KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN TE AMSTERDAM.

PROCEEDINGS OF THE MEETING

of Saturday November 30, 1901.

(Translated from: Verslag van de gewone vergadering der Wis- en Natuurkundige Afdeeling van Zaterdag 30 November 1901, Dl. X).

The following papers were read:

Physics. — "*Some observations on the resolving power of the* MICHELSON *echelon spectroscope*", by Prof. P. ZEEMAN.

§ 1. On a recent occasion [1]) I have given a few observations on this subject. The acquiring of some new data induces me to return to it in this place.

In his "Investigations in optics" Lord RAYLEIGH [2]) expressed the wish that spectroscopists in possession of powerful instruments would compare the actual resolving power with that of which they are theoretically capable and remarked that a carefully arranged suc-

[1]) BOSSCHA Collection of Memoirs. Archiv Néerl. sér. II. T. 6, p. 319. 1901.
[2]) Phil. Mag. 1879, 1880.

cession of tests of gradually increasing difficulty would be of especial value.

I remembered these remarks as I tested the very original echelon, invented by MICHELSON.

The echelon at my disposition, made by HILGER, London, consists of thirty plates each about 7,8 m.m. thick, made of light flint-glas, set with 1 m.m. steps. A clear aperture of 1 m.m. is left beyond the width of the largest glassplate. The number of apertures n, operative in the formation of the spectrum is hereby one more than the number of plates. The mounting was somewhat improvised. Telescope and collimator belonging to a KIRCHHOFF spectroscope were employed. The telescopes had object-glasses of 50 cm. focus and 38 m.m. aperture. It is evident that in order to get greater intensity, glasses of shorter focus would have been preferable.

Denoting by $d\lambda_1$ the difference of wave-length of spectral lines when they are just distinguishable as separate in the spectroscope, by t the thickness of the plates of glass, and by n the above mentioned number then, we know

$$q_t = \frac{d\lambda_1}{\lambda} = \frac{\lambda}{knt} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

if

$$k = (\mu - 1) - \lambda \frac{d\mu}{d\lambda},$$

The resolving power is given by

$$r = \frac{\lambda}{d\lambda_1} = \frac{knt}{\lambda} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

For the green line $\lambda = 5460$ A. M. we obtain in the case of our echelon $r = \frac{0{,}63.\,31.\,7{,}8}{5460.\,10^{-7}} = 280000$ and $q_t = \frac{d\lambda_1}{\lambda} = 3{,}6.\,10^{-6}$.

In the calculation of k I used the following values of the refractive indices given to me by HILGER

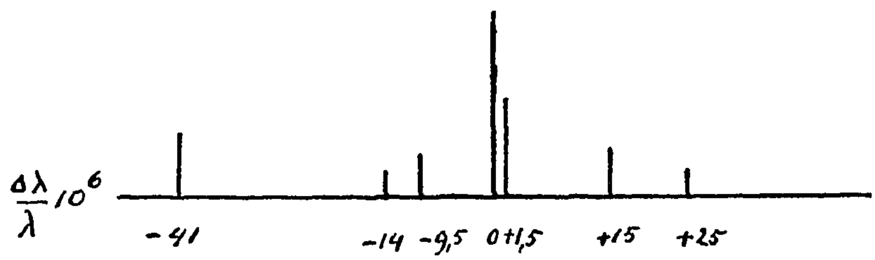
$$\mu_C = 1.5713$$
$$\mu_D = 1.5753$$
$$\mu_F = 1.5853$$
$$\mu_{G'} = 1.5936$$

Henceforth I will denote by q_t the theoretical value of the limit of resolution calculated according to (1), by q_e the experimental value. By means of a HOFFMANN direct vision spectroscope the light of the vacuum tubes (driven by a RUHMKORFF) undergoes the necessary preliminary analysis. In some cases absorbing media were therefore sufficient. In some experiments the mercury arc-lamp of FABRY and PEROT was used.

§ 2. The very intense *green* (5460) line of *mercury* was investigated first. Using the echelon in a position in which two strong lines of equal intensity corresponding to successive orders of the radiation were visible, I could distinguish also 5 faint, very narrow lines between the principal ones. The distance between two pairs of these lines was very small.

As I could not find a table of the wave-lengths of these feeble radiations, I addressed myself to Messrs FABRY and PEROT. I am very much obliged to Messrs PEROT and FABRY for their kindness to investigate for me anew the green radiation of the mercury arc in vacuo.

