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A few experiments were tried to sublime mixtures of the two compounds. The deposit on the concave coveringglass then consists of a network of dentritic, strongly pleochroïc (colourless — yellowish-green) little crystals, between which are found the square-shaped crystals of the nitroso-compound, besides the yellow individuals of the nitro-compound, united in clusters.

The first mentioned crystals contain chiefly the nitroso-compound and probably to a very small amount also the nitro-compound, so this may be a new case of the formation of solid solutions by sublimation. Probably, this pair of compounds lends itself to the measuring of the vapour tensions of these solid solutions.

Zaandam, December 1907.

Physics. — *"Observation of the magnetic resolution of spectral lines by means of the method of* FABRY *and* PEROT." By Prof. P. ZEEMAN.

The interference method of the parallel semi-silvered plates, worked out with so much ingenuity by FABRY and PEROT[1]) excels above all other spectroscopic modes of procedure by the accuracy with which its theoretical foundations may be practically realized.

The principal task of the experimenter in applying this method has become to effect the perfect parallelism of the reflecting silvered plates.

In order to test by an independent method some recent results obtained in an investigation of the magnetic resolution of spectral lines[2]) the method of FABRY and PEROT seemed most appropriate. Especially it appeared possible to extend at the same time the investigation to the behaviour of the lines in weak fields. The present paper is preliminary to a discussion of numerical results. I think it beforehand very improbable that errors of ruling of the ROWLAND grating will turn out to be the reason of the asymmetrical resolution of some lines, which I have described.

The method of FABRY and PEROT is applied in the present paper for the first time to an investigation of the magnetic separation of spectral lines. In some places in the literature of the subject the opinion is expressed that the method of interference fringes of silvered layers cannot be used for the subject under review. The

1) FABRY et PEROT, Ann. de Chimie et de Physique 1899—1904.

2) ZEEMAN, These Proceedings, November 1907.

main objection is derived from the great loss of intensity in the apparatus of FABRY and PEROT. The present paper proves that this objection is not insuperable.

2. Of the two forms in which the method of the parallel plates is employed, the simplest, also requiring the least costly apparatus, has been used for the actual measurement of wave-lengths by FABRY and PEROT[1]), lord RAYLEIGH [2]) and EVERSHEIM [3]). This form of instrument called *étalon,* I also have preferred. The distance of the silvered surfaces is here constant. The glass plates are held up to rounded distance-pieces (made of steel), by adjustable springs, which permit to regulate the pressure. By variation of the pressure the steel and the glass can be deformed in an extremely small degree and the accurate parallelism of the glass plates effected; the parallelism being secured already very approximately beforehand by the accuracy or finish of the distance-pieces.

3. The theory of the comparison of wave-lengths by means of this apparatus is simple, and has been given by FABRY and PEROT. We will apply it to the magnetic resolution of spectral lines and especially to the most simple case, the division into a triplet.

Let λ_0 be the wave-length of the original line (afterwards therefore the middle line of the triplet). To this corresponds a system of rings; let P_0 be the ordinal number of the first from the centre. The ordinal number at the centre p_0 is then the integer number P_0, augmented with a fraction ε_0, hence $p_0 = P_0 + \varepsilon_0$. Ordinarily $0 < \varepsilon_0 < 1$.

The diameter of a ring increases with ε. Let e be the thickness of the plate of air, the order of interference at the centre is $p_0 = \frac{2e}{\lambda_0}$. At an angle i with the normal to the plate the order of interference is $p_0 \cos i$.

If x_0 be the angular diameter of the ring P_0, then we have, observing in the focal plane of a lens, $p_0 \cos \frac{x}{2} = P_0$. Developing the cosinus

[1]) FABRY et PEROT, Ann. de Chim. et de Phys. T. 25, Janvier 1902. C.R. 27 Mars 1904. FABRY et BUISSON, C. R. 16 Juillet 1906. BARNES Astrophysical Journal. Vol. 19. p. 190. 1904.

[2]) Lord RAYLEIGH, Phil. Mag. Vol. 11, p. 685, 1906.

[3]) EVERSHEIM, Zeitschr. f. wissenschaftl. Photographie, Band 5 p. 152, 1907.

$$p_0 = P_0\left(1 + \frac{x_0^2}{8}\right)$$

or

$$\varepsilon_0 = P_0 \frac{x_0^2}{8} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Let λ_r be the wavelength of the outer component of the triplet towards the red then, if P_r, ε_r and x_r have a significance corresponding to that of P_0, ε_0 and x_0,

$$\varepsilon_r = P_r \frac{x_r^2}{8}.$$

We have however $\lambda_0 (P_0 + \varepsilon_0) = \lambda_r (P_r + \varepsilon_r)$, whence

$$\lambda_r = \lambda_0 \frac{P_0}{P_r}\left(1 + \frac{x_0^2}{8} - \frac{x_r^2}{8}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In like manner, λ_v, P_v, x_v determining the component of the triplet towards the violet, we have

$$\lambda_v = \lambda_0 \frac{P_0}{P_v}\left(1 + \frac{x_0^2}{8} - \frac{x_v^2}{8}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

In the case of radiation in a magnetic field this expression may often still be simplified. In many cases we may choose

$$P_0 = P_v = P_r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Looking at the system of rings corresponding to λ_0, while the magnetic force is slowly but gradually increased one sees at the same time rings which proceed from the system λ_0 and are moving outwards and others which are moving inwards. The rings corresponding to λ_r are contracting, those corresponding to λ_v are expanding.

