On the Invisible Radiations Emitted by the Salts of Uranium

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1. Action on Electrified Bodies

At one of the sessions of the Academy, I announced that the invisible radiations emitted by the salts of uranium possessed the property of discharging electrified bodies. I have continued the study of this phenomenon by the use of Hurmuzescu's electroscope and I have been able to establish, in another way than [the work] I have done by photography, that the radiations in question penetrate various opaque substances, in particular, aluminium and copper. Platinum exhibits an absorption considerably greater than that of the two preceding metals.

If we follow the progressive approach of the gold leaves of the electroscope during the discharge, we discover that for deflections which do not exceed 30^{circ} the angular variations are very clearly proportional to the time, so that the speed of approach, or the fraction of a degree through which the gold leaves approach each other in one second, can give an idea of the relative intensity of the active radiations. I shall report here only the numbers relating to the absorption through a plate of quartz, perpendicular to the axis., 5 mm thick. The speeds are expressed in seconds of arc and in seconds of time.

A lamella of the double sulfate of uranium and potassium placed below the gold leaves dissipated the charge of the electroscope with a speed represented by 22.50. The interpositions of the plate of quartz reduced the speed to 5.43. The ratio of the two numbers is 4.15.

I have investigated whether the radiations emanating from the phosphorescent wall of a Crookes tube were weakened by the same quartz plate in a ratio of the same order of magnitude. A Crookes tube was arranged alongside the electroscope, opposite one of the faces of the lantern in which the glass had been replaced by a sheet of aluminium 0.12 mm thick. In front of this sheet was placed a screen of copper pierced with a circular hole 15 mm in diameter. The radiations which passed through the copper were sufficiently weakened to give a negligible effect in the present experiment. When the Crookes tube was excited by an induction coil, the gold leaves of the electroscope rapidly approached each other, about 1° in 1.4 sec., corresponding to a speed of 2571.4 if expressed in the units adopted above.

When the quartz plate closed the circular opening, the speed of the fall of the gold leaves became 163.63, or 15.7 times smaller.

The weakened is nearly four times greater in the second case than in the first, but it is of the same order of magnitude. That is the only point which this experiment demonstrates. The observations is not contrary to the probable hypothesis which would attribute the difference to this: that the rays emitted by the uranium salt and the rays emitted by the tube or by the phosphorescent glass do not have the same wave lengths; but the different conditions of the two experiments permit no assurance of this heterogeneity.

The electroscope has also made it possible to demonstrate the small difference between the emission from a lamella of uranium salt kept eleven days in the dark and the emission from the same lamella brilliantly illuminated by magnesium. In the first case, the speed of the fall of the leaves was 20.69, and after the excitation by light it became 23.08.

It is not known what becomes of the electric charges dissipated in this way, as through dielectrics became conductors while being traversed by these radiations. Experience has been shown that a crystalline lamella, suitably insulated, did not become charged as it discharged the electrometer. In addition, a lamella standing for a long time in the presence of the apparatus communicated no charge to it.

2. Emission by Various Salts of Uranium. Persistence. Excitation.

If the phenomenon of the emission of invisible radiations which we are studying is a phenomenon of phosphorescence, it should be possible to demonstrate its excitation by definite radiations. This study is made very difficult by the prodigious persistence of the emission when the substances are kept in darkness, shielded from luminous radiations or from the invisible radiations whose nature we know. At the end of more than fifteen days, the salts of uranium still radiations which are nearly as intense as on the first day. When on the same photographic plate, above black paper, we arrange a lamella held for a long time in darkness and another which has just been exposed to daylight, the impression of the silhouette of the second is a little stronger than that of the first. The light of magnesium under the same conditions produced only an imperceptible effect. If lamella of the double sulfate of uranium and potassium are vigorously illuminated by the electric arc or by brilliant sparks from the discharge of a Leyden jar, the impressions are considerably blacker. The phenomenon then appears really to be a phenomenon of invisible phosphorescence but does not seem to be intimately linked with visible phosphorescence of fluorescence. Indeed, although the salts of the sesquioxide of uranium are very fluorescent, we know that the green uranous salts, whose curious properties of absorption I have had occasion to study, are neither phosphorescent nor fluorescent. Now, uranous sulfate behaves like uranic sulfate, and emits invisible radiations which are equally intense.

