Radioactive Tin 111

R. A. HINSHAW* AND M. L. POOL
The Ohio State University, Columbus, Ohio
(Received April 13, 1949)

A radioactive isotope of a half-life of 35.0±0.5 minutes has been found in the tin fraction of cadmium bombarded with alpha-particles. Using electromagnetically enriched cadmium the assignment can be made to Sn 111. Positrons of 1.45 Mev and x-rays are observed.

A 20-MINUTE tin activity has been reported[1] resulting from indium bombarded with protons. Positron emission was observed and the assignment was made to Sn^{113}.

Alpha-particle bombardment of cadmium has yielded a 25-minute tin activity.[2] Negative particle emission was reported, however; and the assignment could possibly be made to Sn^{113} also. The 105-day tin activity[3] which decays by K-electron capture is known to be due to Sn^{113}.

In so far that a short lived activity is strongly indicated in the light mass numbered isotopes of tin, it was thought that a positive identification could be made with the aid of electromagnetically separated isotopes.

The chemical identification of the activity is readily established by obtaining the tin chemical fraction from cadmium metal bombarded with 20 Mev alpha-particle. Hilger Lab. No. 10,677 of 99.9999 percent purity was used. The tin fraction was placed in a magnetic field and a Geiger counter was so located as to intercept either positrons or electrons.[4] The positron decay curve is shown in Fig. 1. Upon subtraction of longer period positron activities a new 35.0±0.5 minute activity was found.

Similar bombardments were made with stable isotopes of electromagnetically separated cadmium 106, 108 and 110 enriched to 32.9, 24.8 and 70 percent respectively.** The samples were mounted in sets of two on opposite sides of a rotating internal probe and thus given very nearly identical alpha-particle bombardments. The results showed that the activity was clearly obtained from the Cd^{108} isotope but not from the Cd^{106} or Cd^{110} isotopes. The assignment of the 35-minute activity is thus made to Sn^{111}.

Figure 2 shows a curve of the aluminum absorption measurements of the total activity of the tin fraction.

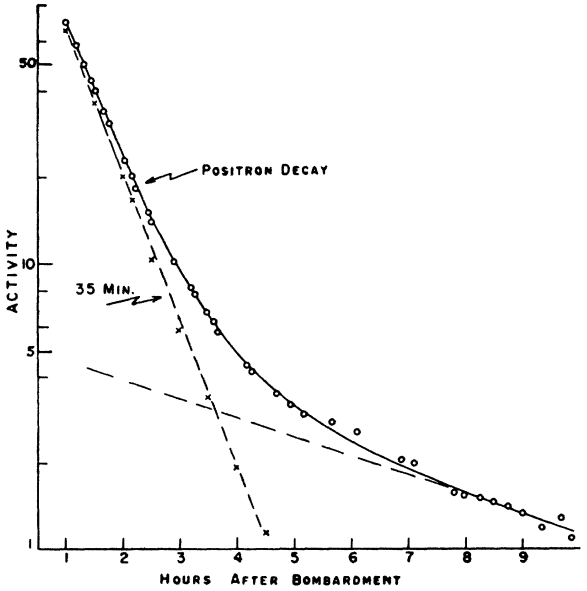

FIG. 1. Decay curve of the tin fraction of cadmium bombarded with 20 Mev alpha-particles.

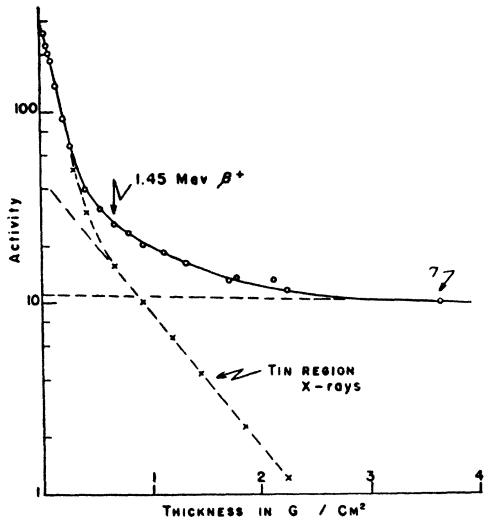

FIG. 2. Aluminum absorption curve taken in the 35.0-minute period of the tin fraction from an alpha-particle bombardment of cadmium. The positron end-point is 1.45 Mev. X-rays in the tin region are also indicated.

* Now at Muskingum College, New Concord, Ohio.

[1] S. W. Barnes, Phys. Rev. **55**, 241 (1939).

[2] J. J. Livingood and G. T. Seaborg, Phys. Rev. **55**, 667 (1939).

[3] S. W. Barnes, Phys. Rev. **56**, 414 (1939); K. D. Coleman and M. L. Pool, Phys. Rev. **72**, 1070 (1947).