It depends upon the value of p of the étalon and upon the intensity of the magnetic field how great the expansion and contraction of the rings, in comparison with the distance of the rings λ_0, will be.

The value of p and the maximum magnetic force will determine whether in the centre new rings will appear or respectively will disappear.

In the case one does not select for measurement the smallest rings but if the rings λ_r and λ_v, *which originate from the same ring* λ_0, are suitable to be measured, ε can become larger than unity.

When we select the rings thus specified the equality (4) applies and then we may determine λ_r and λ_v from the angular diameters of the rings and the value of λ_0, regarded as known; the result is then independent of the accurate value of the thickness of the plate of air.

Of course the position of the new rings between the rings λ_0 will, with a given value of the magnetic force, be determined by the thickness of the plate of air and what might be called "the sensibility" of the system of rings to magnetic forces will increase with the thickness of the plate of air. A limit of this sensibility is (often too soon) attained by the effective width of the spectral lines under consideration.

In some cases it will be desirable to select for measurement rings different from the three specified ones. There are no difficulties about the significance of P; it always means the ordinal number of the measured ring.

However if P_0 differs from P_r or P_v, their values must be known for the calculation according to (2) and (3).

4. Besides the simplification resulting from equation (4) there is still another one to be considered in the investigation of the radiation in a magnetic field.

I mean that the quantity $e = p\frac{\lambda}{2}$, the optical thickness of the plate of air may be treated as an absolute constant.

Ordinarily this thickness depends upon λ. In consequence of the change of phase by reflection upon the silver, which varies with wavelength, the comparison of different coloured systems of rings finally requires a knowledge of the optical thickness for each separate colour.

It is clear that in the application to the subject now under review only systems of rings corresponding to rays differing extremely little in wavelength are considered, hence the variation of thickness with wavelength needs not to be taken into account.

5. Figures 1 and 2 may give an idea of the aspect of the magnetic resolution of the spectral lines observed by means of the method of Fabry and Perot. They are about sixfold enlargements of negatives taken with an étalon with an interval of nearly 5 m.m. between the plates. The source of light in the magnetic field was a small vacuum tube charged with mercury. The order of interference at the centre for the mercury line 5791 is at 16° about 17265,7.

The system of rings was formed in the focal plane of a small achromatic lens of 18 m.m. aperture and of 12 c.m. focus. Its focal plane coincides exactly with the plane of the slit of a small spectroscope. When the slit is opened widely each spectral line is seen as a rectangle with bright rings or parts of rings as the case may be. The part of the spectrum in the figures refers to the two yellow and the green mercury lines. In fig. 1 the two rectangles corresponding to the two yellow mercury lines are superposed. The green mercury line is largely overexposed. I have reproduced it also in order to give an idea of the dispersion used. The intensity of the magnetic field in figures 1 and 2 was about 5000 Gauss.

It is a very beautiful sight to watch the moving system of rings, while the magnetic force is slowly increased. The rings λ_r and λ_v are first seen approaching, then coïnciding, separating, coïnciding for a value of the field of about 15000 Gauss with the next ring λ_0, passing over this ring, etc.

For measurements it is necessary to reduce the width of the slit, as in Fig. 2. Owing to rise of temperature the rings have somewhat expanded.

6. For measurements, which I hope to communicate in a future paper, I have used not only the method of diameters resumed above (§ 3) but also *the method of the coincidences* [1]) for the distinct values of the magnetic force, which bring to coincidence λ_r and λ_v, or λ_r and λ_v with λ_0.

Concerning the difficulties attending the use of the method of coïncidences FABRY and PEROT [1]) remark:

"Même avec ce perfectionnement, la méthode présentait des inconvénients assez graves :

1. La necessité d'éclairer simultanément l'appareil par les deux sources entraîne des pertes de lumière assez importantes ;

2. Les coïncidences ne sont bien observables que lorsque les deux systèmes d'anneaux ont des éclats comparables, et cette condition n'est pas toujours facile à réaliser ;

3. La recherche de la coïncidence entraîne toujours des tâtonnements et l'on n'est jamais sur (lorsque la période est courte) d'en rencontrer une qui soit exacte."

