Citation:

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by means of the hypothetical descending "sap-current", by the newer physiologists they were, as a rule, not explained at all. Now that the existence of a resulting descending current could be proved with *Caulerpa,* which shows so many analogous phenomena, it seems to me to be probable that on closer investigation it will also be found with higher plants, although perhaps in an entirely different form than was originally thought.

Physics. — *"Double refraction near the components of absorption lines magnetically split into several components"*, according to experiments made by Mr. J. Geest. By Prof. P. Zeeman.

It has already appeared from experiments which I had the honour to communicate to the Academy on a former occasion that the magneto-optic theory of Voigt [1]), who established a simple and rational connexion between the magnetic splitting up of the spectral lines and dispersion, accounts extremely well for all the phenomena observed in the region of the absorption lines.

If light traverses parallel to the lines of force very attenuated sodium vapour placed in the magnetic field, the plane of polarization is rotated in the positive direction for all periods lying outside the components of the doublet, but in the negative direction, and very strongly [2]), for periods intermediate between those of the components.

If light traverses the vapour normally to the field, there is double refraction as predicted by Voigt from theory. When placed in a magnetic field, all isotropic bodies should show double refraction, but to a measurable degree only in the neighbourhood of the absorption lines. Voigt in collaboration with Wiechert experimentally verified this result, using a small grating and a flame with relatively much sodium vapour.

I have extended these results [3]) by working with sodium vapour so dilute that, in a strong magnetic field, there were seen the four absorption lines corresponding to the components of the quartet into which the line D_1 is split by the magnetic field. The mode of dependency of double refraction on the period could, in this special case with some reserve, be predicted from Voigt's theory. Observations, in which Mr. Geest took part, confirmed the theoretical result. Mr.

1) Voigt, Wiedemann's Annalen. Bd 67, p. 359, 1899.

2) Zeeman, Proc. Acad. Amsterdam, May 1902, see also Hallo, Thesis for the doctorate, Amsterdam, 1902.

3) Zeeman en Geest, Proc. Acad. Amsterdam, May 1903.

30[1]

GEEST has now extended these observations and will give a more detailed exposition of his results elsewhere[1]); I intend to give here a short explanation of them.

The arrangement of the apparatus was for the most part the same as in our former experiments. Plane polarized light, under azimuth 45° to the vertical, falls on a BABINET's Compensator with horizontal edges. The light then traverses a second Nicol with its plane of polarization perpendicular to that of the first. An image of the system of parallel interference bands in the compensator, is thrown on the slit of the spectroscope. The light is then analysed by means of a large ROWLAND grating mounted for parallel light. The greater part of the experiments were made with a compensator of which the prisms had angles of about 50′, but for the study of some details compensators were used with angles of 10′ or of 3°. In the spectroscope a few dark horizontal interference bands are observed as long as the magnetic field is off. The fine absorption lines of the vapour are then coincident with the reversed sodium lines due to the arc light. As soon as the field is on, the bands become distorted. Their vertical displacements are, with the method used, proportional to the difference of phase between vibrations respectively parallel and normal to the field.

For the simplest case of a line split by the field into a triplet, VOIGT deduced a formula giving the difference of phase as a function of the wave length[2]). The sodium lines D_1 and D_2 being split, however, by the magnetic field into a quartet and a sextet, it was, in order to compare theory with observation, necessary to deduce the formulae for these cases. Mr. GEEST has made these calculations according to the method already indicated by VOIGT[3]) on another occasion. According to his calculation, the difference of phase between vibrations normal and parallel to the field, the light having traversed a layer l of the absorbing vapour, is given by:

$$\Delta = \frac{\omega_0 \varepsilon l}{V^2} \left\{ \frac{4\delta^2 - d'^2 \vartheta_0^2}{(4\delta^2 - d'^2 \vartheta_0^2)^2 - 4c^2 R^2 \delta^2} - \frac{1}{4\delta^2 - d^2 \vartheta_0^2} \right\} .$$

In this formula V indicates the velocity of light in the aether, R the strength of the field, ε, d, d' and c being constants characteristic of the medium. Moreover $2\pi\vartheta_0 = \tau_0$ is the period of vibration and $\delta = \partial\vartheta$. The formula given applies to the case of the sextet; for the quartet, $d' = o$ and for the triplet, moreover $d = o$. Figs. 1—3

1) GEEST, Thesis for the doctorate, Amsterdam, 1904.

