the new nucleon distribution. The second contribution is

$$\sum_{i=1}^{A} (\psi_i, T_i\psi_i) = \sum_{i=1}^{A} (\psi_i, E_i\psi_i) - (\psi_i, V_0\psi_i)$$

$$= \sum_{i=1}^{A} E_i - \int \rho(\mathbf{r}) V_0(\mathbf{r}) d\mathbf{r}, \qquad (9)$$

where $V_0(\mathbf{r})$ is the original potential. Evaluation of these expressions gives, for (8), $-4280mc^2$ and for (9), $-3950mc^2+7950mc^2$, or a total binding energy of about 140 Mev, which is much too small.

This discrepancy may be due to an inadequacy in the model used or to the neglect of exchange in the energy calculation. The use of antisymmetrized wave functions to overcome the latter defect does not, however, alter the nucleon distribution, so that the result obtained here is not necessarily in error. In any event, one would expect the boundary diffuseness to be chiefly deter-

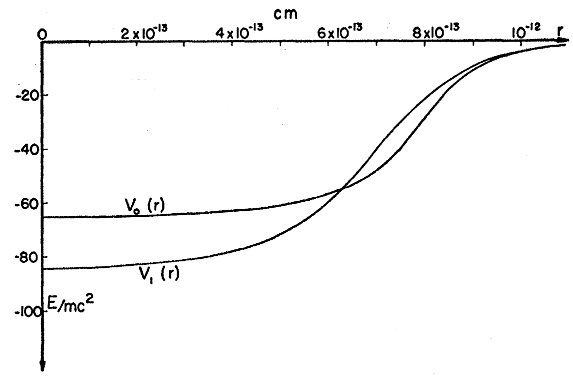

FIG. 4. The original nuclear potential $V_0(r)$ and the nuclear potential obtained from the new nucleon distribution, $V_1(r)$.

mined by the force range, which is a relatively certain parameter.

The author wishes to thank Professor E. P. Wigner, who proposed this calculation, for his guidance.

PHYSICAL REVIEW VOLUME 102, NUMBER 2 APRIL 15, 1956

Decay of Ca^{49} and Sc^{49}†

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(Received January 6, 1956)

Ca^{49} has been found to decay with a half-life of 8.9±0.2 minutes. It emits two principal beta components of energies 2.12±0.10 and about 1.0 Mev in coincidence, respectively, with gamma rays of 3.07±0.05 and 4.04±0.06 Mev. The intensity ratio of these two branches is 8.5:1. The intensity of a possible ground-state beta branch is less than 1%, and that of a possible 0.98-Mev gamma transition between the 3.07- and 4.04-Mev levels is less than 3%. These data indicate that these excited states are respectively the single-particle $p_{\frac{3}{2}}$ and $f_{\frac{5}{2}}$ levels available for excitation of the twenty-first proton in Sc^{49}. Sc^{49} is found to emit in turn a single beta component of energy 1.80±0.10 Mev.

I. INTRODUCTION

UNTIL recently little was known of the decay of Ca^{49} except for a report[1] that it emitted beta rays of 2.7 Mev with a half-life of 8.5 min. The daughter Sc^{49} has been reported[2] to emit a single beta ray of 2.00 Mev with a half-life of 57 min. The decay of Ca^{49} seemed to be of particular interest from the point of view of the single-particle model since the daughter Sc^{49} nucleus has a closed shell of 28 neutrons and one proton outside the closed shell at 20. Beta-decay systematics[3] indicated that there should be about 5 Mev of energy available for the decay. It seemed possible that one might see in this case the relatively pure single-particle excited states available to the twenty-first proton and expected to lie 3 Mev or more above the ground state.

A very recent report[4] has verified that this is indeed the case. Two gamma rays of 3.10 and 4.05 Mev were observed with intensities in the ratio 9.0:1. This is consistent with the belief that the excited states from which they originate are the $p_{\frac{3}{2}}$ and $f_{\frac{5}{2}}$ levels respectively, while the ground state is $f_{7/2}$. One additional gamma ray was observed at 4.68 Mev with intensity indicating that 0.38% of the decays passed through the corresponding level. There was found to be no direct beta transition to the ground state. The highest energy beta component, leading to the 3.10-Mev excited state, was reported to be 1.95 Mev, giving a Q-value for the decay of 5.05 Mev. The half-life was reported to be 8.75 min. The daughter Sc^{49} was found to decay with a period of 57.2 min and emit a single beta ray of 2.05 Mev.[5]

† This work was carried out under the auspices of the U. S. Atomic Energy Commission.
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[5] *Note added in proof.*—See also M. McKeown and G. Scharff-Goldhaber, reported in *Nuclear Level Schemes A=40–92*, edited by K. Way *et al.* (U. S. Atomic Energy Commission Report TID-5300, 1955). A gamma ray of 3.00 Mev is reported to be in coincidence with a beta ray of 2.0 Mev.