The drawbacks to the method, mentioned sub 1. and 2. are eliminated in the application to radiation in a magnetic field, now under consideration. By variation of the current in the electromagnet the coincidence can be attained with the desired degree of accuracy and hence also the third objection is obviated.

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[1]) FABRY et PEROT, Ann. de Chim. et de Phys. p. 12, T. 25, Janvier 1902

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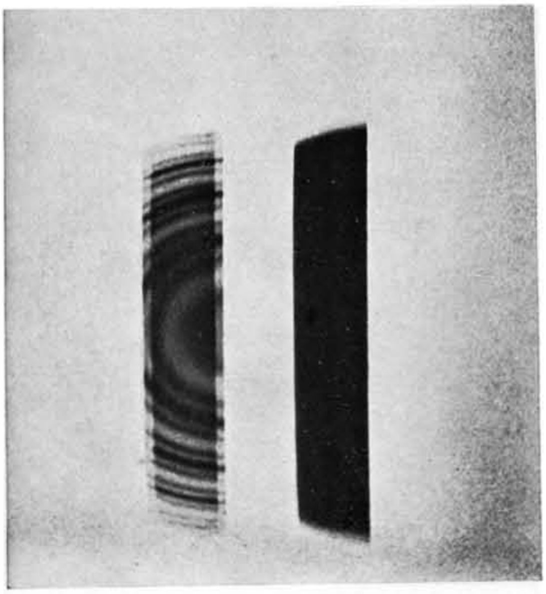
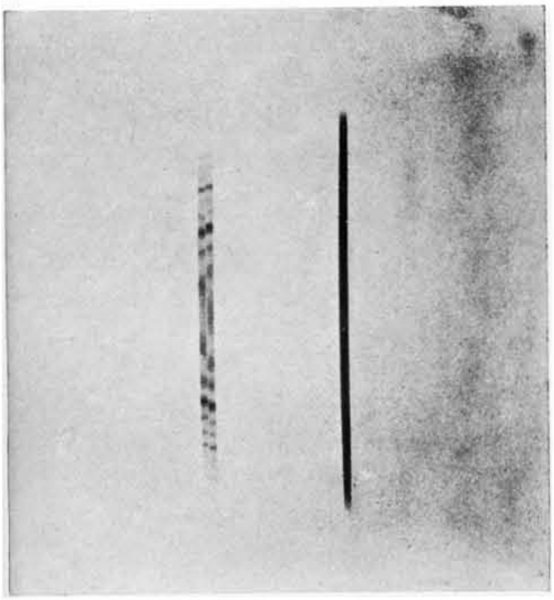


1. The yellow mercury lines in magnetic field. Very wide slit. Green mercury line overexposed.



2. The same lines. Narrow slit for measurement of the yellow mercury lines.

7. Some further details concerning the apparatus may finally be given.

The mounting and the plates of the 5 m.m. étalon are by JOBIN. The inner surfaces of the plates are accurately flat. The outer surfaces need only ordinary flatness, they are inclined at an angle of 1′ to the inner ones. The plates of the étalon are vertical, and the whole apparatus is capable of the necessary adjustments in azimut, while also a horizontal sliding motion parallel to the plates of the étalon was provided for.

An image of the vacuum tube was focussed upon the étalon by means of an achromatic lens of 12 cm. focus, the enlargement being four times. All optical pieces were mounted upon double *T*-pieces and therefore rigidly connected.

The figures clearly indicate that for the investigation of the magnetic separation of the yellow mercury lines, it would be of no value to use an étalon of greater optical thickness of the plate of air. On the contrary the effective width of the yellow mercury lines when under magnetic influence is rather large, so that the limits of the method in this case are being rapidly approached.

Physics. — "*Isotherms of monatomic gases and their binary mixtures. I. Isotherms of helium between* + 100° *C. and* — 217° *C.*" Communication N°. 102[a] from the Physical Laboratory at Leiden. By Prof. H. KAMERLINGH ONNES.

§ 1. On account of the important rôle, which VAN DER WAALS' theory plays in many chapters of thermodynamics, experimental data concerning the equation of state of a substance are of the greater value as the interaction of the molecules of this substance conforms the better to the hypotheses from which VAN DER WAALS started. The knowledge of the equation of state of the monatomic gases, whose molecules we must consider as the simplest for the present, is of the greatest importance from this point of view.

In Comm. N°. 69 (April 1901) on the isotherms of diatomic gases and their binary mixtures it was already observed that the investigation of the net of isotherms of argon and of helium promised still more important results than the completion of the net of isotherms of the gases formerly called permanent, particularly of hydrogen, at low temperatures, on which subject my attention had been chiefly fixed since the establishment of the cryogen laboratory (cf. Comm. N°. 14, Dec. '94). But the difficulty of obtaining argon and helium in so pure a state and in such quantities as are required for