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CONTENTS.

hysics. — "*The universality of the* ZEEMAN-*effect with respect to the* STARK-*effect in canal-rays.*" By H. DU BOIS. (Communication from the BOSSCHA-Laboratory).

(Communicated in the meeting of November 28, 1914).

Notwithstanding several efforts [1]) no one had succeeded in demon-rating the smallest influence of electrostatic fields on spectral lines ntil STARK [2]) observed such a specific effect for lines emitted by the

[1]) See G. F. HULL, Proc. Roy. Soc. **78** p. 80, 1907. P. ZEEMAN, These Proc. p. 957, 1911; **20** p. 731, 1911. F. PASCHEN & W. GERLACH, Phys. Ztschr. **15** 489, 1914.

[2]) J. STARK and his collaborators, Sitz.ber. Berl. Akad. **47** p. 932, 1913; Ann.

canal-rays of [illegible]um and lithium. In his experiments the electric f[illegible] values of more than 150 electrostatic units, viz. $\mathfrak{E}_m$ in electromagnetic units was more than 45 kilovolt/cm; the largest separation surpassed 2 $\mu\mu$ for H_{γ} ($\lambda = 434{,}1$ $\mu\mu$).

Starting from the theoretical equivalence of $\mathfrak{E}_m$ and the vector-product $[\mathfrak{B}\,\mathfrak{H}]$ .W. WIEN[1]) then presumed an analogous specific magnetic separation of spectral lines of hydrogen canal-rays and experimentally verified this. In his experiments the maximum velocity in the canal-rays, $\mathfrak{B}$, reached a value of 7700 km. per second; while the magnetic field $\mathfrak{H}$ was about 17 kilogauss. The separation observed for H_{γ} was of the order of 0,5 $\mu\mu$, i. e. very much larger than that of the ordinary ZEEMAN-effect, for which the normal separation in this field would amount to about 0,03 $\mu\mu$ only.

As far as we can now already judge, we have here two separate, without doubt closely connected, phenomena, which are both proportional with the field and which appear to depend on the velocity of the charges. With an extremely sensitive method PASCHEN and GERLACH sought for an electric effect ($\mathfrak{E} = 15$ kilovolt/cm) in mercury vapour; but in vain. From this they rightly conclude, that there is no question here of an electric analogon of the real ZEEMAN-effect. For this is generally shown by many lines of emission, absorption and fluorescence of vapours and selective crystals: the unsensitiveness of certain lines moreover may be only apparent ($d\lambda < 0{,}002$ $\mu\mu$ say).

As early as 1899 this problem was treated theoretically by VOIGT[2]); according to him an electro-optic displacement or separation probably would occur, though maybe a very small one, proportional with $\lambda^5\,\mathfrak{E}^2$. Therefore it would be favourable for observation to choose these two factors as large as possible. Recently, before the publication of WIEN's experiments however, WARBURG and SCHWARZSCHILD[3]) have developed formulae, the former starting from the theory of quanta, the latter by means of purely attractory considerations. SCHWARZSCHILD

d. Phys. **43** p. 965—1045, 1914; Phys. Ztschr. **15** pp. 215, 265, 1914; Verh. D. Phys. Ges. **16** p, 304, 1914. Elektr. Spektr. anal. chem. Atome, Leipzig 1914. A. LO SURDO, Rend. Acc. Lincei (1) **23** p. 143, 1914; Phys. Ztschr. **15** p. 122, 1914. H. WILSAR, Gött. Nachr. **9** p. 20, 1914. H. LUNELUND, Ann d. Phys. **45**. p. 517, 1914.

1), W. WIEN, Sitz. Ber. Berl. Akad. **48** p. 70, 1914.

2) W. VOIGT, Wied. Ann. **69** p. 297, 1899; Ann d. Phys. **4** p. 197, 1901; Arch. Néerl. (2) **5** p. 366, 1901. Magneto- und Elektrooptik pp. 357, 380, Leipzig 1908; Gött. Nachr. **9** p. 1, 1914; Ann. d. Phys. **45** p. 461, 1914.