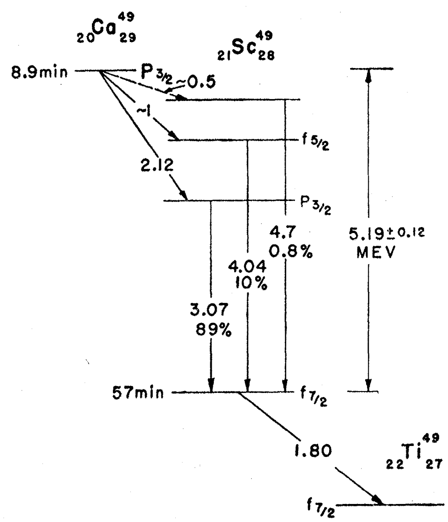

FIG. 1. Decay scheme of Ca^{49} and Sc^{49}.

Simultaneous independent studies at this Laboratory have led to results in essential agreement with the above, except for some discrepancy in the beta-ray energies. The improved results obtained since our preliminary report[6] are briefly summarized below.

II. EXPERIMENTAL RESULTS

The gamma-ray spectrum was studied using $2\frac{1}{4}$-inch cubic NaI(Tl) crystals and the Argonne 256-channel pulse-height analyzer. The spectrum observed in a well-collimated arrangement indicated only two gamma rays of energies 3.07±0.05 and 4.04±0.06 Mev and intensity ratio 8.5:1. The 4.68-Mev gamma ray reported by O'Kelley *et al.*,[3] was at first overlooked, but on closer examination the data are consistent with its existence. Our data indicate an energy 4.7±0.1 Mev and an intensity representing 0.8% of the decays. The entire pulse spectrum was found to decay with a half-life of 8.9±0.2 minutes, except for a low-energy continuum due to Sc bremsstrahlung. Calibration was based on the 4.45-Mev gamma ray of a Po—Be source, and on the gamma rays and sum peak of Na^{24}.

Pulse distributions taken in coincidence with each of the several peaks associated with these two gamma rays yielded no pulses above the random coincidence rate other than those due to annihilation quanta and back-scattered Compton quanta. In particular, the intensity of a possible 0.98-Mev gamma ray in cascade with the 3.07-Mev radiation does not have an intensity in excess of about 3% of the latter.

Beta-gamma coincidence absorption curves were obtained in which the beta rays were detected by an anthracene crystal. Beta rays of 2.12±0.10 Mev were found to be coincident with the 3.07-Mev gamma ray, and others of about 1.0 Mev were in coincidence with the 4.04-Mev gamma ray. The source was left undisturbed until the Ca activity had disappeared, after which the absorption curve of the beta rays of the Sc^{49} daughter was obtained. The result gave an energy of 1.80±0.10 Mev. The discrepancy between these results and those of O'Kelley *et al.*,[3] in the relative energies of the Sc and Ca beta rays is well outside quoted errors.

Anthracene pulse distributions of the beta rays were in qualitative agreement with the absorption results. From these distributions, the intensity of a possible 5.2-Mev ground-state beta branch can be asserted to be less than one percent. Logft values deduced from this fact and from the gamma-ray intensities indicate that all three transitions to the 3.07-, 4.04-, and 4.7-Mev levels are allowed, while the ground-state transition is at least 2nd forbidden. Also, the Sc beta transition is allowed. All these statements are fully consistent with the level assignments shown in Fig. 1. The assignments shown are just those predicted by the single-particle model, and are identical with those of O'Kelley *et al.*[3] The lack of a strong 0.98-Mev transition between the 4.04- and 3.07-Mev levels indicates that their assignments cannot be interchanged. Crude single-particle estimates[7] of transition probabilities predict that a 0.98-Mev $M1$ transition would be several times as probable as a 4.04-Mev $E2$ transition.

The Q-value of the decay obtained from our results is 5.19±0.12 Mev.

Thanks are expressed to Dr. O'Kelley, Dr. Lazar, and Dr. Eichler for communication of their results in advance of publication.

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