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Physics. — *"On the influence of an electric field on the light transmitted and dispersed by clouds."* By C. M. HOOGENBOOM. (Communicated by Prof. ZEEMAN.)

(Communicated in the meeting of June 24 1916).

1. *Introduction.* The researches, which will be communicated here and which will be treated more completely in my dissertation, are the continuation of the experiments of Prof. ZEEMAN and HOOGENBOOM, the results of which have been published already in these Proceedings [1]. They refer to the double refraction some clouds, especially of ammonium chloride, show in an electric field and to the influence of the electric field on the intensity of the transmitted and the dispersed light.

BLOCH [2]) has been the first to remark some action of the field on the propagation and the dispersion of light in and by a cloud of ammonium chloride. The details of this phenomenon have then been investigated by Prof. ZEEMAN and the author, by which research was found that such a cloud shows dichroism as well as double refraction. As to the double refraction it was found that a recently formed cloud is positively double refracting, while after some time it becomes negatively double refracting. This change we then connected with the dimorphism of ammonium chloride, which after having been observed probably for the first time by STAS, has recently drawn more attention.

Until now somewhat accurate measurements on the electric double refraction of ammonium chloride had not been made. This has been done now and the results of this research have been given in the first part of this communication. Further the dispersion phenomena of the double refraction and the results reached with other nebulae will be discussed.

In the second part those phenomena are discussed in which the field acts on the *intensity* of the transmitted and the dispersed light. A first observation of this kind has been made by BLOCH. The dichroism too belongs to this group of phenomena; further the authors had found already earlier, that in a direction perpendicular to the lines of force the transmitted natural light is weakened by the field.

Now a more complete research has been made where all cases

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[1]) ZEEMAN and HOOGENBOOM, These Proceedings XIV p. 558 and 786, XV p. 178. These papers will be referred to as Communication I, II and III. See also Phys. Zs **13**, 913, 1912.

[2]) BLOCH C R. **146** 970. 1908.

have been treated systematically, the results of which are given here together.

I. *Electric double refraction in clouds of ammonium-chloride and other substances.*

Dispersion phenomena.

2. *Arrangement.* The arrangement used for the investigation of clouds of ammonium chloride is essentially the same which has formerly been used by Prof. Zeeman and the author. Fig. 1 represents it schematically. The light of the source V is rendered parallel by a lens L. This parallel beam then traverses successively the polarizator P, a curved glass bar B, which serves as compensator, the condensator vessel with ammonium chloride, in which an electric field can be excited, and the analyzer A. The nicols are crossed, their polarization directions make angles of ± 45° with those of the electric force. Looking through the analyzer we see the neutral line of the bar as a black band in a light field. Double refraction of the ammonium chloride will now be revealed by a displacement of the band towards the place where it is compensated. Dichroism will weaken the band or cause it quite to vanish.

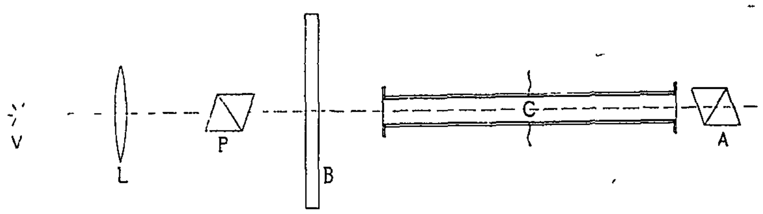

Fig. 1.

Some particulars will be discussed in details.

The ammonium chloride was contained in a glass *condensator vessel* nearly equal to that, which was described before.[1] For the measurements however it was altered in so far that the leaves of tinfoil which serve as condensator plates are applied to the inner side of the glass.

The ammonium chloride was again formed in the vessel from NH_3 and HCl.

For the *electric field* I could dispose of a Wimshurst machine and of two transformators.