3) E. WARBURG, Verh. D. Phys. Ges. **15** p. 1259, 1913. K. SCHWARZSCHILD, ibidem **16** p. 20, 1914.

finds a separation proportional with $\lambda^{7/8}\mathfrak{E}$, WARBURG however a broadening proportional with $p^2\lambda^2\mathfrak{E}$, where p denotes the number of the series. The formulae of GARBASSO, GEHRCKE and BOHR [1]) differ from that of WARBURG in so far only as, besides other numerical factors, they contain $p^2\lambda\mathfrak{E}$ as a parameter. The simultaneous influence of a magnetic and an electric field was treated both theoretically and experimentally by ZEEMAN, STARK, GARBASSO and GEHRCKE [2]).

Luminescent vapours always more or less cause a migration of electricity which in the experiments of STARK e.g. amounted to several milliampères. It seemed to me interesting to examine the influence of a purely dielectric displacement. As ZEEMAN already pointed out (loc. cit.) for this purpose we must consider an insulating, selectively absorbing crystal. Among the series of substances formerly tested ruby will be found a very good material for such experiments [3]). It is not hygroscopic, it insulates extremely well and has an ordinary index of refraction $n_\omega = 1{,}769$ (for $\lambda = 589\ \mu\mu$), and $n_\omega^2 = 3{,}13$. Considering the analogy with quartz we may expect the dielectric constant to be much larger still. In connection with this research SELÉNYI [4]) already investigated in the BOSSCHA-laboratory the influence of an elastic deformation on the absorption lines of ruby. For a pressure of 150 kg/mm² however he could not detect an appreciable effect, at least no more than 0,02 $\mu\mu$.

The electrostatic experiment had to be delayed several years by the difficulty of obtaining artificial rubies of sufficient size, because of a monopolistic tendency in their preparation. Only recently I was kindly furnished with sufficient material. From this two disks were cut, about 3 mm thick, one ⊥ and one ∥ the crystal axis. By means of sealing wax these were fixed within ebonite plates of the same thickness. Unsymmetrical contraction by sudden cooling or high electrostatic tension (during a short time) did not appreciably injure these slides. To both sides of the dielectric plates small brass disks were fixed. In the middle of these a slit was made so that an eventual longitudinal effect might be observed. Extremely thin tubes of German silver fitted in glass tubes connected the brass

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[1]) A. GARBASSO, Phys. Ztschr. **15** pp. 123, 310, 1914. E. GEHRCKE, Phys. Ztschr. **15** pp. 123, 198, 344, 839, 1914; Verh. D. Phys. Ges. **16** p. 431, 1914. N. BOHR, Phil. Mag. (6) **27** p. 506, 1914.

[2]) P. ZEEMAN, These proceedings, **14** p. 2, 1911. J. STARK, Verh. D. Phys. Ges. **16** p. 327, 1914. A. GARBASSO, Phys. Ztschr. **15** p. 729, 1914. E. GEHRCKE, Phys. Ztschr. **15** p. 839, 1914.

[3]) H. DU BOIS and G. J. ELIAS, These proceedings, **10** pp. 578, 734, 839, 1908; Ann. d. Phys. **27** p. 233, 1908; **35** p. 617, 1911; **45** p. 1160, 1914.

[4]) P. SELÉNYI, Verh. D. Phys. Ges. **15** p. 290, 1913.

disks with a WIMSHURST electrical machine, giving a tension of more than 90 kilovolt. A vacuum-glass was half filled with liquid air and covered with an ebonite stopper, which was perforated for the glass tubes. Though the moisture in the laboratory hardly ever exceeded 30 to 40%, the whole apparatus was placed under the case of an exsiccator. In this way the ruby could for some time endure a tension of about 60 kilovolt, that is of $60/0,3 = 200$ kilovolt/cm. $= 667$ electrostatic units.

