Beta-Rays of High Energy

The primary β-rays of a radioactive substance form, in general, a continuous spectrum with a definite upper limit to the energy or velocity. Some experimenters, however, using the method of direct magnetic deviation have obtained evidence of the emission of weak bands of much greater average energy. In particular Curie and d'Espine[1] reported in 1925 that radium E emitted a band of β-rays with values of $H\rho$ between 7000 and 10,000 whereas the main spectrum ends in the neighborhood of $H\rho$ 5500.

To test this result, the following experiment was performed. Radium (D+E) was deposited on a watch glass and placed 3 cm below an electroscope lined with cardboard except for the window which consisted of 0.200 Al, 0.200 Al signifying a sheet of aluminum of mass/cm^2=0.200 g. Above the active material was placed 0.200 cardboard +0.212 Pb. The rays coming through this absorber were tested by sheets of graphite (0.85 C) of mass/cm^2=0.85 g. The results are shown in Table I.

TABLE I.

	Absorber	Intensity
1	0.200 Cbd+0.212 Pb+0.200 Al	10.0
2	0.200 Cbd+0.212 Pb+0.85 C+0.200 Al	9.3
3	0.200 Cbd+0.212 Pb+1.70 C+0.200 Al	8.64

With this initial intensity of 10 divisions a minute, the intensity of the β-rays, allowing for absorption was 1,000,000 divisions a minute. In the first absorber the function of the cardboard was to prevent production of x-rays in the lead, of the lead to absorb the γ-rays from the source, and of the aluminum to absorb the characteristic L radiation which is produced in the lead by the γ-rays. This absorber has a total mass/cm^2=0.612 g which is necessary to ensure the total absorption of the β-rays in the main spectrum, permitting at the same time a considerable number of the high energy β-rays to pass through it.

It will be noticed that the first sheet of graphite causes a reduction in intensity of seven percent, as also does the second sheet. The first sheet of graphite is thick enough to absorb all high energy β-rays passing through the first absorber. If any do pass through absorber number 1, then the second sheet of graphite should cause a reduction in intentity of less than seven percent. This is not the case, so that this experiment affords no evidence whatever of the emission of β-rays of high energy from radium E.

We are certain that we could have detected these β-rays quite easily if of the ten divisions a minute due to rays passing through absorber number 1, 0.1 had been due to β-rays of high energy. Assuming for the moment that they have this intensity, it is easy to show that only one β-ray in 2,000,000 disintegrations can be a β-ray of high energy.

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[1] Curie and d'Espine, Comptes rendus **181**, 31 (1925).

The Gamma-Rays of Radium E

As a result of some experiments carried out several years ago by W. J. Henderson and J. A. Gray, the latter came to the provisional conclusion that the γ-rays of radium E were not primary rays but were x-rays excited by β-rays in the atoms from which these β-rays are emitted.

To test this view, some pure radium E was deposited on paper of mass/cm^2=0.0033 g. This source was placed 20 cm from an ionization chamber the window of which consisted of two sheets of cellophane. β-rays were deflected from this chamber by means of a magnetic field, so that only γ-rays or x-rays produced near the source on substances placed close to it, could enter the ionization chamber. The absorption of the γ-rays was first found in aluminum. The first curve obtained could be represented approximately by the equation

$$I=19.3^{-136m}+40^{-31m}+18.4^{-5.22}+22.3^{-0.303m},$$

where m is the mass per unit area of absorbing screen and the numbers such as 136, mass absorption coefficients.

A mass absorption coefficient in aluminum of 136 corresponds to a wave-length of 2.2A and an energy of 5600 ev, so that there is some very soft radiation present. To see whether soft x-radiation was produced in other substances filter paper, aluminum and gold were used. The results obtained with gold of mass/cm^2=0.00328 g are given in Table I, the absorber being aluminum. The

TABLE I.

Absorber (g/cm^2)	Intensity γ-rays	Intensity x-rays	Absorber (g/cm^2)	Intensity γ-rays	Intensity x-rays
0.000	100	100	0.0329	49	47
0.00656	80	77	0.073	34.7	33
0.0164	64.5	66	0.1744	22.6	20
0.0230	57	57	0.294	18.4	16.8

x-ray intensities were found by first placing the foil near the source and then near the ionization chamber and taking the differences of the readings.

The first column shows how the γ-rays are absorbed, the second how the x-rays excited in the gold foil are, and a glance at the figures show that in both cases the rays are of the same type. The intensities are given in arbitrary units, the initial intensity of the x-rays being about 35 percent that of the γ-rays.

We have also examined the x-rays produced in thick foils of cardboard, aluminum, copper, tin and lead and have found that up to a thickness of 2 cm of lead the absorption of the x-rays is almost identical with that of the γ-rays. We conclude therefore that the γ-rays of radium E are really x-rays produced by β-rays in escaping from the atoms in which they are produced. Whether the very soft rays found are due to slow β-rays we are not prepared to say.

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