The following scheme represents the constitution of this very complex radiation according to their observations. The ordinates are *approximately* proportional to the intensities.



The given numbers are only approximate, especially (— 14) and (— 9,5).

The radiation (+ 1,5) was observed by FABRY and PEROT only in the radiation of a MICHELSON tube; it is too approximate to the principal radiation to be seen separately in the arc light. In the photographical reproduction in the Astrophysical Journal [1]) of the interference fringes of the green mercury line the radiation (— 41) coincides with the radiation (+ 15) and is therefore invisible.

I could distinguish very clearly the radiations (—9,5) and (—14)

[1]) FABRY and PEROT Astrophysical Journal. Vol. 13. p. 272. 1901.

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as separate lines. For these radiations $q = \frac{d\lambda}{\lambda} = 4,5.10^{-6}$ or $r = 222000$ and hence q_e rather smaller; calculation gave $q_t = 3,6.10^{-6}$.

Using the *green* line of *thallium*[1]) I extremely easily distinguished the faint radiation at a distance $\frac{d\lambda}{\lambda} = 21.10^{-6}$ from the principal radiation, but I could not see as a separate line the one determined by $\frac{d\lambda}{\lambda} = 3.10^{-6}$.

Hence q_e exceeds 3.10^{-6} but is smaller than 21.10^{-6}.

Indeed for the thallium radiation (5440)

$$q_t = \frac{5440.10^{-7}}{0,63.31.7,8} = 3,6.10^{-6}.$$

For the *green* (5086) line of *cadmium* it was just possible to see that this line is a double one. The distance of the components is according to FABRY and PEROT $\frac{d\lambda}{\lambda} = 5.10^{-6}$.[2]) For $\lambda = 5086$ I calculate $q_t = 3,2.10^{-6}$. Hence with the mentioned echelon it is possible to almost reach the limit of the theoretical resolving power.

§ 3. Perhaps the best series of tests of gradually increasing difficulty can be obtained by observation of the change of spectral lines in magnetic fields of gradually increasing intensities, a Nicol between source and apparatus being used in order to reduce the complexity of the radiation. In this manner all values between e.g. 0.001 A. U. to about 1 A. U. can be obtained. Corresponding herewith are the values $q_t = 0,2.10^{-6}$ and $r = 5\,000\,000$ resp. $q_t = 200.10^{-6}$ and $r = 5000$. The performances of echelons and interferometers and of ordinary spectroscopes with a few glass prisms lie between the limits indicated. This test I have not yet applied systematically to the mentioned echelon.

In order however to show its fitness I will use some observations of Lord BLYTHSWOOD and Dr. MARCHANT[3]). In their § 6 „Results obtained of the ZEEMAN Effect on the Chief Lines of the Mercury Spectrum" p. 397 these authors communicate observations with an

1) FABRY et PEROT. Ann. de Chim. et de Phys. (7) 16, p. 134. 1899.

2) l. c. p. 137.

3) Phil. Mag. Vol. 49. p. 384. 1900.

echelon spectroscope concerning the difference in wave-length between the components of the outer components of the sextet of the blue (4358) line of mercury. The following table is an extract ($\delta\lambda_3$ in A.U.)

H	$\delta\lambda_3$
5.000	.....
12.100	.....
12.900	0.052
20.000	0.098?
21.300	0.09
23.400	0.098

For a value of the field between 12.100 and 12.900 the splitting up of the lines becomes sufficient to make them appear as separate lines *on a photograph* (upon which the measurements were taken). Two lines can of course be *seen* separated at a considerably smaller distance.

Thus now $q = \frac{0{,}052}{4358} = 11{,}9.10^{-6}$ and q_e considerably smaller. For the echelons of these observers we have $t = 7{,}5$, $n = 15$.

With these data I calculate $q_t = 5{,}3.10^{-6}$.

Thus it appears from the data given in this paper that it is possible to manufacture echelons, performing nearly as well as they are theoretically capable.

Mathematics. — "*Considerations in reference to a configuration of* SEGRE". By Prof. P. H. SCHOUTE. (Second part).

5. We have already remarked that the form of the equations of the fifteen lines obtained in the first part of this communication was not yet a quite regular one. If we shorten $x_1 - x_3 = x_5$ into $(1-3)$, $x_1 = x_2$ into 12 and if everywhere we omit the equations $x_1 = 0$, $x_2 = 0, \ldots x_5 = 0$, then the following table gives the obtained result in the form of the determinant repeatedly used