(Note that $dV_P = m_\alpha dEdP_H d\theta$.) The total current **I** is to be obtained by integration over dE and dP_H. This leads to an expression for **I** as a linear function of **E** where the coefficients are integrals involving **H** through ω_t so that in principle the relationship of **I** to **E** is reduced to quadratures for all values of **H**.

This result is formally more general than that of Davis[1] which extends to terms in H^2 and that of Wilson[2] which is restricted to eliptical surfaces and $\tau = \tau(E)$.

Equation (4) can be evaluated for large values of **H** for various assumed forms of $\mathbf{v}(\theta)$ and $v(\theta)$. It is hoped that by these means the energy surface parameters[3] for germanium can be determined from magnetoresistance measurements on single crystals.[4,5]

The writer is indebted to G. L. Pearson and H. Suhl for stimulating discussions of their data, to J. Bardeen, I. Estermann, and F. Seitz for several discussions and to the last for the opportunity to see his manuscript dealing with spherical surfaces but varying τ.

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The Question of Isomerism in Ca^{49}

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In the course of a systematic investigation of isomers produced by slow neutron bombardment it seemed to us of interest to study in greater detail the case of isomerism in Ca($Z = 20$), the element of lowest charge for which isomerism has been reported. Walke[1] had assigned periods of 30 min. and 2.5 hr. to Ca^{49}. In view of the connection between isomers of the even-odd type and nuclear shell models recently discussed by Feenberg, Nordheim, and Mayer, this problem takes on added interest.

To our surprise, we were unable to confirm the existence of either of the reported activities when Ca enriched in the isotope of mass 48 (62 percent Ca^{48}) was exposed to slow neutrons from the Argonne heavy water reactor. Instead, we noticed two activities of 8.5 min. and 1 hr. half-life as shown in Fig. 1, upper curve. By chemical separation we could show that the 8.5-min. activity was due to a Ca isotope, Ca^{49}, and the 1-hr. activity due to a Sc isotope, Sc^{49}. The relative intensities of the 8.5 min. and 1 hr. activities were compatible with the interpretation that the 1-hr. Sc^{49} is the daughter of 8.5-min. Ca^{49}. A 57-min. Sc^{49} was also observed by Walke[1] in the Sc fraction after neutron or deuteron bombardment of Ca. The isotopic activation cross section of Ca^{48} was found to be 1.1×10^{-24} cm^2 and the cadmium ratio ~ 35, similar to that of Al, which behaves approximately like a $1/v$ absorber.

The energy of the beta-rays of Ca^{49} as determined by absorption in Al in a calibrated arrangement, was found to be ~ 2.7 Mev. Hard gamma-rays capable of producing photo-neutrons from Be and D were also present, with an intensity comparable to that of the beta-rays (see Fig. 1, lower curve). The beta-rays of Sc^{49} were found to have an energy of ~ 2.4 Mev. The assignment of the 8.5-min. activity to Ca^{49} was further checked by bombarding ordinary Ca, and Ca enriched in the isotope of mass number 46.

In the spin-orbit coupling model of nuclear shell structure the onset of isomerism involving reasonably long lifetimes should not take place until $g_{9/2}$ and $p_{1/2}$ levels start competing for the lowest level. This occurs for 39 odd nucleons.[2] From the point of view of this model which has been remarkably successful in predicting the spins of the ground states of the nuclei—though not so successful in predicting parity changes in isomeric transitions—it is satisfactory that of the reported cases of isomerisms for nuclei with 29 neutrons that of Ca^{49} could not be substantiated. However, another case of isomerism is believed to exist for 29 neutrons, that of Ti^{51} where a 72-day and a 6-min. period have been reported.[3] We were able to confirm the 6-min. activity in Ti of high purity bombarded with slow neutrons, but the intensity of the 72d activity, if present, was at least 10 times smaller than ex-