I shall report still another interesting experiment. It is known that uranium nitrate ceases to be either phosphorescent or fluorescent when is solution or melted in its water of crystallization. I then took a crystal of this salt and, after having placed it in a little tube closed by a thin plate of glass, I warmed it in darkness, managing to avoid even the radiations from the alcohol lamp that heated it. The salt melted, I let it crystallize in darkness and I then placed it on a photographic plate wrapped in black paper, protecting the salt always from the action of light. One might have expected to observe no effect, since all luminous excitation had been avoided from the moment when the substance ceased to be phosphorescent. Nevertheless the impression was as strong as for salts exposed to the light, and, at the points where the salt adhered to the glass plate, the impression was stronger than that of a fragment of uranic sulfate placed for comparison on the same plate.

On this same photographic plate there were other crystals of uranium nitrate resting with different faces on glass slips, for which the effects were substantially the same.

I also arranged some continuous surfaces, of uranic sulfate and also of the double uranium–potassium sulfate, and on these surfaces I projected the spectrum of the electric arc through an apparatus of quartz. The ultraviolet excitation bands were very sharply traced by fluorescence, but, when I reproduced the silhouette of these surface on a photographic plate, the silhouette had become almost uniformly black,indicating either that the characteristic emission of the substance masked the weak differences which might have been observed for the different regions excitation, or that the excitation did not take place in the region of the spectrum projected on the surface studied.

3. Absorption by Various Substances

It is very easy to make a qualitative study of the absorption by various substance of the radiations with which we are concerned by arranging on the same photographic plate, sheets of these substances or little flat tubes full of liquids and by covering these with a lamella of the double uranium–potassium sulfate or by any other salt of uranium.

Using various substance at thicknesses differing little from 2 mm, I discovered that water was very transparent; most of the solutions, even solutions of metallic salts, copper nitrate, gold chloride, uranium nitrate, an alcoholic solution of chlorophyll, behaved as sufficiently transparent; it was the same with paraffin and modeling wax; uranium glass was more opaque, as was a red–colored glass, aluminium at this thickness is hardly transparent, tin is more opaque, and a blue cobalt glass was more opaque than the preceding metals.

In another series of experiments I arranged various crystals, and various optical combinations, intended to exhibit the phenomena of double refraction and polarization. The images obtained were too weak for me to give any results today; nevertheless, it was discovered that quartz absorbs more of these invisible radiations than does Iceland spar; native sulfur behaved as if transparent.

Finally, the experiments in air and in the rarefied air I mentioned at the end of my last Note, without giving very notable differences, show plainly that the negatives in the rarefied air are a little stronger, which would demonstrate an absorption by the air.

4. Refraction

The facts I mentioned in my last Note provide evidence for refraction by glass. To these experiments the following may be added: on one of the faces of a crown glass prism, a few millimeters from the edge and parallel to it, a little tube of very thin glass was fastened, about 1 mm in diameter and filled with crystalline uranium nitrate, forming a line source for the emission of invisible radiation.

The other face of the prism was set on a photographic plate. When the plate was developed three days later, a diffuse impression was seen below the base of the prism, an impression separated from the trace of the edge by a white line, whose displacement is of the order of magnitude of that obtained under the same conditions with light. The tremendous decrease in luminous intensity when the sources were removed a little from the photographic plate has so far not permitted any measurements of the index of refraction.

5. Anomalies Presented by Various Substance

Uranium salts emit invisible radiations with a remarkable constancy, but it is not the same with other phosphorescent substances.

I had obtained with calcium sulfide results of the same order as those which the salts of uranium give, and in my last note I mentioned a negative of remarkable intensity made through 2 mm of aluminium. The same phosphorescent material placed on a second photographic plate under the same conditions displayed no activity, and since then I have not succeeded im obtaining any images with calcium sulfide. I have had the same lack of success with pieces of hexagonal blende of various origins. I then attempted to transmit a new activity to these substances by various known procedures. I heated them in the presence of the photographic plate without heating the latter, and I obtained no impression. In another series of experiments, the various substances were chilled to $-20°$, excited by daylight and the light of magnesium, then placed on the photographic plate; only the salts of uranium gave any images.

Finally, I excited the sulfides and the hexagonal blende by sparks from the discharge of a battery, and the substances (which become vividly phosphorescent) still displayed no activity through black paper. In the course of these experiments I learned that our eminent colleague, M. Troost, had observed a similar effect. Very old specimens of hexagonal blende, which had given him energetic results at first, had later given progressively decreasing results, then had become inactive. Here is a curious fact for which further experiments will perhaps give us the explanation.