2) VOIGT l. c.

3) VOIGT Wied. Ann. 68 p. 352. 1899.

give the graphical representation of Δ as a function of δ for each of these three cases.

The result of the observations is represented in figs. 4—8. These drawings are made with the aid of photographic negatives. We have not yet succeeded in getting negatives that showed all details simultaneously and equally well. Hence ocular observations had to supply the imperfections of the photographic records.

Figs. 1, 4, 5 refer to the triplet (type line D_2 in feeble fields); figs. 2, 6, 7 to the quartet (type line D_1); figs. 3, 8 to the sextet (type line D_2).

When comparing the results of observation with theory, it should be taken into account that the theoretical curve indicates the distortion which one single interference band would undergo. With the method of observation used, the central part of the field of view contained also parts originating from bands lying higher and lower than the one considered. The theoretical figure must therefore be completed with parts of theoretical curves lying above and below the one represented.

We will first of all consider the quartet. We indicate the bands by *a*, *b*, *c*, *a* being the superior one, and by 1, 2, 3, 4, we indicate the positions in the spectrum which would be occupied by the components. The double curved line between 2 and 3 shows entirely the same character in both figures. This sinuous line (figs. 6 and 7) thickens out at the extremities into more intense parts (where the double refraction is at a maximum or at a minimum) turning their concave side towards band *b*. These intense parts correspond to the loop of the theoretical curve, the loop between 1 and 2 belonging to band *c*, and the one between 3 and 4 to band *a*. It was not to be expected that the two branches which asymptotically approach the components, would be seen separated from the loops. The distance is too small by far to allow that. The vertical central line in the figure is the reversed sodium line due to the arc. With increased vapour density the loops increase their distance from their band. Fig. 7 relates to this case, which is also in accordance with theory. As the vapour density increases, fewer details become visible, but we will not go further into this point now.

The observations concerning the sextet are very difficult on account of the extremely small distance of the components. It is already difficult to observe the inverse sextet, and hence so much the more to observe phenomena occurring between its components. Only under very favourable circumstances could the phenomenon be observed as it is represented in fig. 8. The other phenomena observed with

D_2 are most readily interpreted by considering them as originating from a triplet and not from a sextet.

It seems rather superfluous to give any further explanation of figs. 3, 4, 5; in the case relating to fig. 5, the vapour density is again greater than in fig. 4. All the phenomena we have considered are qualitatively in excellent accordance with VOIGT's theory.

The phenomena described for D_1 and D_2 again demonstrate the existence of very characteristic differences between different spectral lines, differences no less striking here than in the case of the related phenomena of the magnetic separation of the spectral lines and of the rotation of the plane of polarization in the interior [1] of, and close to, the absorption line. It is certainly very interesting that the theory explains the entirely different behaviour of D_1 and D_2 in the case now considered by differences between the velocities of propagation of vibrations normal and parallel to the field, assuming, of course, the magnetic division of the lines.

Physics. — "*The motion of electrons in metallic bodies*". I. By Prof. H. A. LORENTZ.

It has been shown by RIECKE [2], DRUDE [3] and J. J. THOMSON [4] that the conductivity of metals for electricity and heat, the thermo-electric currents, the THOMSON-effect, the HALL-effect and phenomena connected with these may be explained on the hypothesis that a metal contains a very large number of free electrons and that these particles, taking part in the heat-motion of the body, move to and fro with a speed depending on the temperature. In this paper the problems to which we are led in theories on these subjects will be treated in a way somewhat different from the methods that have been used by the above physicists.