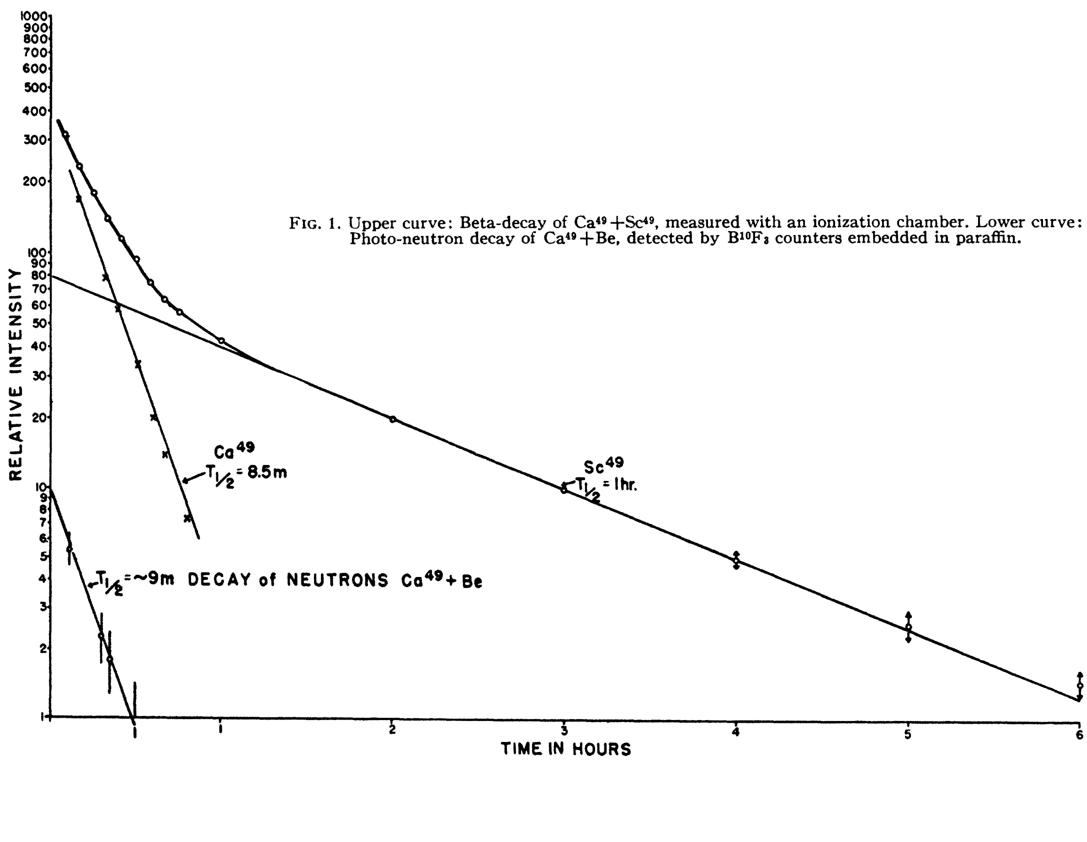

FIG. 1. Upper curve: Beta-decay of $Ca^{49}+Sc^{49}$, measured with an ionization chamber. Lower curve: Photo-neutron decay of Ca^{49}+Be, detected by $B^{10}F_3$ counters embedded in paraffin.

pected from the cross section reported by Seren *et al.*[4] A detailed search for the 72-day activity is reported in the succeeding note by Miskel, der Mateosian, and Goldhaber.[5]

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The Question of Isomerism in Ti^{51}

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IT was shown in the preceding note[1] that of the two reported cases of isomerism for 29 odd neutrons in even-odd nuclei, *viz.*, Ca^{49} and Ti^{51}, the first case could not be confirmed. In the second case, some doubt was thrown on the existence of the 72-day activity[2] of Ti^{51}, isomeric with 6 min. Ti^{51}. To investigate this activity further we obtained a source of Ti^{51} (72d) of nominally 0.5 millicurie intensity, from Oak Ridge, where it had been produced by slow neutron bombardment of TiO_2.

To find clues for possible chemical impurities in the sample the photon component was studied with the help of physical devices of fairly specific response, which were in use here for other work: a proportional counter for low energy photons[3] and a photoneutron detector for high energy photons.[4] In this way the presence of Hf^{181} (46d) was established with the help of the L radiation accompanying its decay and that of Sb^{124} (60d) with the help of the photo-neutrons which its gamma-rays produce in Be. The spectroscopic analysis accompanying the TiO_2 sample had revealed neither Hf nor Sb. After precipitation of Sb as sulfide, the titanium was purified by repeated distillation of $TiCl_4$ (b.p. 136.4°C) prepared from the irradiated TiO_2. Carriers were added for suspected impurities during the purification. After purification a sample of $\sim$200 mg TiO_2 spread over an area of about 10 cm^2 showed an activity of only 4 counts/min. when measured with a thin end window counter (3 mg/cm^2 of mica). This activity was not studied further. It represented a reduction in intensity from the original activity by a factor of $\sim 10^5$. It is therefore probable that no 72d Ti^{51} exists, and that previous observers were measuring an apparent activity caused by a number of impurities of comparable half-life. In agreement with expectations from the spin orbit coupling model[5] of nuclear shell structure, no case of isomerism for less than 39 odd nucleons is now established for even-odd nuclei.

