

FIG. 1. Potentials and densities for protons and neutrons inside the nucleus.

distribution lies inside the neutron distribution. For the heaviest elements the difference in radii could easily be $\frac{1}{3}$ to $\frac{1}{2}$ the thickness of the sloping part of the nuclear potential; the latter is likely to be of the order of the meson Compton wavelength. Thus the radius of the proton distribution may turn out smaller than the neutron radius by about 10^{-13} cm.

A more detailed examination of the nucleon orbits gives qualitatively the same result. The intercept of the energy level with the radial potential determines a point of inflection for the wave function; beyond this point the wave function is always convex to the axis. This point will be different for different angular momenta but will lie at systematically smaller radii for protons. In addition, the higher potential barrier for protons outside this point causes proton wave functions to vanish more rapidly than neutron wave functions. The lower part of Fig. 1 gives a qualitative picture of the proton and neutron densities within the nucleus.

In experiments with nucleons and π mesons which interact strongly with nuclear matter, one may find the surface of the nucleus at radii where practically no protons are present and the neutron density is well below its plateau value. In experiments with electrons and μ mesons which interact only with the electrostatic field, one may find the smaller radii characteristic of the proton distribution.

* Work supported by the U. S. Atomic Energy Commission.

A New Titanium Nuclide: Ti^{44}

R. A. SHARP AND R. M. DIAMOND

Department of Chemistry, Harvard University, Cambridge, Massachusetts

(Received November 30, 1953)

A LONG-LIVED titanium activity has been produced by the irradiation of scandium oxide with 30-45-Mev protons. Spectroscopic analysis showed that the scandium oxide available¹ contained about 1 percent each of zirconium and calcium and about $\frac{1}{2}$ percent each of thorium and combined rare earths; initial studies indicated that these impurities caused too much radioactive contamination to observe any long-lived titanium activity. The necessary scandium purification was accomplished by the development of a solvent extraction method using thenoyltrifluoroacetone (TTA).² Samples of approximately 70 mg of the purified oxide were wrapped in aluminum foil and bombarded

for ~ 1 microampere hour in the internal beam of the Harvard 95-inch synchrocyclotron, yielding ~ 100 dis/sec of the new activity.

After the 3.1-hour Ti^{46} and the 3.9-hour Sc^{43} and Sc^{44} activities had been allowed to decay, the target material and 10 mg of titanium metal as carrier were dissolved in boiling 6*N* HCl. Hydrogen peroxide was added to insure that all the titanium was in the (IV) state and was then destroyed by further boiling. The titanium fraction was isolated by repeated cupferron precipitation from chilled 6*N* HCl solution and subsequent extraction into chloroform.³

By a similar procedure the scandium daughter could be separated from its titanium parent, and this separation was effected several times during a period of months to the titanium fractions from targets from three bombardments. Immediately after separation, the activities of both parent and daughter fractions were followed in an argon-filled, chlorine-quenched, end-window Geiger counter, a windowless proportional counter using a mixture of 95 percent argon, 5 percent CO_2 as counting gas, and a thallium-activated NaI scintillation counter.

With all counters the scandium daughter activity showed a 4-hour decay which turned over into a small amount of a long-lived component, probably because of incomplete separation of the titanium parent. The fact that approximately the same amount of 4-hour scandium activity could be separated repeatedly from the titanium fraction over a period of several months shows the presence of a long-lived parent nuclide, and the 4-hour half-life of the daughter indicates mass number either 43 or 44. Since Sc^{43} has a 1.46-Mev positron and a 1.16-Mev gamma, whereas Sc^{44} has 1.18- and 0.77-Mev positron groups and a 375-kev gamma,³ an aluminum absorption curve taken with the Geiger counter and an integral gamma pulse-height curve taken with the scintillation counter on the scandium daughter showed unambiguously that the daughter was Sc^{44} . This assignment of the activity to Ti^{44} is to be expected from a consideration of beta-decay systematics.

When the Geiger and proportional counters were used, the activity of the freshly separated titanium fractions was observed to grow from just above background to the final equilibrium values with a 4-hour half-life, indicating no particulate radiation (<5 percent abundance) in the decay of Ti^{44} . Integral gamma pulse-height curves taken with the scintillation counter during the growth of the daughter activity showed the presence of an ~ 1.2 -Mev gamma activity growing with a 4-hour half-life and another of 160 ± 60 kev of constant intensity. The high-energy gamma is the 1.16-Mev gamma of the growing Sc^{44} activity, whereas the lower energy gamma must be associated with the Ti^{44} decay itself. Taking the counting efficiency of the 1.16-Mev gamma in the large well-type NaI crystal used as approximately equal to that of the experimentally determined average value for the 1.17- and 1.33-Mev gammas of Co^{60} and assuming that the counting effi-

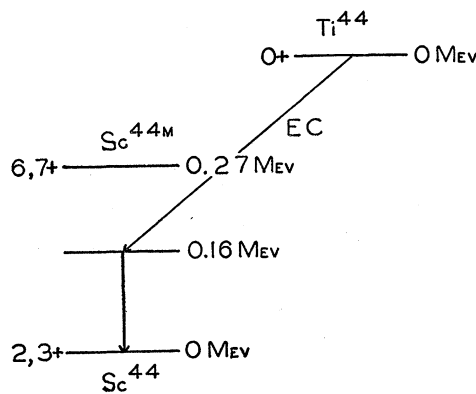


FIG. 1. Proposed decay scheme of Ti^{44} .