§ 1. I shall begin by assuming that the metal contains but one

1) ZEEMAN, Proc. Acad. Amsterdam May 1902, see also the description of another phenomenon in VOIGT, Gottinger Nachrichten, Heft 5, 1902.

2) E. RIECKE, Zur Theorie des Galvanismus und der Wärme, Ann. Phys. Chem. 66 (1898), p. 353, 545. 1199; Ueber das Verhältnis der Leitfähigkeiten der Metalle für Wärme und für Elektrizität, Ann. Phys. 2 (1900), p. 835.

3) P. DRUDE, Zur Elektronentheorie der Metalle, Ann. Phys. 1 (1900), p. 566; 3 (1900), p. 369.

4) J. J. THOMSON, Indications relatives à la constitution de la matière fournies par les recherches récentes sur le passage de l'électricité à travers les gaz, Rapports du Congrès de physique de 1900, Paris, 3, p. 138

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Triplet

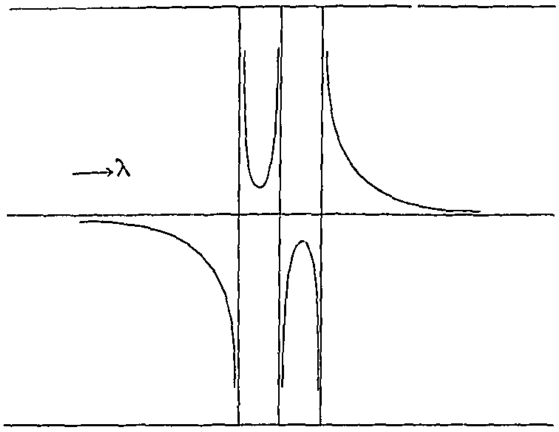

Fig 1
(theoretical curve)

Fig 4
(observed)

Fig 5
(observed)

Quartet

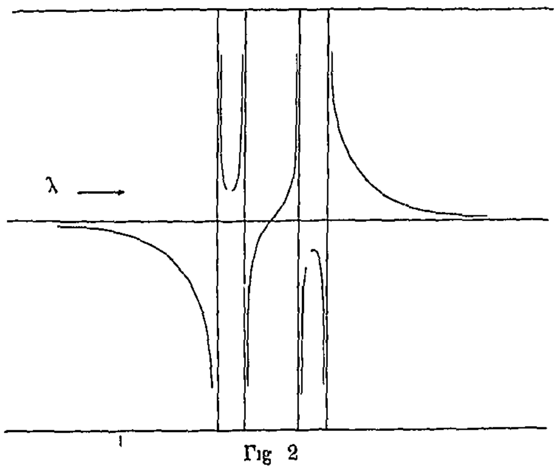

Fig 2
(theoretical curve)

Fig 6
(observed)

Fig 7
(observed)

Sextet

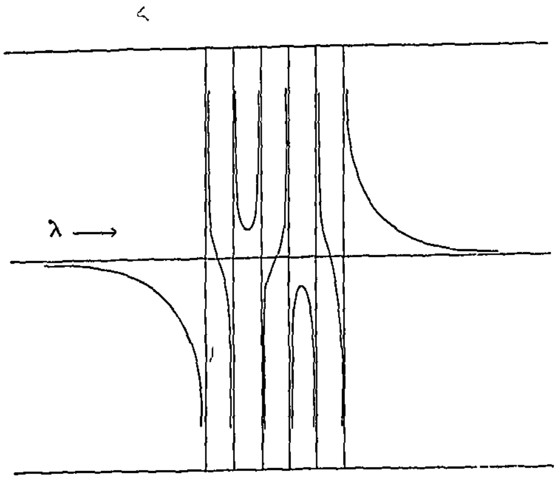

Fig 3
(theoretical curve)

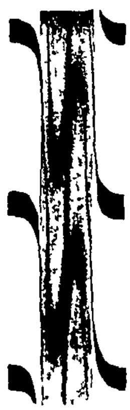

Fig 8.
(observed)