The *Wimshurst* was driven by a three phase motor of about $\frac{1}{4}$

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[1] Zeeman and Hoogenboom, Communication I.

horse power. In order to obtain constant potential differences the two electrodes were connected with two needle systems in front of each other, while further a large resistance, a small wooden stick, was inserted between one electrode of the electrical machine and one of the plates of the condensator vessel.

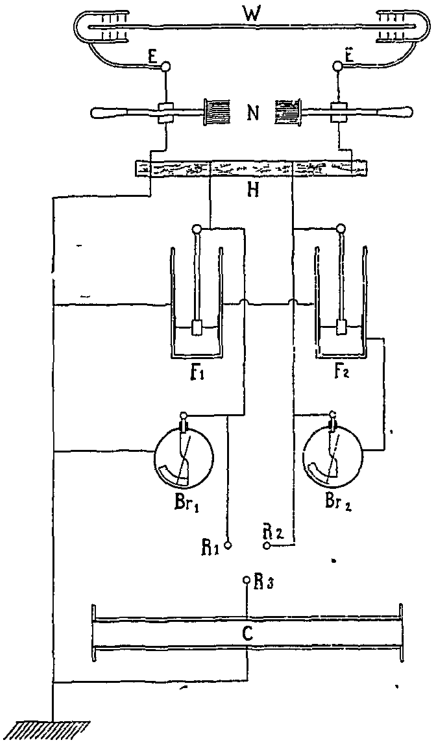

Fig. 2.

W the Wimshurst, EE the electrodes, N the needle-systems, H the wooden stick, F_1 and F_2 Leyden jars, Br_1 and Br_2 electrometers of BRAUN, R_1, R_2 and R_3 clamps of a key, C the condensator vessel.

The other electrode and the other plate were earthed. Moreover a Leyden jar of great capacity had been connected in parallel with the condensator vessel. In this way satisfying results were reached. When during the research it proved to be necessary, that two different potential differences could be worked with soon after each other, the arrangement was altered a little bit. It now became as is shown by fig. 2.

For experiments with an *alternating* field I could dispose of two transformators. One of these transformators (Tr_1) could transform the tension of the municipal net of 110 volt to 10.000 volt, the other (Tr_2) to 50.000.

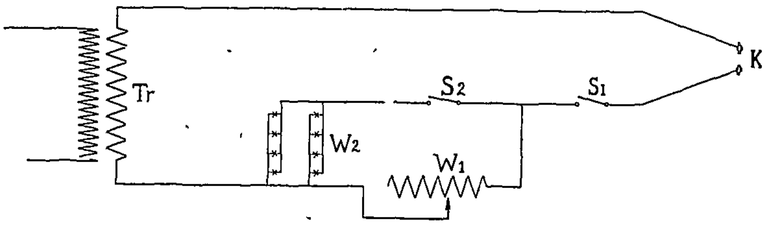

Fig. 3.

K clamps of the transformatorboard, S_1 and S_2 switches, W_1 large resistance, W_2 small (lamp-) resistance, Tr transformator.

If in the case of an alternating field observations at different potential differences had to be made soon after each other, the arrangement of fig. 3 was used. Here the primary circuit only has been indicated; the condensator vessel forms part of the secondary circuit. By first shutting the switch S_1 and then S_2, we obtain in a simple way between the ends of the secondary circuit very different potential differences soon after another at least if the resistances W_1 and W_2 are very different from each other.,

Electrometers of **Braun** were used to measure the tension. They had been calibrated before. The curved glass bar was again very useful as a sensitive *compensator* by means of which differences in phase of $6 \times 10^{-5} \lambda$ may still be detected, as has been found formerly.

As a source of light in some cases a Nernst lamp was used, generally however an arc lamp.

3, *Measurements of the electric double refraction of a cloud of ammonium chloride.*

By means of the arrangement described in the preceding paragraph, the phenomena could be investigated with the naked eye qualitatively only. Therefore a camera or a telescope with an ocular-micrometer were used for the measurements. Both were inserted behind the analyzer (see fig. 1).