ency for the low-energy gamma is 80 percent (or higher), we obtain a 1:1 correspondence in the number of the low- and high-energy gammas at radioactive equilibrium between the parent and daughter. Because of the assumptions made and the complicating presence of annihilation radiation from the Sc^{44} positron, this ratio could possibly be as large as $\frac{3}{2}$ or as small as $\frac{1}{2}$; but certainly the association of a low-energy gamma with every Ti^{44} disintegration is suggested. Consideration of a possible decay scheme, Fig. 1, confirms this view. Decay of Ti^{44} to the $3+$ or $2+$ ground state of Sc^{44} would be at least second-forbidden with a $\log(ft)$ value of 13–14.⁴ Decay measurements made over a period of one half-year indicate, by a least-squares analysis, a half-life of 2.7 years with a rather large estimated error of ± 0.7 year

because of the small amount of titanium activity available. Such a value for the half-life would require an impossibly large decay energy to yield a $\log(ft)$ value of 13–14. No decay to the 2.4-day Sc^{44m} would be expected because of the high-spin change involved, and none is observed. Thus a less forbidden transition to an excited state of Sc^{44} followed by gamma emission to the 4-hour ground state is to be expected.

[†] This work was supported by the U. S. Atomic Energy Commission.

¹ This scandium oxide was generously given by Professor G. Wilkinson. It had been prepared from thortveitite ore by the late Professor G. P. Baxter.

² Details to be published elsewhere.

³ Hollander, Perlman, and Seaborg, *Revs. Modern Phys.* **25**, 469 (1953).

⁴ L. W. Nordheim, *Revs. Modern Phys.* **23**, 322 (1951).

PHYSICAL REVIEW

VOLUME 93, NUMBER 2

JANUARY 15, 1954

Proceedings of the American Physical Society

MINUTES OF THE 1953 AUTUMN MEETING OF THE NEW YORK STATE SECTION
AT POUGHKEEPSIE, OCTOBER 16 AND 17, 1953

THE thirtieth meeting of the New York State Section convened at Poughkeepsie, New York, on October 16 and 17 with just under 100 registrants. The meeting was sponsored jointly by Vassar College and International Business Machines Corporation.

Following tours through the IBM laboratories on Friday morning, registrants attended an invitation luncheon at which Dr. A. L. Samuel spoke on "Functions of the IBM Research Laboratory." The Friday afternoon session, held in the Physics Laboratory at Vassar College, was devoted to three invited papers. The Section met with faculty and students of Vassar College on Friday evening for a lecture by Dr. George B. Collins of Brookhaven National Laboratory on "Particle Physics."

A group of three invited papers followed the

business meeting of the Section on Saturday morning. The major item on the agenda for the business meeting was discussion of two proposed amendments to the constitution—one having to do with the definition of specific procedures for amending the constitution, the other with removal of a phrase in the article on "membership" which defines the geographical limits of the Section as "exclusive, in general, of the Metropolitan area of New York City." Vote on the amendments will be taken at the next meeting of the Section.

A list of the invited papers is appended.

L. W. PHILLIPS, *Secretary*
New York State Section
The University of Buffalo
Buffalo 14, New York

Invited Papers

The 701 Calculator. C. FRIZZELL, *International Business Machines.*

Transistor Physics. L. P. HUNTER, *International Business Machines.*

Dielectric Constant Measurements of Barium Titanate. D. R. YOUNG, *International Business Machines.*

The Use of Radioactive Iodine in the Study of Thyroid Function. ROSALYN YALOW, *Bronx Veterans Administration Hospital.*

A Simple Bent-Crystal X-Ray Spectrograph for a Senior Experiment. JOHN WEYMOUTH, *Vassar College.*

Some New Applications of X-Ray Diffraction. ISADOR FANKUCHEN, *Brooklyn Polytechnic Institute.*

MINUTES OF THE 1953 AUTUMN MEETING OF THE OHIO SECTION OF THE AMERICAN PHYSICAL SOCIETY
AT GENERAL ELECTRIC LIGHT INSTITUTE, NELA PARK, CLEVELAND, OHIO, OCTOBER 23 AND 24, 1953

THE regular fall meeting of the Ohio Section of the American Physical Society was held at the General Electric Light Institute, Nela Park, Cleveland, Ohio, on Friday and Saturday, October 23–24, 1953. No program, save a trip through the Light Institute, was prepared for Friday morning, but this trip was of sufficient interest that 80 persons appeared for it. Invited papers began at

1:00 P.M. on Friday with more than 150 in attendance. The following invited papers on the general theme of the electric lamp development were presented:

Physics and Physicists in an Ohio Industry—Electric Lamps. R. N. THAYER, *Lamp Development Laboratory, Nela Park.*

Physical Processes in Fluorescent Lamps. B. T. BARNES, *Lamp Development Laboratory, Nela Park.*