We wish to thank Maria Mayer for stimulating discussions.

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† Work carried out under the auspices of the AEC.
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Neutron-Induced Radioactivity in Palladium

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NEUTRON capture in Pd^{110} gives radioactive Pd^{111} which decays by beta-emission with a half-life of 26 min. to Ag^{111}. The 7.5-day activity of Ag^{111} has been studied by several investigators. Helmholz and others[1] found the beta-ray spectrum to be simple with an upper energy limit of 1.06 Mev. Steinberg[2] reports for the beta-rays energy limits of 0.24 Mev and 1.0 Mev. Kraus and Cork[3] report little or no gamma-radiation, and other investigators report no gamma-rays.

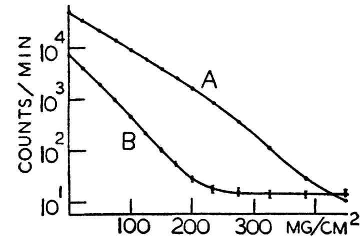

FIG. 1. Absorption of Ag^{111} beta-rays, A, and corresponding beta-gamma-coincidence rate, B.

The neutron-induced radioactivity in palladium has here been investigated with a sensitive scintillation counter. Palladium from Johnson, Matthey & Co., London, of purity 99.995 percent was irradiated in the Harwell pile. The irradiated palladium was dissolved and a small amount of inactive $AgNO_3$ added. The silver was precipitated as the chloride and then redissolved in ammonium hydroxide and reprecipitated.

In addition to the well-known beta-rays, the silver precipitate was found to emit gamma-rays of weak intensity. The activities were followed for six weeks with special attention toward any difference in half-life between the beta- and gamma-activities. The half-lives were found to be equal, both being in agreement with the 7.5 days previously reported for Ag^{111}. An absorption measurement of the gamma-rays gave an absorption coefficient in lead of 0.31 g^{-1} cm^2 which corresponds to an energy of 0.33 Mev. The gamma-rays were found to be in coincidence with the beta-rays. Curve A in Fig. 1 shows the counting rate of the total beta-radiation *versus* thickness of the aluminium absorbers, curve B is the corresponding coincidence rate multiplied by a factor of 100. The upper energy limit of the main beta-spectrum and the upper energy limit of the beta-rays giving rise to coincidences differ roughly by the energy 0.33 Mev of the gamma-rays, though the weak intensity of the gamma-radiation prevents an accurate determination. The intensity of the gamma-rays was found to be 6.5 gamma-rays per 100 beta-particles. No gamma-gamma-coincidences were recorded.

The conclusion is that 6.5 percent of the beta-decay of Ag^{111} has an upper energy limit of 0.73 Mev and leads to an excited state of Cd^{111} at 0.33 Mev. Both this and the 1.06-Mev beta-transition to the ground state appear to be once forbidden. These facts and the conversion coefficients for the transitions[1] in Cd^{111} may be explained by assuming that the 0.33-Mev excited state and the ground state both have the same parity and spin equal to 1/2, while the excited states at 0.247 Mev, 0.396 Mev and 0.420 Mev have spins of 5/2, 13/2 and 9/2 respectively, with parities opposite to that of the ground state.

From the solution the palladium was precipitated with di-methyl-glyoxim. This precipitate showed the 87 kev gamma-rays following the 13-hour activity of Pd^{109} and the very soft components of the 17-day activity of Pd^{103}, but, except for the internal bremsstrahlung no harder component was found in the precipitate.

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The Bohr Formula for the Rydberg Constant

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THE first great triumph of the Bohr theory for the hydrogen atom was the derivation of the Rydberg constant for infinite mass in terms of certain atomic constants. For the past third of a