The Disintegration of Sc^{47}

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The radiations accompanying the disintegration of Sc^{47} have been investigated with a lens spectrometer and a scintillation spectrometer. The beta-spectrum is complex and consists of two components of allowed shape with end-point energies, 0.622 ± 0.005 Mev and 0.435 ± 0.008 Mev. A gamma-ray of energy 0.185 ±0.007 Mev has been found. The 0.435-Mev beta-ray is in coincidence with the 0.185-Mev gamma-ray.

THE assignment of the 3.43-day activity to Sc^{47} was definitely confirmed by bombarding various enriched Ti samples with deuterons. Aluminum absorption measurements showed a beta-ray with an end-point energy of 0.61 Mev and an associated gamma-ray.[1]

I. ABSORPTION MEASUREMENTS

For the present investigation about 10 mg of enriched Ti^{49}, which contained Ti^{46}, Ti^{47}, Ti^{48}, Ti^{49}, and Ti^{50} in abundances of 2, 1.5, 17, 78, and 2 percent, respectively, was bombarded with 10-Mev deuterons.[2] All measurements were started two days after bombardment without any chemical separation. Aluminum absorption measurements of the beta-rays showed two end-point energies, 0.62 Mev and 0.43 Mev. Lead absorption measurements showed two gamma-rays of energies 1.1 Mev and 0.2 Mev. The 0.2-Mev gamma-ray as well as the beta-rays decayed with a half-life of about 3.4 days, while the 1.1-Mev gamma-ray decayed with a much longer half-life. It is thus expected that the beta-spectrum of Sc^{47} is complex and an associated gamma-ray of energy about 0.2 Mev is present. The subsequent investigations were made with the use of a lens spectrometer and a scintillation spectrometer.

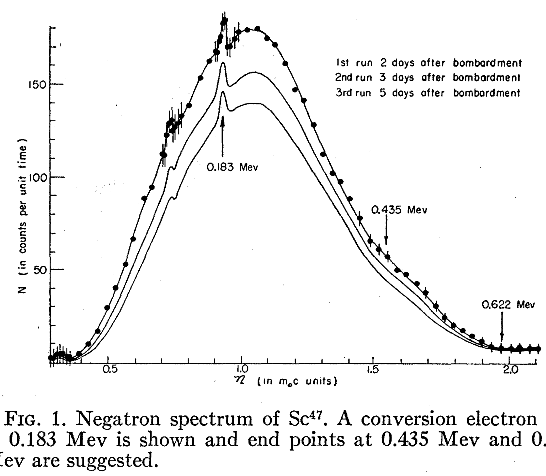

FIG. 1. Negatron spectrum of Sc^{47}. A conversion electron line of 0.183 Mev is shown and end points at 0.435 Mev and 0.622 Mev are suggested.

[1] N. L. Krisberg and M. L. Pool, Phys. Rev. **75**, 1693 (1949).
[2] Supplied by the Y-12 plant, Carbide and Carbon Chemicals Corporation through the Isotope Division, Atomic Energy Commission, Oak Ridge, Tennessee.

II. BETA-RAY SPECTRUM

The resolution of the lens spectrometer was 3 percent. Figure 1 shows a plot of the counting rate *versus* momentum in three consecutive sets of measurements. The beta-spectrum as a whole decayed with a half-life in the neighborhood of 3.4 days. The long-lived activities of V^{48} and Sc^{46} prevented the counting rate to drop to zero beyond 0.622 Mev as shown in Fig. 1. It is observed that besides the continuous beta-spectrum

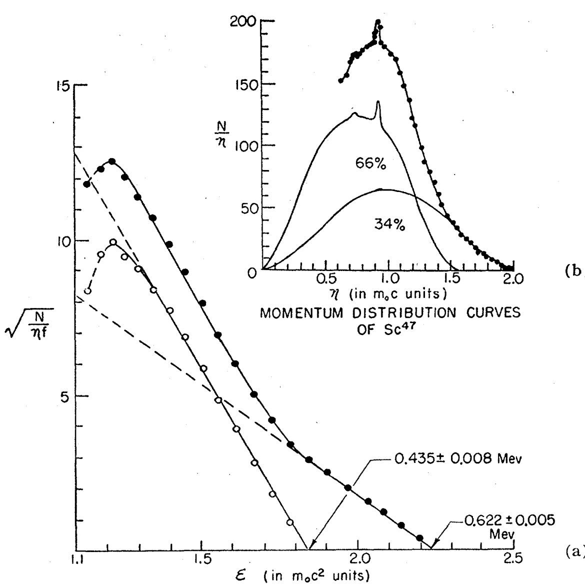

FIG. 2. (a) Fermi plot of negatron spectrum of Sc^{47}. The end-point energies are 0.435 Mev and 0.622 Mev. (b) Momentum distribution curves of Sc^{47} which show the relative abundance of the two spectra.

a conversion electron line of kinetic energy 0.183 Mev is present. The small rise in counting rate at 0.130 Mev just falls outside the range of statistical fluctuation, which is 5 percent.

