical particles (except for spin orientation) outside a compact core; the initial states are both 0^+, $T=1$; the final states are both 1^+, $T=0$; the radiation is pure Gamow-Teller; and the log ft values are, respectively, 3.05 ± 0.03 and 2.92 ± 0.01. The decay of O^{14} populating the ground state of N^{14} is similar except for the anomalously small matrix elements for beta transitions to the ground state of N^{14}.

The mode of decay of Ne^{18} populating the excited state of F^{18} is analogous to the corresponding mode of decay of O^{14} populating the excited state in N^{14}. Again, there are two identical particles outside a compact core; the initial and final states are all O^+, $T=1$; the radiation is pure Fermi; and the log ft values are, respectively, 3.48 ± 0.13 and 3.49 ± 0.01.

The decay of Ne^{18} is almost unique in one respect. The decay is observed to proceed via only two channels, one of which involves pure Fermi radiation, and the other pure Gamow-Teller radiation. (C^{10} and O^{14} are the only other known examples in which this situation occurs.) Thus, from the branching ratio of the decay of Ne^{18}, one can calculate the ratio of Gamow-Teller and Fermi coupling strengths for the particular value of Z involved, if the overlap of the wave functions for the Ne^{18} ground state and the F^{18} ground state can be calculated, or if the lifetime of the 1.04-Mev state is measured.

If one assumes charge symmetry of nuclear forces, and assumes that the Coulomb effects can be treated as a small perturbation, the reduced matrix element for the decay of Ne^{18} to the ground state of F^{18} should be the same as that for the decay of F^{18} to the ground state of O^{18}. The Ne^{18} transition should then be $(2J+1)=3$ times faster because of the $J=1$ spin of the ground state of F^{18}. The log ft value[25] of the F^{18} transition is 3.620 ± 0.016, which is in reasonable agreement with the value obtained from Ne^{18} decay, $3.050\pm0.025+\log 3=3.527\pm0.025$.

ACKNOWLEDGMENTS

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