[4] L. L. Woodward and D. A. McCown, Rev. Sci. Inst. **19**, 823 (1948).

** Supplied by the Y-12 plant, Carbide and Carbon Chemicals Corporation through the Isotopes Division, U. S. Atomic Energy Commission, Oak Ridge, Tennessee.

During the time that the activity was in the 35-minute period the measurements were taken on a Wulf electrometer attached to an ionization chamber.

A beta-end point of 0.68 g/cm^2 was found corresponding to about 1.45 Mev. Evidence is also seen for the presence of x-rays of an absorption coefficient characteristic of the tin region. The ratio of K-electron process, as suggested by the x-rays, to the positron decay process is about 26.

Acknowledgment is gratefully made for support received from the Ohio State University Development Fund and the Graduate School. The chemical separations were performed by H. L. Finston and R. M. Dyer. E. C. Mallary kindly helped in taking some of the data.

PHYSICAL REVIEW VOLUME 76, NUMBER 3 AUGUST 1, 1949

A Note on Perturbation Theory as Applied to Collision Stimulated Processes

JAMES N. SNYDER* AND W. H. FURRY
Department of Physics, Harvard University, Cambridge, Massachusetts

(Received April 4, 1949)

If a particle which can decay spontaneously is subjected to collisions with other particles the transition probability may be changed. The calculation of such an effect by the usual time-dependent perturbation methods is complicated by the circumstance that energy can be conserved in some intermediate states, because of the possibility of elastic scattering. The perturbation calculation is here modified in such a way that the resulting expression for the whole transition probability does not contain any divergences or spurious effects. By suitable approximations the expression is separated into two parts, one of which gives the probability of elastic scattering followed by a spontaneous transition, and the other the true stimulated transition probability which causes a change in the lifetime.

I. INTRODUCTION

IF a particle which is subject to decay suffers a collision with another particle, it is conceivable that its lifetime will be altered. Such a process is exemplified by a meson interacting with a nucleon, for which the stimulated lifetime has been calculated.[1]

Such a stimulated decay is a three-step process, the collision accounting for two steps, and the decay, the third. If the collision be viewed as absorption and reemission, and standard time dependent perturbation theory[2] be applied, the result for the transition probability per unit time, $w_{f\leftarrow i}$ is

$$w_{1\leftarrow i}=2\pi/h|H_{fi}|^2\rho_f, \tag{1}$$

where ρ_f is the density of final states, and

$$H_{fi}=\sum_{I\,II}\frac{H_{fII}H_{II\,I}H_{Ii}}{(E_i-E_{II})(E_i-E_I)}. \tag{2}$$

Here the H's are the matrix elements connecting the initial, first intermediate, second intermediate, and final states, and the E's are the energies of these states.

To calculate the stimulated decay of the incident particle it is necessary to integrate $w_{f\leftarrow i}$ over a set of variables describing the final state. Since momentum is conserved at every step of such a process, the energy of the second intermediate state, E_{II}, could be chosen as one of these variables. If this is done it is seen that the integrand (1) has a quadratic divergence at $E_{II}=E_i$. The origin of this difficulty is simply that energy *could* be conserved in the second intermediate state as well as in the final state. This corresponds to an elastic scattering of the particle followed by its spontaneous decay.

This divergence difficulty can be circumvented by re-examining the development of (1)–(2) and retaining those terms which are negligible in ordinary problems ($E_I, E_{II}\neq E_i$) but are important here. These are the boundary terms which arise at each step in the calculation of the probability amplitudes of the intermediate states, since all amplitudes except that of the initial state are required to vanish initially. If this is done the transition probability becomes

$$P_{f\leftarrow i}(t)=\sum\int\cdots\int dE_{II}dE_f\cdots\rho_f$$
$$\times\left|\frac{e^{i(E_f-E_i)t/\hbar}-1}{E_i-E_f}\sum_{I\,II}\frac{H_{f\,II}H_{II\,I}H_{I\,i}}{(E_i-E_{II})(E_i-E_I)}\right.$$
$$\left.-\sum_{I\,II}\frac{e^{i(E_f-E_{II})t/\hbar}-1}{(E_{II}-E_f)(E_i-E_{II})}\frac{H_{f\,II}H_{II\,I}H_{I\,i}}{(E_i-E_I)}\right|^2, \tag{3}$$

where the sum and integrals are to be performed over the variables of the final state; only the pertinent E_f and E_{II} integrals are shown. This integrand does not suffer from any singularity at $E_{II}=E_i$. But this line of attack is immediately precluded by the fact that (3)

* Now at Department of Physics, University of Illinois, Urbana, Illinois.

[1] W. H. Furry and J. N. Snyder, Phys. Rev. **75**, 1265 (1949).

[2] See W. Heitler, *The Quantum Theory of Radiation*, (Oxford University Press, London, 1944) Second Edition.