A typical Fermi plot is shown in Fig. 2. The end-point energies are 0.622 ± 0.005 Mev and 0.435 ± 0.008 Mev. By extrapolation of the Fermi plots back to the low energy region it is possible to construct the momentum distribution curve for each continuous spectrum and then to estimate the relative intensities of these two spectra. Thus the ratio of the intensity of the 0.622-Mev spectrum to that of the 0.435-Mev spectrum has been estimated to be 34±4 to 66±4.

III. GAMMA-RAY SPECTRUM

Since the sources used were too weak to allow the gamma-ray spectrum to be measured in a lens spectrometer, a scintillation counter with a NaI(Tl) crystal was therefore used. Figure 3 shows five sets of measurements of the gamma-spectrum. The energy of the gamma-ray has been determined as 0.185±0.007 Mev. The 0.134-Mev gamma-ray of Ce^{144}, the 0.084-Mev, the 0.330-Mev, and the x-rays of Ba^{133} were used for calibration. The value 0.185 Mev agrees very well with the value of the gamma-ray energy, 0.188 Mev, determined from the conversion electron line observed in the beta-spectrum. The peaks shown in Fig. 3 decayed with a half-life of about 3.4 days.

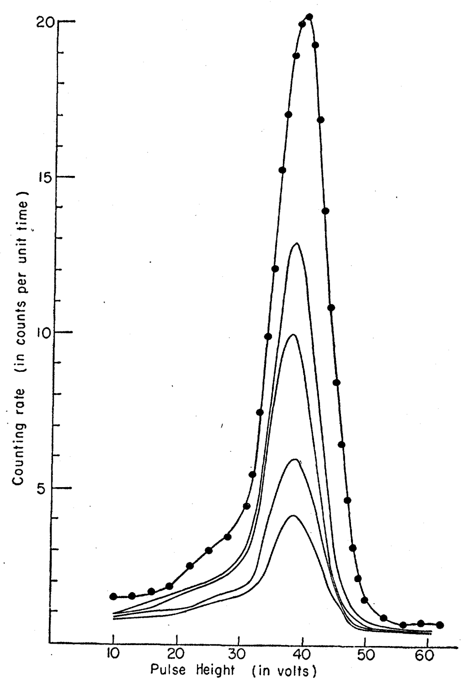

FIG. 3. Gamma-spectrum in scintillation counter of 0.185-Mev radiation from Sc^{47} measured at different times during the decay.

An attempt to resolve the peak and a search for low energy gamma-ray did not give definite results. However, a 0.51-Mev gamma-ray and a 1.04-Mev gamma-ray were observed to decay with a half-life about 20 days. Also a 2.4-Mev gamma-ray with half-life of about 2.2 days was observed. These gamma-rays were of low intensities and may substantiate the existence of the V^{48}, Sc^{48}, and Sc^{46} mentioned above.

IV. COINCIDENCE ABSORPTION MEASUREMENTS

In order to learn the relationship between the 0.185-Mev gamma-ray and the two groups of beta-rays, coincidence measurements were performed. The source was set between a Geiger counter and a scintillation counter. The latter was set at the properly determined voltage bias with a gate width of about 0.015 Mev. The pulses from the two counters were fed into a coincidence circuit, which had a resolving time of 1 microsecond. With enough aluminum in front of the scintillation counter to stop all beta-rays, the beta-gamma coincidence counting rate was then measured as a function of the thickness of aluminum absorbers in front of the Geiger counter. After correction for chance coincidence the result is shown in Fig. 4. It is seen that the beta-gamma coincidence rate drops practically to the gamma-gamma coincidence rate background beyond 110 mg/cm² of aluminum, which corresponds to 0.39 Mev. This indicates that the 0.435-Mev beta-ray is followed by the 0.185-Mev gamma-ray, while the 0.622-Mev is not.

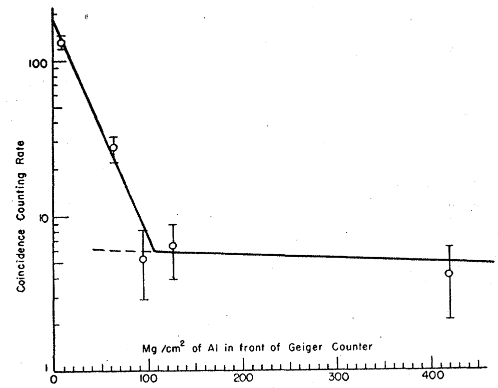

FIG. 4. Coincidence measurements of the 0.185-Mev gamma-ray as a function of the absorption of the beta-rays.