In order that the place of the black band could be determined, two horizontal wires were stretched on the bead, one horizontally and one vertically. Along the latter the distances could be measured. The image, formed by the lens of the camera or the objective of the telescope, is represented by fig. 4. $\frac{a}{b}$ determines the place of the band. If now in the path of the light a double refracting substance is inserted with its principal directions parallel to those of the bead, this ratio becomes $\frac{a_1}{b}$. From the theory of the bead it now follows, that $\frac{a_1-a}{b}$ is proportional to the difference in index of refraction of the ordinary and the extra-ordinary beam $(n_q - n_b)$. In the case of the photographic method the values a and b were measured on the plates. In the observations by means of the telescope the ocular micrometer with a scale division of five per mm. enabled to read the places directly, from which thus the displacements which were proportional to $(n_q - n_b)$ could again be derived easily.

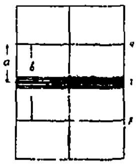

Fig. 4.

A difficulty of the measurements was the change the same cloud undergoes in the course of time. These changes are of different nature: 1. the particles, by which the nebulum is formed, gradually become larger; 2. constantly particles disappear; 3. a certain number of them is charged and by a constant electric field these are conducted to one of the condensator plates; 4. the cloud of ammonium chloride especially undergoes still a change which becomes obvious by the change of sign of the double refraction from positive to negative; perhaps this is connected with a change in form or the change in dimensions, mentioned sub 1, of the small crystals. In my dissertation I will show in what way I tried to overcome these disturbing influences.

4. *Results of the measurements.* I first measured the double refraction of the α-modification and that in an alternating field. The condensator vessel used for this and also for all the following experiments of this paragraph had plates on the inside; it had the following dimensions: length 44,5, height 10 cm and inner width 9,5 mm, while to the middle of the vertical sides strokes of tinfoil of 40 × 4 cm. were applied. The observations were made photographically.

With one plate 4 observations were made:

one without field and then successively for the tensions V_1, V_2 and V_1. In the ordinary way this plate was developed and treated further. Afterwards the distances were measured on it. Then the values $\frac{a}{b}$, $\frac{a_1}{b}$, $\frac{a_2}{b}$ and $\frac{a_3}{b}$ are known for the four observations and therefore also the ratios $\frac{a_1-a}{b}$ etc. which are proportional with n_q-n_b of the cloud for fields of V_1 etc.

In order that the cloud may not be changed during the four measurements, $\frac{a_1-a}{b}$ must be equal to $\frac{a_3-a}{b}$. In some cases this difference was rather small, as is shown by this table.

$\frac{a_1-a}{b}$	$\frac{a_3-a}{b}$
0.106	0.104
0.050	0.056
0.077	0.078
0.077	0.085

But even in cases, in which the difference is greater, such a plate has still some value. For if the obtained results are represented graphically, the tensions being taken as abscissae and the values $\frac{a_1-a}{b}$ etc. as ordinates, we find one point for V_2 and two for V_1. The curve must therefore pass through 1 the origin, 2 through the point for V_2, 3 between the points for V_1. If now the values $\frac{a_1-a}{b}$ and $\frac{a_3-a}{b}$ are very different from each other, there is a rather great distance between the two points found for V_1. But at any rate we know that the curve must pass between those two points.

In order to determine other points I took new clouds, which I investigated in the fields V_3, V_2, V_3 etc. The second field was always equal to that used with the first plate. By measuring the distances on the plates, we now obtained the ratios $\frac{a_1'-a}{b}$, $\frac{a_2'-a}{b}$, $\frac{a_3'-a}{b}$ or quantities proportional with these. So we may also make $\frac{a_2'-a}{b}=\frac{a_2-a}{b}$, if only at the same time the other forms are changed in the same ratio. In this way we might obtain a new point for the curve, at least if these considerations are right. In order to know this I investigated *two or more clouds* in the *same* fields, successively V_1, V_2, V_1 to see, whether the ratio of the double refraction in the fields V_1 and V_2 was the same.

