The Disintegration of I^{128}

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The β- and γ-radiations of the 25-min. activity of I^{128} have been investigated by means of a β-spectrograph and a special technique for the γ-determination. The disintegration is shown to be complex. The main transition (93 percent) occurs to the ground level in X^{128} with the release of 2.02-Mev energy. A faint γ-ray of 0.428 Mev is found, corresponding to an excited level in X^{128}.

IF iodine is irradiated with slow neutrons, an activity with the half-life of 25 min. is produced. As this element has only one stable isotope with the mass number 127, the activity must be assigned to I^{128}. The active isotope is quite easily obtained and, in spite of its somewhat short half-life, has frequently been used in tracer work. For this and other reasons it is of importance to acquire exact knowledge of the disintegration.

The half-life has been accurately determined by Hull and Seelig,[1] who found the value 24.98 ± 0.02 min. Some disagreement seems to exist concerning the occurrence of a γ-radiation. Thus Bacon, Grisewood, and van der Merwe[2] obtained with the Wilson chamber technique a highly complex β-spectrum with upper limits 1.05 and 2.10 Mev. However, they were unable to detect any γ-radiation. Livingood and Seaborg,[3] by means of absorption measurements, estimated the γ-radiation to have the energy 0.4 Mev. On the other hand, Roberts and Irvine,[4] with the aid of γ-sensitive GM counters, could detect no γ-radiation in the order of 0.1 γ-ray per β-ray.

500-ml ethyl iodide was irradiated with slow neutrons from the 32″ cyclotron of this institute for about one hour. The active iodine was extracted by shaking the ethyl iodide with an aqueous solution of sodium bisulphite and potassium carbonate and was then precipitated as Ag I. Preliminary experiments showed that the active sample emitted a very faint γ-radiation of small energy. The half-life of the γ-radiation was about 25 min. and could thus be attributed to the I^{128} isotope.

Since the previous investigations diverged rather strikingly as regards both the energy limit and the form of the β-spectrum, we found it advisable to make a new determination of the spectrum with the more accurate β-spectrograph technique. The active powder was spread out over an area of $\phi = 8$ mm on a thin zaponlac foil (0.5μ) which was suspended over a circular ebonite frame, the diameter of which was 2 cm. The powder was covered with 0.1μ zaponlac foil. The sample could be quickly brought into the spectrograph by means of a lock device. The β-spectrograph, which is of the lens type with a high transmission factor, will be described elsewhere.[5]

Figure 1 shows the β-spectrum obtained. The appearance of the spectrum shows no definite complexity owing to its rather symmetric form. For the purpose of obtaining the most accurate upper limit of the spectrum, the Fermi diagram is given in Fig. 2. The diagram is slightly curved, partly owing to the fact that the amount of substance was not of negligible weight. The value of E_{max} from this curve is 2.02 Mev.

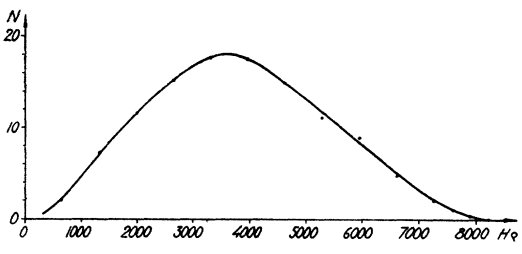

FIG. 1. The β-spectrum of I^{128}.

[1] D. E. Hull and H. Seelig, Phys. Rev. **60**, 553 (1941).
[2] R. H. Bacon, E. N. Grisewood, and C. van der Merwe, Phys. Rev. **59**, 531 (1941).
[3] G. T. Seaborg and J. J. Livingood, Phys. Rev. **54**, 775 (1938).
[4] A. Roberts and J. W. Irvine, Phys. Rev. **53**, 609 (1938).
[5] Kai Siegbahn, in print.

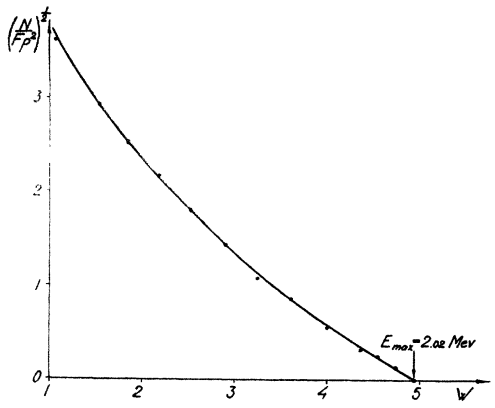

FIG. 2. The Fermi plot of I^{128}.

In the preliminary absorption measurements the existence of a weak γ-radiation was established. To obtain more precise information about the energy of the γ-radiation a measurement was made by means of the photo-Compton method. The photo- and Compton electrons expelled from a suitable radiator in which the sample was placed were investigated in the lens spectrograph. The radiator consisted of a cylindrically formed copper cap ($\phi=8$ mm, $l=6$ mm), the wall thickness of which was sufficient to absorb completely the β-spectrum. In front of the copper cap a Pb foil of 0.1 mm was placed. Owing to the faintness of the γ-radiation a large amount of active sample had to be used. Nevertheless, the whole activity amounted to only about 0.5μC Ra γ-equivalence.

The distribution of the secondary electrons thus formed is shown in Fig. 3. To give an impression of the sensitivity of the method the number of impulses per min. in the GM counter is plotted along the ordinate axis instead of the intensity ($P/H\rho$). In the figure may be seen a continuous distribution with a small drop in intensity before a pronounced peak. This continuous distribution is due to the Compton effect in the copper.