V. DISCUSSION

The results of the present study can be summarized in the following proposed decay scheme shown in Fig. 5. The nuclear shell theory would predict the configuration $f_{7/2}$ for the ground states of Sc^{47} and of Ti^{47}. From the momentum distribution curve shown in Fig. 2b an estimate of the total conversion coefficient of the

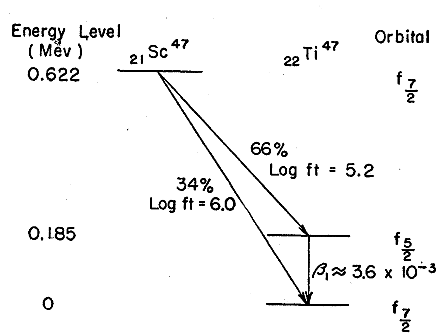

FIG. 5. Proposed energy level diagram for the disintegration of Sc^{47}.

0.185-Mev gamma-ray can be made by comparing the area under the conversion peak and that under the momentum distribution curve of the 0.435-Mev beta-spectrum. The result is $(3.6\pm0.9)\times10^{-3}$. The theoretical K conversion coefficients for electric dipole radiation and for magnetic dipole radiation of the 0.185-Mev gamma-ray are $\alpha_1=4.0\times10^{-3}$ and $\beta_1=3.5\times10^{-3}$, respectively.[3] Although the experimental conversion coefficient seems to fit the theoretical conversion coefficient for magnetic dipole radiation best, the assignment cannot be made definitely. However, the nuclear shell theory would predict the two beta-spectra in the proposed scheme to be of different order of forbiddenness if an electric dipole is assigned to the gamma-ray. The predicted relative intensities of these two beta-spectra would then not be consistent with that observed. Furthermore, the log ft values of the two modes of disintegration of Sc^{47} can be estimated.[4] The log ft values of the 0.435-Mev and the 0.622-Mev beta-spectra are thus found to be 5.2 and 6.0, respectively, which indicate that both spectra belong to allowed transitions.[5] Thus the assignment of $f_{5/2}$ to the excited state of Ti^{47} seems reasonable. If the excited state of Ti^{47} is a $f_{5/2}$ level, then the 0.185-Mev gamma-ray is a magnetic dipole radiation.

Thanks are due Mr. Brock Dale and Mr. Staneyl Fultz for use of their scintillation spectrometers. Grateful acknowledgment is made for the support received from The Ohio State Development Fund.

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

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Disintegration of 24-Minute Ag^{106}†‡

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The 24-minute isomer of Ag^{106} was produced by the (γ,n) reaction on metallic silver. A conversion line of a 512-kev gamma-ray was found. The activity has a positron group of energy 1.96 Mev, a weak lower energy positron, and a possible weak negative beta-group. An upper limit of 0.1 percent is placed on the positron component in the 8-day isomer of Ag^{106}. Previously unreported conversion lines of 66-minute half-life were found in silver following bombardment of Pd by deuterons.

I. INTRODUCTION

The short-lived isomer of Ag^{106}, decaying by emission of positrons, has not been studied previously with a magnetic spectrometer by other workers. However, investigations have been reported using cloud chambers and other methods.[1] This isotope is produced in quite pure form by the (γ,n) reaction on Ag^{107}. The competing Ag^{108} activity, produced by the (γ,n) reaction on Ag^{109}, decays quickly. It was felt that the equipment available in this laboratory made a further study of this activity worth while.

II. APPARATUS

The sources were irradiated with x-radiation from the 22-Mev University of Illinois betatron, usually at about 22-Mev and for about an hour. The probe technique[2] was employed. While the earlier work[3] employed a 180° magnetic spectrometer, the results reported here were obtained with a double-focusing spectrometer of 15-cm orbit radius. The magnet of this instrument is of the double-mushroom type. It is quite similar to that of Kurie *et al*,[4] but differs in that the pole pieces extend over only 270°. Unlike the instrument of Kurie *et al.*, the magnet is not part of the vacuum chamber. A resolution of 0.33 percent has been obtained utilizing the maximum transmission of 0.22 percent. The magnetic field is controlled, stabilized, and measured by an electronic system essentially the same as that employed with the 180° spectrometer.[5] The scintillation spectrometer is described elsewhere.[6]

III. 24-MINUTE RADIATIONS

Sources were in the form of sheets of silver, 0.0001 inch to 0.020 inch thick. The initial 24-minute activity was about 2 to 7 millicuries per gram. The half-life of

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[5] Brown, Bendel, Shore, and Becker, Phys. Rev. **84**, 292 (1951).

[6] Shore, Bendel, Brown, and Becker, (to be published).