On a Means to determine the Pressure at the Surface of the Sun and Stars, and some Spectroscopic Remarks

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wave-velocity derived from the experiment with the square film, we must reject this latter explanation.

The two experiments may be made to give the same wave-velocity by supposing a change of phase equal to half a period to take place at each reflection. In the first experiment the side of the square has to be taken equal to $\frac{1}{2}$ wave-lengths, and in the second the height of the triangle as equal to $\frac{1}{2}$ wave-lengths. The two expressions for the wave-velocity become $\frac{2}{3} \times \frac{1}{2} \times 92$, and $\frac{2}{3} \times 1 \times 152$, both of which expressions are equal to $33\frac{1}{3}$. Hence we are perhaps justified in inferring that the edges are stationary, and that the wave-velocity in the soap-film is nearly 34 inches in a second.

VII. *On a Means to determine the Pressure at the Surface of the Sun and Stars, and some Spectroscopic Remarks.* By EILHARD WIEDEMANN*.

IN a former paper I tried to show that we can calculate, at least approximately, the time elapsing between two encounters of the molecules of a gas by measuring the greatest difference in the length of path at which interference of two rays of light coming from the same source of light is possible. I may be allowed here to quote a passage out of that paper†:—

“Two rays of light can only interfere if they emanate from the same source of light, and if there is no sudden change of phase in the source of light during the time elapsing between the two instants at which the first and second ray leave the source. That difference in phase at which interference is still possible is therefore a measure of the time during which no sudden change in phase has taken place at the source of light. A luminous body sends out light coming from a great number of atoms or molecules. Each molecule will only vibrate regularly as long as it does not come within the sphere of action of another molecule; that is, it will only vibrate regularly in the time elapsing between two encounters. For the different molecules, the time elapsing between two encounters may, according to the molecular theory of gases, be either zero or

* Read June 12th.

† Wied. Ann. v. p. 503 (1878); Phil. Mag. [5] vii. pp. 79, 80.

infinitely large. But during a very short fixed time only a small number of molecules will have suffered encounters; only that small number will produce an even illumination of the field of view: the greater number will have vibrated regularly during the whole time; and for all of these interference is possible. The interference-bands in that case are sharp. If, however, the time which we consider to elapse between the emanation of the two interfering rays increases, a greater number of molecules will have suffered encounters, and the bands will therefore be less distinct. It follows that the higher the order of interference-bands, the more diffused and indistinct the bands will be. If the difference of phase corresponds to a difference in time greater than that necessary for the completion of the mean free path, the bands will rapidly disappear, as in that case the greater number of molecules have suffered encounters during the time considered."

Fizeau and Foucault, and, more recently, J. J. Müller and Mascart, have determined the greatest difference of path at which interference is possible. According to the last-mentioned observer, a difference in path of 50,000, and even 100,000 wave-lengths still produces appreciable interference-bands in sodium light. The time corresponding to this difference of phase is about 0.5×10^{-10} second. Calculating approximately the mean free path (as we only want to compare the orders of magnitude) for hydrogen at 0° and atmospheric pressure, we find for the time necessary to traverse this free path 1.14×10^{-10} second. The two numbers are sufficiently close to justify the assumption that the sodium atoms may vibrate during 50,000 oscillations without sudden change of phase. We see at the same time that the disappearance of Newton's bands need not be due to the widening of the lines *producing* them.

As the mean time elapsing between two encounters depends chiefly on the pressure, and far less on the temperature, we have a means of determining approximately the pressure of a gas by an examination of the light which it sends out.

The determination of the quantities relating to large difference of paths in the light sent out by the sun, its protuberances, and stars may give us important information on their physical constitution; and I should like to draw the attention of spectroscopists to this point, now that we may soon expect a renewal of the sunspot maximum.

In order to make the measurements, we need only decompose the light we want to examine by means of a spectroscope, separate a ray, which must be as homogeneous as possible, and count the number of Newton's rings visible between two adjustable pieces of glass. We might also determine the thickness of a plate of Iceland spar which still shows interference-bands if it is placed between two Nicol's prisms. The plate must be cut parallel to the axis; and particular attention must be paid to its homogeneity.

The spectroscopic evidence hitherto has only related to the presence of a substance in the sun; and we only derive from it very general notions as to the physical state. The radiation of heat is, as Janssen has recently again had occasion to observe, a very complicated phenomenon. We must take account of all the different layers on the sun's surface; and the same difficulty besets the interpretation of the Fraunhofer lines. Their thickness and darkness is a function of at least three variables—temperature, pressure, and thickness of absorbing layer; only after having successfully investigated the separate effect of these three variables, will a more perfect interpretation of the phenomena be possible.

If electric phenomena are going on at the solar surface, the difficulty of the ordinary methods of investigation will be still further increased; for, as I have shown,

(1) Very often, if a spark traverses a mixture of gases, one gas only becomes luminous. This result has recently been confirmed by the photographs of H. W. Vogel.

(2) A gas may, by means of an electric discharge, be made luminous below 100° C.

I have concluded from my investigations that the electric discharge increases the oscillatory energy of a gas independently of its translatory motion; and I compared these phenomena to fluorescence.

Hasselberg has confirmed my results, and has drawn some conclusions from them concerning the aurora borealis, comets, &c. I did not in my first communication refer to these matters, as I hoped first to be able to make some experimental investigations in order to fix the relations existing between pressure, luminosity, and quantity of electricity; but I had thought of these evident applications.

The curious forms of prominences which rise and float freely over the solar surface, and which Lohse has tried to refer to chemical processes, may also be explained by electrical causes.

The two results which I have mentioned must render us very cautious before we apply results arrived at by means of the electric arc or vacuum-tubes to solar phenomena. I believe that we cannot at all employ them for the determination of temperature and pressure.

It is by no means necessary that we should have the same relative intensity of the lines in the spectra produced by the two different causes. The effect of the electric discharge is first of all to displace the æther spheres surrounding the molecules; and the vibrations which are caused are in the beginning independent of the translatory motion, which latter chiefly determines the temperature. By means of the encounters of the vibrating molecules the rotatory motion is changed into translatory motion; and then only is the temperature raised so high that the gas may become luminous owing to its heat. This may take place in the narrow parts of a Geissler tube.

If, on the other hand, we produce spectra by means of heating only without calling electricity to help, we first of all increase the translatory motion, which must be increased considerably; for the gas becomes luminous, and then the changes in the forces binding the atoms together to a molecule must affect the spectrum.

At any rate we must carefully investigate the effects of the electric discharge on the nature of spectra before we can draw any conclusions from spectra produced by electricity on questions relating to temperature and pressure. I intend to discuss this point in another paper.

VIII. *On a new Instrument for the Detection and Measurement of Inflammable Gas in Mines.* By E. H. LIVEING, Assoc. R.S.M.*

[Plate II.]

THE instruments hitherto contrived for the detection of gas

• Read June 26th, 1880.