Rutherford's Discovery of Alpha and Beta Radiation

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I. History leading up to the Discovery of Alpha and Beta Radiation

By 1898, Becquerel had switched his research interests to the Zeeman effect (which was also discovered in 1896, the year of radioactivity's discovery). Ernest Rutherford, a student of J.J. Thomson, decided to begin research into radioactivity. Rutherford (with Thomson) had just completed research concerning the fact that X-rays made gases electrically conducting. Since Becquerel has discovered that his "uranium rays" also made gases conducting, it seemed like a natual evolution of Rutherford's research.

His work would culminate in the winning of the Nobel Prize for 1908, and also lead to his most famous achievement, the theory of the nuclear atom, in 1911.

By the way, Pierre and Marie Curie also began their studies into radioactivity in 1898. Very quickly, they discovered that thorium also acted like uranium. Soon to follow were the discoveries of the new elements polonium and radium. In 1903, they, along with Henri Becquerel, were honored with the Nobel Prize. Marie Curie, in 1911, would be awarded a second Nobel for her continued work.

So, Rutherford begins to work with uranium rays, thinking (along with Becquerel) that uranium rays are very similar to X-rays.

II. The Discovery of Alpha and Beta Radiation

Rutherford used an electrometer to measure an electric current created by the radiation rather than the more crude technique of photograhic plates. Here is the experimental set up reproduced from his 1899 paper:

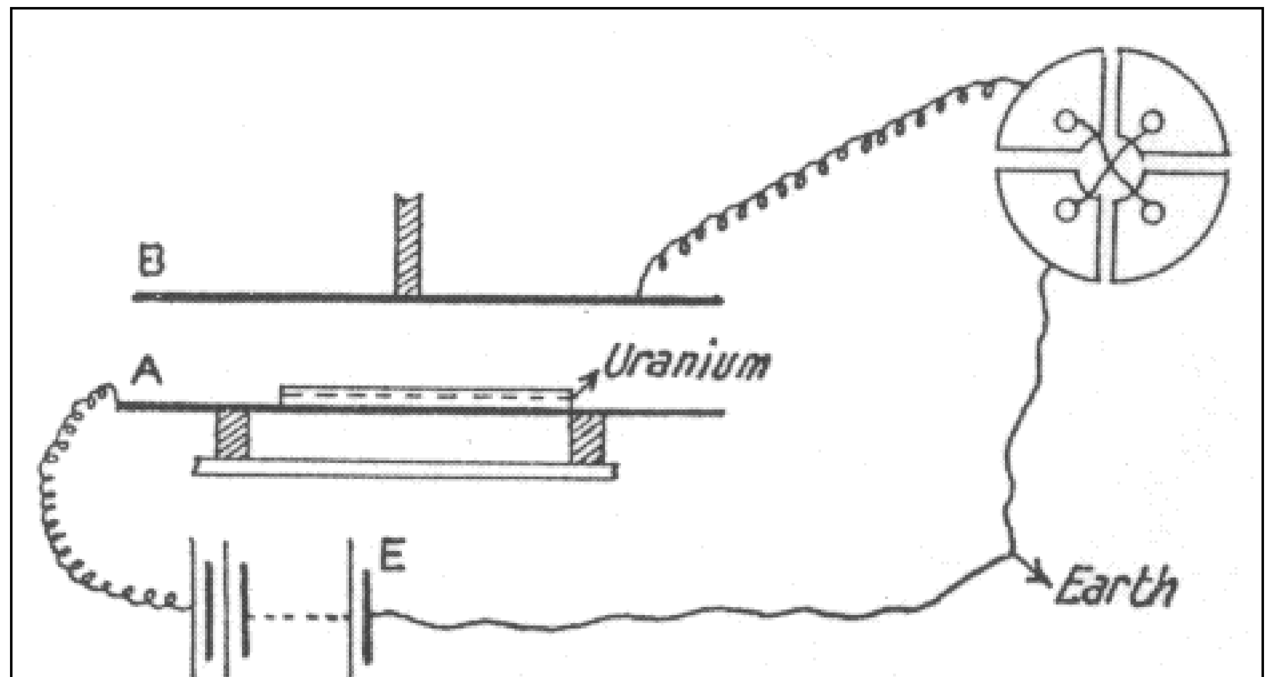

Fig. 1

A uniform layer of powered uranium compound was spread on plate A and the rays allowed to ionize the gas between plates A and B. The amount of ionization is measured by the "saturation current" received at B when the potential difference between A and B is great enough to pull all the ions to the plates before they are able to recombine.

Rutherford then proceeded to cover the uranium with aluminum sheets of various thicknesses and measure the current, using the electrometer. Becquerel had already concluded (by March 30, 1896; more than two years before Rutherford began working in this area) that the uranium radiation consisted of rays which were unequally absorbed, that is to say that the uranium radiation was made of of two or more distinct parts. With his crude photographic plate technique, he could go no farther.

Rutherford was in the process of checking to see if this was true or not, because Becquerel had also made other claims about uranium radiation which turned out to be incorrect. Now, what Rutherford did find was that there were at least two different "rays" being emitted by the uranium and he called them α and β. What led him to this conclusion?

He used this equation:

$$r = \exp(-\lambda d)$$

r is the ratio of "the intensity of the radiation after passing through a distance d of the substance to the intensity when the substance is removed."

A more modern way of expresing this equation is:

$$I = I_o \exp(-\lambda t)$$

I_o being the current with nothing covering the uranium on plate A. I is the current at each thickness, which is called t.

The key value is λ, the coefficient of absorption. If the uranium rays are homogeneous (i.e., made up of only one type of ray), then λ will remain constant as t is increased and I goes down.

This did not happen!! He found that λ stayed constant for a few hundredths of a millimeter of aluminum (or a few centimeters of air) covering the uranium on plate A and then suddently dropped to another value, where it remained as the thickness of the aluminum layer was increased.

So he concluded that there were two (at least) part to the uranium rays. The easily absorbed ones, he named alpha (α) and the more penetrating ones he named beta (β).

Well, I'll bet he was glad to get that done. Now, he could relax and be a stuffy professor the rest of his life. Oh no, not our boy!! Discoveries seems to follow Rutherford around, begging him to be discovered. Rutherford was one of the fortunate ones. Oh, he worked hard, but it almost seems like all he had to do was open the door to his lab and a new discovery would bonk him on the head.

Alpha and beta are discovered to be particles, not rays

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