



On the propagation of electromagnetic waves in ice, and on the dielectric power of this substance

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the time of adjustment or distribution of energy among the degrees of freedom should not extend to long periods.

The difficulties connected with any considerable increase in the duration of the experiments will undoubtedly be great, as it will be necessary to maintain the temperature so very uniform; but we hope shortly to attack the problem again from this point of view.

I am, Gentlemen,
University College, Bristol,
November 12, 1894.

Yours obediently,
A. P. CHATTOCK.

ON THE PROPAGATION OF ELECTROMAGNETIC WAVES IN ICE,
AND ON THE DIELECTRIC POWER OF THIS SUBSTANCE. BY
M. BLONDLOT.

In a previous note (*Comptes Rendus*, July 25, 1892) I enunciated the following proposition:—The length of the waves which an electromagnetic oscillation can emit is the same whatever be the insulating medium in which the experiment is made; in other words, the wave-length depends on the oscillator alone, just as in acoustics the wave-length of a pipe depends only on the length of the pipe.

The confirmatory experiments described in the Note cited referred to oil of turpentine and to castor-oil; the law holds perfectly for both these substances, and everything leads to the belief that this will be the same for other dielectrics.

There is, however, a doubt about ice, in consequence of the exceptional properties ascribed to it. The experiments of M. Bouty (*Comptes Rendus*, March 7, 1892) show in fact that ice has a dielectric power of 27, that is to say incomparably greater than that of all other substances. Suspecting that the law relative to the propagation of waves might not apply to a dielectric so different from the others, I resolved to submit the question to experiment.

For these investigations I availed myself of the intense and prolonged frosts of the winter of 1892–93. M. M. Dufour has helped me in carrying them out, which the rigour of the cold rendered difficult and even painful. I thank him for his extreme kindness on this occasion.

The method which I adopted was the following, which, with slight modifications necessitated by the solid character of the dielectric, is the same as that I used in the case of turpentine and castor oil.

Electromagnetic waves were transmitted along two tinned copper wires 2·5 millim. in diameter, stretched horizontally and parallel to each other at a distance of 0·8 metre. A resonator of gilt copper is placed in a fixed position between the wires; the portion of the transmitting wires beyond the resonator is contained in a wooden trough 4 metres in length. The trough being filled with liquid, the position is sought at which a movable bridge must be placed joining the wires beyond the resonator to cause the spark to disappear; the distance from the bridge to the resonator is then

a quarter of the specific wave-length of the resonator; the position of the bridge is accurately noted.

That done, I surround the part of the resonator forming the condenser with a watertight bag of parchment-paper which I fill with distilled water, and then freeze this water; the layer of air is thus replaced by one of ice. Measuring the wave-length afresh, it is found to be considerably greater than in the first experiment, having become $\frac{141}{100}$ of what it was.

The trough is then filled with water which is frozen, and then the position of the bridge for disappearance of the spark is again sought. For this purpose the ice at the distant end of the trough is broken and progressively removed. I ascertained that this position is *exactly* the same as in the first case, when the dielectric was air.

The experiment four times repeated, varying each time the capacity of the condenser, always gave the same result. The position relative to the wave-length is therefore true for ice as well as for other dielectrics. Hence, as shown in my previous Note, Maxwell's relation that the dielectric power is also equal to the square of the refractive index also holds for electromagnetic waves in the case given.

The preceding results, partly unforeseen, led me to determine the dielectric constant of ice, using electromagnetic undulations. The experiment cited above gave all the data necessary for this determination.

For if λ and λ' are the wave-lengths corresponding to a given resonator, working respectively in air and in a substance of dielectric power K , we have

$$\frac{\lambda'}{\lambda} = \sqrt{K}.$$

As stated above, I found

$$\frac{\lambda'}{\lambda} = \frac{141}{100},$$

whence

$$K=2 \text{ in round numbers.}$$

The experiment repeated a dozen times always gave the same result. I consider the relative error does not exceed $\frac{1}{250}$, for the plate of ice was almost entirely free from air-bubbles. According to this, ice does not present exceptional dielectric properties.

It remains to be explained how MM. Bouty and A. Perot obtained values of a totally different order for the dielectric power of ice. In the first place, in M. Bouty's method the charge and discharge were enormously slower than in my experiments. Is it not probable, then, that the physical magnitudes measured by M. Bouty and myself were in themselves very different. In any case we know at present too little about the dielectric properties of bodies to be surprised at the divergences of numbers obtained by two methods so dissimilar, however great they are.—*Comptes Rendus*, October 8, 1894.