tion to a state of Ni^{61} 0.652 Mev above the ground state. The end point energy of this spectrum would be 1.205−0.652=0.553 Mev. This assumption is in agreement with the findings of Cook and Langer that the positron spectrum shows a deviation for energies lower than about 0.511 Mev. For this energy the ratio of K-capture to positron emission is about 5, which means that in the momentum distribution of the positrons a complexity of about 1–2 percent must be expected.

We wish to thank Professor Scherrer for his kind interest in and active support of this work.

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Half-Life for Double Beta-Decay*

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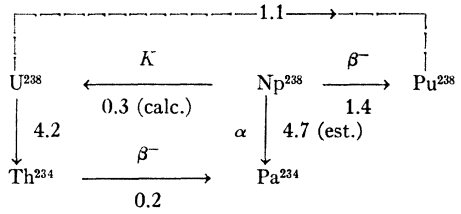
FIREMAN[1] has reported the results of a rather difficult beta-particle coincidence counting experiment in which the decay of $_{50}Sn^{124}$ to $_{52}Te^{124}$ by the simultaneous emission of two negative beta-particles, with a half-life between 4×10^{15} and 9×10^{15} years, seems to have been observed. This note reports the results obtained from a different and somewhat simpler method of looking for the phenomenon of simultaneous emission of two beta-particles. These results are negative so far and show that this process is considerably less probable in the case chosen by us than in that reported by Fireman.

Our method consists of looking in uranium samples for 90-year Pu^{238} which would come from U^{238} by the double beta-particle mechanism since Np^{238} is heavier than U^{238}, which in turn is substantially heavier than Pu^{238}, in the isobaric triplet $_{92}U^{238}-{}_{93}Np^{238}-{}_{94}Pu^{238}$. This chemical method of investigation is particularly applicable to this isobaric triplet because there appears to be no other mechanism to account for the Pu^{238} should it be found. The energetics of the situation are summarized in the following diagram, where the disintegration energies (in Mev) are derived from sources which may be traced through a recent compilation.[2]



The alpha-disintegration energy of Np^{238} is estimated from alpha-decay systematics.[3]

Our experiment consisted of taking 14 kg of very pure, 6-year old, UO_3 and extracting and separating the plutonium fraction by chemical means. The method consisted essentially of dissolving the oxide in nitric acid and precipitating Pu(IV) with lanthanum fluoride, followed by solution of the lanthanum fluoride and oxidation of the plutonium to Pu(VI), which was extracted into diethyl ether and then re-extracted into water. Similar cycles were repeated five times in order to separate completely from UX_1 and to reduce the amount of lanthanum carrier, after which the final sample was plated out on flat platinum with total carrier weight probably less than 50 micrograms. The use of tracer Pu^{239} in this separation established that the chemical yield amounted to 10 percent.

This final sample was measured for the presence of the 5.51-Mev alpha-particles of Pu^{238} on the alpha-pulse analyzer apparatus in this laboratory.[4] This analysis showed that the counting rate of the Pu^{238} alpha-particles at essentially 50 percent counting yield amounted to 0.00±0.01 counts per minute above background. This indicates that the "half-life" of U^{238} for simultaneous emission of two beta-particles, for which a total energy of 1.1 Mev is available, is greater than 6×10^{18} years.

This experiment could be extended to reach longer half-lives through the use of larger and older sources of uranium such as pitchblende ore. In this case, of course, the plutonium fraction so isolated will contain a certain amount of Pu^{239} as has already been demonstrated.[5] The extraction of plutonium from a ton of pitchblende (50 percent uranium) with 10 percent yield could detect a half-life as long as some 10^{22} years for the same limits of counting accuracy.

This result appears to disagree with that of Fireman although it may not be possible to be positive about this in view of the difference in energies and atomic numbers and possible difference in degree of prohibition involved. The theory for the double beta-decay process sets widely differing ranges of half-life depending upon whether the process can take place without neutrino emission.[6] Fireman's results are in the range predicted for double beta-decay without neutrino emission while our half-life limit seems to be above this predicted range and perhaps points toward the emission of two neutrinos in this process.

A recent investigation[7] of the double beta-transition $_{52}Te^{130}\rightarrow{}_{54}Xe^{130}$, by a similar method in which the xenon present with a tellurium ore was analyzed, also points toward a two-neutrino process, but is subject to experimental uncertainty with respect to the age of and the degree of xenon retention by the ore.

It is a pleasure to acknowledge the assistance of Dr. L. B. Magnusson in the chemical procedure.

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On the Reaction $Mg^{24}(p, \gamma)Al^{25}$

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THE bombardment of ordinary magnesium with protons gives the following reactions:

(1) $Mg^{24}(p, \gamma)Al^{25}$ Q=2.3 Mev
(2) $Mg^{25}(p, \gamma)Al^{26}$ Q=8.4 Mev
(3) $Mg^{26}(p, \gamma)Al^{27}$ Q=7.3 Mev.

