Antoine Henri Becquerel

On the rays emitted by phosphorescence

[read before the French Academy of Science 24 Feb. 1896 (*Comptes Rendus* **122**, 420 (1896)) translated by Carmen Giunta]
In an earlier session, M. Chairman Henry announced that phosphorescent zinc sulfide placed in the path of rays emanating from a Crookes tube augmented the intensity of rays passing through the aluminum.

Elsewhere, M. Niewenglowski recognized that commercial phosphorescent calcium sulfide emits rays which pass through opaque bodies.

This fact extends to various phosphorescent bodies, and in particular to uranium salts whose phosphorescence has a very brief duration.

With the double sulfate of uranium and potassium, of which I have a few crystals forming a thin transparent crust, I was able to perform the following experiment:

One wraps a Lumière photographic plate with a bromide emulsion in two sheets of very thick black paper, such that the plate does not become clouded upon being exposed to the sun for a day.

One places on the sheet of paper, on the outside, a slab of the phosphorescent substance, and one exposes the whole to the sun for several hours. When one then develops the photographic plate, one recognizes that the silhouette of

negative. If one places between the phosphorescent substance and the paper a piece of money or a metal screen pierced with a cut-out design, one sees the image of these objects appear on the negative.

One can repeat the same experiments placing a thin pane of glass between the phosphorescent substance and the paper, which excludes the possibility of chemical action due to vapors which might emanate from the substance when heated by the sun's rays.

One must conclude from these experiments that the phosphorescent substance in question emits rays which pass through the opaque paper and reduces silver salts.

On the invisible rays emitted by phosphorescent bodies.

[read before the French Academy of Science 2 March 1896 (*Comptes Rendus* **122**, 501 (1896)) translated by Carmen Giunta]
In the previous session, I summarized the experiments which I had been led to make in order to detect the invisible rays emitted by certain phosphorescent bodies, rays which pass through various bodies that are opaque to light.

I was able to extend these observations, and although I intend to continue and to elaborate upon the study of these phenomena, their outcome leads me to announce as early as today the first results I obtained.

The experiments which I shall report were done with the rays emitted by crystalline crusts of the double sulfate of uranyl and potassium [$SO^4(UO)K+H^2O$], a substance whose phosphorescence is very vivid and persists for less than 1/100th of a second. The characteristics of the luminous rays emitted by this material have been studied previously

point out some interesting peculiarities which these luminous rays manifest.

One can confirm very simply that the rays emitted by this substance, when it is exposed to sunlight or to diffuse daylight, pass through not only sheets of black paper but also various metals, for example a plate of aluminum and a thin sheet of copper. In particular, I performed the following experiment:

A Lumière plate with a silver bromide emulsion was enclosed in an opaque case of black cloth, bounded on one side by a plate of aluminum; if one exposed the case to full sunlight, even for a whole day, the photographic plate would not become clouded; but, if one came to attach a crust of the uranium salt to the exterior of the aluminum plate, which one could do, for example, by fastening it with strips of paper, one would recognize, after developing the photographic plate in the usual way, that the silhouette of the crystalline crust appears in black on the sensitive plate and that the silver salt facing the phosphorescent crust had been reduced. If the layer of aluminum is a bit thick, then the intensity of the effect is less than that through two sheets of black paper.

If one places between the crust of the uranium salt and the layer of aluminum or black paper a screen formed of a sheet of copper about 0.10 mm thick, in the form of a cross for example, then one sees in the image the silhouette of that cross, a bit fainter yet with a darkness indicative nonetheless that the rays passed through the sheet of copper. In another experiment, a thinner sheet of copper (0.04 mm) attenuated the active rays much less.

Phosphorescence induced no longer by the direct rays of the sun, but by solar radiation reflected in a metallic mirror of a heliostat, then refracted by a prism and a quartz lens, gave rise to the same phenomena.

seems to me quite important and beyond the phenomena which one could expect to observe: The same crystalline crusts, arranged the same way with respect to the photographic plates, in the same conditions and through the same screens, but sheltered from the excitation of incident rays and kept in darkness, still produce the same photographic images. Here is how I was led to make this observation: among the preceding experiments, some had been prepared on Wednesday the 26th and Thursday the 27th of February, and since the sun was out only intermittently on these days, I kept the apparatuses prepared and returned the cases to the darkness of a bureau drawer, leaving in place the crusts of the uranium salt. Since the sun did not come out in the following days, I developed the photographic plates on the 1st of March, expecting to find the images very weak. Instead the silhouettes appeared with great intensity. I immediately thought that the action had to continue in darkness, and I arranged the following experiment:

At the bottom of a box of opaque cardboard I placed a photographic plate; then, on the sensitive side I put a crust of the uranium salt, a convex crust which only touched the bromide emulsion at a few points; then, alongside, I placed on the same plate another crust of the same salt but separated from the bromide emulsion by a thin pane of glass; this operation was carried out in the darkroom, then the box was shut, then enclosed in another cardboard box, and finally put in a drawer.

I did the same with the case closed by a plate of aluminum in which I put a photographic plate and then on the outside a crust of the uranium salt. The whole was enclosed in an opaque box, and then in a drawer. After five hours, I developed the plates, and the silhouettes of the crystalline crusts appeared in black as in the previous experiments and

the crust placed directly on the emulsion, there was scarcely a difference in effect between the points of contact and the parts of the crust which remained about a millimeter away from the emulsion; the difference can be attributed to the different distance from the source of the active rays. The effect from the crust placed on a pane of glass was very slightly attenuated, but the shape of the crust was very well reproduced. Finally, through the sheet of aluminum, the effect was considerably weaker, but nonetheless very clear.

It is important to observe that it appears this phenomenon must not be attributed to the luminous radiation emitted by phosphorescence, since at the end of 1/100th of a second this radiation becomes so weak that it is hardly perceptible any more.

One hypothesis which presents itself to the mind naturally enough would be to suppose that these rays, whose effects have a great similarity to the effects produced by the rays studied by M. Lenard and M. Röntgen, are invisible rays emitted by phosphorescence and persisting infinitely longer than the duration of the luminous rays emitted by these bodies. However, the present experiments, without being contrary to this hypothesis, do not warrant this conclusion. I hope that the experiments which I am pursuing at the moment will be able to bring some clarification to this new class of phenomena.

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