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LIV. Motion of atoms in electric discharges

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shows that the greatest rate of decrease of θ after passing the maximum is only $\frac{1}{8}$ of its initial rate of increase.

$$\text{When } \phi = \frac{1}{2}\phi' \text{ or } = 2\phi', \quad \theta = \frac{4}{5}\theta';$$

$$\text{when } \phi = \frac{1}{3}\phi' \text{ or } = 3\phi', \quad \theta = \frac{3}{5}\theta';$$

and if ϕ be further increased beyond $3\phi'$, the rate of diminution of θ will become less and less rapid.

We also notice that the maximum value of θ is inversely proportional to $a h^2$, thus agreeing pretty closely with the results of Prof. Perry's first experiments.

When ϕ is large compared with ϕ' my formula gives approximately

$$\theta = \frac{15w}{16Eha^3\phi}.$$

Owing, however, to our assumption that $a\phi$ is small compared with unity, little value can be attached to this result. It can only hold if the strip is very thin indeed, and $a\phi$ is a small quantity intermediate in order of magnitude between h/a and unity.

Cambridge, September 1890.

LIV. *Motion of Atoms in Electric Discharges.*

By JOHN TROWBRIDGE*.

THE application of spectrum analysis to the measurement of the approach or recession of a star in a direction directly away or directly toward an observer's eye is generally regarded as one of the greatest achievements of modern science. Experiments upon the oscillating discharge of electricity led me to reflect whether the method which has been used in star-observation might not be employed to test the question whether the atoms of the metals of the terminals between which the oscillating discharge passes are conveyed to and fro by the oscillating discharge, or whether they are shaken, so to speak, by the discharge so that they emit to the æther the ripples which appeal to our senses as light and heat. No mention is made here of a convection effect, which would take place too slowly to give a spectroscopic effect.

After I had made the experiments which I will shortly describe, and while I was in doubt whether to publish my results, a paper by Professor J. J. Thomson, director of the Cavendish Laboratory, Cambridge, England, appeared in the

* Communicated by the Author.

August number of the *Philosophical Magazine* (1890), "On the Velocity of the Transmission of Electric Disturbances," which contains the following passage :—

"The very rapid rate with which the electric discharge is propagated through a rare gas compels us to admit that the electricity is not carried by charged atoms moving with this velocity. For if it were, then if the discharge were to take place in air at atmospheric pressure between two parallel plates one centimetre apart, charged to a potential difference of approximately 30,000 volts, the kinetic energy which would have to be communicated to the atoms to make them move with this velocity would be greater than the original potential energy of the charged plates, assuming that the charge on each atom is that deduced from electrolytic considerations."

The unusual dispersion afforded by a Rowland concave grating led me to test this hypothesis in as far as it relates to the question, Are the molecules of metals carried with the oscillations of electricity from terminal to terminal between which the oscillations take place?

A circuit of wire giving a suitable value of self-induction was arranged in connexion with a series of Leyden jars. The time of oscillation was calculated from the well-known formula $t=2\pi\sqrt{LC}$, in which L is the value of the self-induction of the circuit, C the capacity of the Leyden jars. Preliminary examination of the electric spark taken through this circuit with a revolving mirror showed that the discharge was an oscillatory one. Two different values of self-induction were employed. One gave the duration of a double oscillation $t=.0000003$ of a second, the other gave $t=.0000024$ of a second.

If we denote by V the velocity of light, $-\lambda$ and λ wavelengths, S the speed of approach of the atom, we shall have

$\lambda = \left(\frac{V}{V+S} \right)$. The distance across which the oscillations took

place is 6 millimetres. Calculation shows that if the iron atoms were conveyed to and fro between the terminals, a broadening of the iron lines in the spectrum would result which could be readily detected. The broadening might amount to a space equivalent to a whole tenth-metre.

The oscillating spark passed between two iron terminals. One of these terminals was hollow. The hollow terminal was placed in a line perpendicular to the slit of the spectroscop, so that the oscillation of the spark should be toward and away from the slit. If therefore the iron atoms moved to and fro with the oscillations of electricity across the air-gap, a dis-

Oscillations
of spark
perpendi-
cular to slit.

Oscillations
of spark
parallel
to slit.



placement of the iron lines in the spectrum of the metal would result. There would be both a displacement toward the less refrangible end caused by the recession of the atom, and one toward the more refrangible end of the spectrum caused by the approach of the atom. The great amount of dispersion afforded by a concave grating of 20,000 lines to the inch enabled me to easily detect a movement equivalent to a tenth-metre. I accordingly took a photograph of the iron lines with the terminals in the position I have described, and on the same plate immediately above this photograph a comparison photograph was taken with the terminals paral-
lel to the slit. In this case the iron atoms did not make their supposed excursions away and toward the slit, and therefore no displacement of the spectrum-lines was to be expected.

The photographic plate was exposed in the neighbourhood of the great H-lines. A movable shutter enabled me to expose different portions of the same plate without changing any adjustments of the apparatus. The resulting photographs showed no displacement of the iron-lines. The iron-lines in the two photographs met exactly (continued in an unbroken line across the double photograph), and were of the same breadth throughout their extent (see figure).

The conclusion seems to be a strong one that the electrical oscillations do not carry the atoms of metals with them—in spark-discharges. The atom is merely shaken up and caused to emit the vibrations or subsidiary ripples which appeal to our senses as light and heat, while the electrical waves pass on without conveying the atoms.

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LV. *The Greater Influence of First Quantities of Electrolytes on Volta-Electromotive Force.* By Dr. G. GORE, F.R.S.*

IN thermochemical research, Favre and others observed that, on adding equal quantities of water in succession to a fixed amount, either of nitric or sulphuric acid, the quantity of heat evolved was greater with the first than with any succeeding dilution (Watts's 'Dictionary of Chemistry,' vol.iii. p. 310); and similar effects were noticed by J. Thomsen on diluting concentrated hydrochloric, hydrobromic, and hydriodic acids. Nicol has observed that the total contraction of volume of a saline solution increases with the proportion of dissolved salt, and that each successive equivalent weight of the salt produces less contraction. Kohlrausch and others

* Communicated by the Author.