These reactions have been investigated by Curran and Strothers.[1] They separated the reactions by the positrons accompanying some of the resonances, ascribing these resonances to reaction (2). Hole, Holtsmark, and Tangen[2] found eight sharp resonances between 200 and 500 kv. Tangen,[3] using the same technique as

Curran and Strothers, found resonances in reaction (3) at 290, 314, 336, 388, 430, 451, and 494 kv, and resonances at 222, 310, 392, 417, 492, 508, and 525 kv accompanied by positron activity. Finding the γ-radiation from the strongest of the latter resonances, those at 222 and 417 kv, to have a mean energy of 1.5 Mev or less, he concluded that these resonances probably belong to reaction (1).

To solve this problem targets of separated Mg isotopes have been prepared in the isotope separator of the Nobel Institute in Stockholm,[4] and exposed to protons from the 500 kv van de Graaff machine of the University of Oslo. The thickness of the targets was about 35 μg/cm^2 Mg^{24}, for Mg^{25} and Mg^{26} the isotopic quantities corresponded to twice the amount of Mg^{24}. The targets were bombarded for 20 sec., giving saturation intensity of the positron activity, and the positrons escaping through a thin window in the target tube were counted for 15 sec. with a thin-walled G-M tube. As the proton current at present does not exceed 2 μA, only the strong resonances at 222 and 417 kv could be investigated. Positron activity corresponding to these resonances was found only on the Mg^{24} target, showing that the reaction $Mg^{24}(p, \gamma)Al^{25}$ is that actually taking place. Of course, there may also be resonances yielding positrons from the Mg^{25} reaction, such as suggested by Curran and Strothers.

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Pd Film Fast Neutron Detector

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PRELIMINARY information has been obtained on resistance variations of a palladium film fired on a ceramic core due to recoil-proton bombardment. In view of the large magnitude of resistance changes, it is proposed here that this resistor might be employed to measure the energy absorbed per gram of tissue as a result of fast neutron flux, after L. H. Gray.[1] The resistors which have been exposed this far were manufactured by Continental Carbon, Inc., according to a process described in "Printed Circuit Techniques."[2] Through the courtesy of Dr. J. W. Jira, of Continental Carbon, resistors with exposed palladium films were obtained before the protective coats of vitreous enamel and paint were applied. One of these resistors was coated with paraffin and placed in an-air-cooled hole in the Oak Ridge pile. A fifteen-hour exposure at full power reduced the resistance from 48,300 to 234 ohms. A similar resistor in a chamber evacuated to approximately nine microns showed a resistance change of from 51,000 to 252 ohms within two minutes after 44 centimeters of hydrogen were applied to the system. The resistors were maintained at approximately room temperature during both the proton-recoil and hydrogen gas experiments.

Another resistor of the same type was placed in a stream of nitrogen within an oven which was brought to 900°C, and then allowed to cool. Again the resistance change was approximately from 50,000 to 200 ohms.

The resistance film initially has a dull gray appearance, and a negative temperature coefficient of resistance, indicating the presence of palladium oxide, but, after the resistance has been reduced by any one of the three treatments described above, the film is bright and shiny and the temperature coefficient of resistance is positive. This would suggest that the oxide has been reduced to the metal. The surface of the film is rough as seen under a low power microscope, both before and after the resistance has been reduced. It is doubtless important to the mechanism that palladium itself is a reducing catalyst, and can also occlude large quantities of hydrogen.

This phenomenon was first observed in the fall of 1947 at Argonne National Laboratory, when NEPA conducted radiation damage tests on electronic components under the direction of Mr. E. S. Bettis and Dr. E. R. Mann. In these tests, and again recently at the Oak Ridge pile, the vitreous enamel covered palladium film resistors of Continental Carbon were exposed in jackets of paraffin, polystyrene, graphite, cadmium, and aluminum. The resistance decreased substantially in the case of the hydrogenous covered resistors, sometimes to 4 percent of the initial value. The agreement in the results between resistors of the same value exposed under identical conditions was poor, and it seems probable that this was due to variations in the thickness of the protective vitreous enamel. Under the same bombardment the resistors covered with graphite, aluminum, and cadmium did not suffer an appreciable change in resistance.

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Nuclear Induction Due to Free Larmor Precession*

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IN the study of transient and steady state phenomena concerning nuclear magnetic resonance it is well known that the nuclear magnetic moment possesses a flipped spin state having a phase memory of the order of T_2, the total relaxation time, which ranges from $\sim 10^{-5}$ to a few seconds in various substances. On the basis of this property Bloch[1] has pointed out that one can expect to obtain a nuclear induction signal in the absence of an applied r-f field after having suddenly perturbed the spin ensemble by the application of an r-f field pulse of short duration at the resonance condition $\omega = \omega_0 = \gamma H_0$. ω is the applied r-f angular frequency, γ is the gyromagnetic ratio, H_0 is the large d.c. magnetic field applied to a given ensemble of spins, and ω_0 designates the natural Larmor frequency of this ensemble. Directly following the removal of the pulse a resultant component of nuclear magnetization M_{xy} will remain the xy plane perpendicular to the large field H_0, which formerly established this magnetization in the z direction at thermal equilibrium. An inductive coil with its axis in the xy plane first provides the pulse, and thereafter has induced in it a nuclear induction r-f voltage as a consequence of the free Larmor precession of the magnetic moment M_{xy}.

Reported here is an experiment which displays this effect using conventional r-f techniques for providing r-f pulses and amplifiers capable of fast response in conjunction with typical nuclear induction apparatus. Only a single LC tuned circuit is essential for