The absorption lines, especially the two strongest lines R_2 and R_1 in the red (691,8 and 693,2 $\mu\mu$) were observed in the first order of a concave grating (radius 181 cm., 5684 rulings per cm.), which was mounted in the ordinary way. 1 mm corresponded fairly well to 1 $\mu\mu$, so that a change of the order of 0,005 $\mu\mu$ could not escape observation. No influence of electrification could however be detected; in any case the displacement or separation is less than one hundredth part of the magnetic longitudinal effect in a field of 50 kilogauss. For the latter we formerly found the values:

		R_2	R_1
Axis ∥ field; triplets	with extreme separation $d\lambda$ ·	0,37	0,43 $\mu\mu$
Axis ⊥ field; quadruplets	,, ,, ,, $d\lambda$:	0,62	0,62 $\mu\mu$.

Probably an interferential method might give a sharper criterion than the rather small dissolving power of the grating. Such experiments might be made with the corresponding fluorescence spectrum of the ruby at a very low temperature; they must be delayed however until a more sunny season of the year. As this subject is of great importance it seems to me interesting even to determine the minimum limits in negative researches.

I also made experiments with the neodymnitrate-hexahydrate ($Nd(NO_3)_3 . 6H_2O$) from the series of the rare earths. A natural monocline plate about 1 mm thick was cut ⊥ to one of the axes and in the manner above mentioned mounted between two very thin glass plates by means of Canada balsam. Observations were made at —190° on the group of bands in the red, numbered from I to VIII in a former paper (loc. cit. § 32). On account of the smaller thickness of this slide the electric field was even stronger here than in the case of the ruby; but again no perceptible influence on the absorption bands was found. Now in a magnetic field the bands VII and VIII (676,6 and 677,2 $\mu\mu$) give doublets the separation of which reaches the largest observed value viz. $d\lambda = 1,0$ and 1,1 $\mu\mu$ for 50 kilogauss.

For the sake of completeness I repeated the experiment with an alcoholic solution of the salt in a trough, which contained platinum electrodes 2 cm distant from each other. A potential difference of 100 volt was applied. At 18° the current density was 75 milliamp./cm² and in the viscous solution just above the freezing point of aethyl-alcohol (—118°) 30 milliamp./cm². I also worked with a dilute solution in amyl-alcohol (—134°). With a spectral apparatus of very great dispersion I observed in this case considerably broadened and diffuse absorption bands, the aspect of which did not change when the current was made. It must be remarked however that under these circumstances the velocity of the negative ion is very small as yet.

Physics. — *"The calculation of the molecular dimensions from the supposition of the electric nature of the quasi-elastic atomic forces".* By Dr. J. J. VAN LAAR. (Communicated by Prof. H. A. LORENTZ).

(Communicated in the meeting of October 31, 1914).

1. In four papers[1]), in which some new relations between the critical quantities were given, I have also tried to determine the form of the function $b=f(v,T)$. While the dependence of b on the volume appeared to be pretty intricate — that namely the found relations at the critical point and at the same time the limiting condition at $v=v_0$ be satisfied — the dependence on the temperature could be given by a very simple relation, namely (see III, p. 1053, formula (36)):

$$\frac{b_g-(b_0)}{(b_0)}=0{,}041\sqrt{T_r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which (b_0) represents the value of the limiting volume $b_0=v_0$, extrapolated from the direction of the so-called straight diameter at T_k. This formula was an extension of that which was found at the critical point, namely (loc. cit. p. 1051):

$$\frac{b_k-(b_0)}{(b_0)}=2\gamma_k-1=0{,}038\sqrt{T_k}, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which γ_k is the coefficient of direction of the "straight diameter" in the neighbourhood of the critical point. The table (p. 1052) calculated to support this relation may be reproduced here.

1) These Proc. of March 26, April 23, May 29 and Sept. 26, 1914.