The high peak is explained by the K-photo-effect in the lead foil and the lower peak is the corresponding L-photo-line. Obviously we are concerned here with only one γ-line. The energy of this is obtained with good accuracy from the K-photo-line by adding the K-binding energy in Pb (0.088 Mev) to 0.340 Mev. As an effective check on this result the same γ-energy can be determined from the L-photo-line. By adding the L-binding energy (0.016 Mev) to the energy of this photo-line we obtain $E\gamma=0.429$ Mev, which gives strong evidence of the correctness of the value calculated above for the γ-energy. The search for other γ-lines with higher energies than this gave negative results.

The presence of this γ-ray requires a complexity in the β-spectrum. Since the γ-radiation is of small intensity, its emission in cascade with a simple β-transition is eliminated.

The usual method of determining the relative intensities of the β-transitions is impracticable here. This is caused by the fact that the two β-components differ only slightly in energy. The accurate resolution of the Fermi curve into two components is still more complicated by the small magnitude of the β-component of lower energy.

The degree of complexity was therefore determined in another way.

If two I^{128} samples, the relative intensities of which are known, are measured under the same geometrical condition, one with a β-counter and the other with a γ-counter, the number of γ-quanta per electron can be determined, provided that the net efficiency factor of the counter for the γ-energy concerned is known. This factor can be determined by making an analogous measurement with an active isotope, where a γ-radiation of the same energy is emitted in a known proportion to the β-radiation. This is the case[6] with Au^{198} where the β-spectrum is known

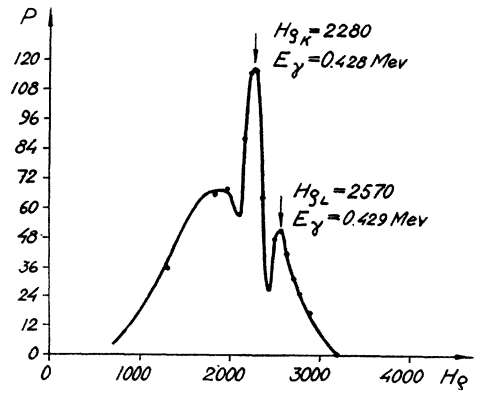

FIG. 3. Secondary electrons expelled from a radiator by the faint γ-radiation of I^{128}.

[6] Kai Siegbahn, "Slow neutron-induced activity in Au," Proc. Roy. Soc. (1946), in print.

to be followed by a γ-ray of $E\gamma = 0.401$ Mev in cascade, i.e., about the same energy as for I^{128}

We first measured the γ-intensity from a large amount of active I^{128} in a standard arrangement. A small accurately known part of the total sample was allowed to decay for a period sufficiently long to give an activity that could be measured in the β-counter in the same arrangement. The time for the decay was measured. This permitted a recalculation of the activity to the same time as employed in the γ-intensity investigation. The net efficiency factor for the γ-counter was then determined by placing a thin activated Au foil in the same standard arrangement. The results of these measurements showed that 7 γ-quanta were emitted per 100 β-particles.

The disintegration scheme for I^{128} may now be obtained from the results of the above determinations of the β- and γ-components. The term scheme is uniquely established as shown in Fig. 4. The partial half-lives t_1 and t_2 for the two transitions are 21,400 and 1600 sec., respectively. Following the notation of Konopinski[7] the corresponding ft-values may be calculated. We then find $(ft)_1 = 4.1 \times 10^6$ and $(ft)_2 = 0.78 \times 10^6$. Both transitions must evidently be placed in the $1B$-group, which means that they are both forbidden and of the same order, i.e., the first.

By using the selection rules for the β-decay proposed by Gamow-Teller[8] some information may be gained concerning the spins and parities of the various levels. X^{128} contains an even number of protons and neutrons and the ground state may therefore be assumed to have zero spin and even parity. A first forbidden transition

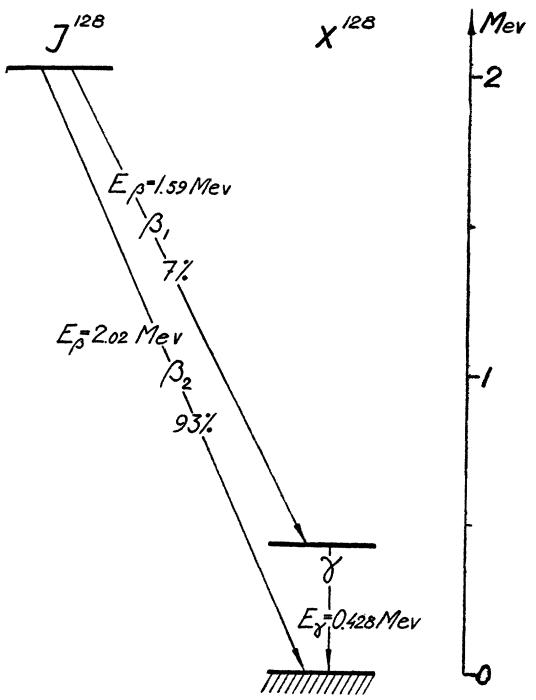

FIG. 4. The term scheme for the disintegration of I^{128}.

is accompanied by a parity change; consequently the ground state in I^{128} must have odd parity and the excited state in X^{128} even parity. The spin relations cannot be so uniquely established. According to the selection rules I^{128} may have spin = 1 or 2 while the spin in the excited state of X^{128} may be 0 or 1 or 2. The spin 0 of the latter level would imply a γ-transition to the ground level with a spin change $0 \rightarrow 0$. This is highly forbidden and should give a very high coefficient of internal conversion. Since this is not the case, we can exclude this possibility.

[7] E. Konopinski, Rev. Mod. Phys. **15**, 209 (1943).
[8] G. Gamow and E. Teller, Phys. Rev. **49**, 895 (1936).