Some of these ratios for equal fields are given here.

$\frac{a_1-a}{b}:\frac{a_2-a}{b}$	Tensions
1.13; 1.19; 1.14	$V_3 = 510$ volt $V_1 = 925$--1050 „
1.54; 1.44	$V_2 = 1000$ volt $V_1 = 2500$ „
1.36; 1.30	$V_2 = 510$ volt $V_1 = 1900$—1970 „

From the rather small differences I am inclined to conclude, that the results with different clouds may be combined to one single curve.

In the following table the results obtained with different tensions have been put together.

Tensions	$\frac{a_2\ a}{b}$	$\frac{a_1 - a}{b}$
$V_2 = 1000$ volt $V_1 = 3500$ „	50	71—80
$V_2 = 1050$ volt $V_1 = 1800$ „	51	63—70
$V_2 = 1000$ volt $V_1 = 2500$ „	50	70—78

Here the tensions have been indicated by the potential differences between the plates in volts. The two following columns give values proportional with $\frac{a_n - a}{b}$ and therefore with $n_b - n_g$ of the cloud in the corresponding electric fields; for a tension difference of 1000 volts has been taken the value ± 50.

Representing this graphically we obtain this curve, where the

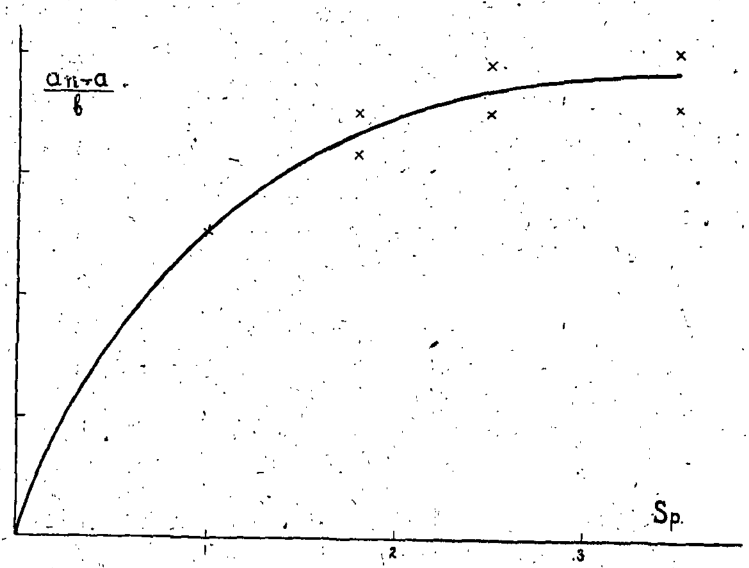

Fig. 5.

tension is measured along the axis of X in kilovolts and the values $\frac{a_n - a}{b}$ or quantities proportional with these along the Y axis.

We see that the double refraction approaches asymptotically a maximal value.

The electric double refraction of ammonium chloride is thus proved to be not proportional with the square of the intensity of the field. For if it were so it should have to show a same dependency on the field in an *alternating* field. Since this is not the case however the dependency on the field cannot be derived from the above curve, also by the uncertainty where in this case of the 50 alternations per second the band of the bead will appear; for the band follows the alternations, as has been proved by means of a stroboscopic method.

Therefore an investigation in a *constant* field was required. For this purpose the electric arrangement sketched in fig. 2 was used, with a few changes in the case of weaker fields. The observations were made photographically.

Again one plate was exposed four times with one and the same cloud: first without field and then with the tensions V_1, V_2 and V_1. In the same way as above, the plates were again developed etc. and then the distances were measured. Now too measurements were made for a series of different clouds, the results of which were

Tensions V_1 in volts, while $V_2 = 510$, sometimes $= 530$ volt	$\frac{a_1 - a}{b}$, while $\frac{a_2 - a}{b}$ has been put $= 50$	
210	18	19
210	20	23
240	33	35
270	36	49
330	34	36
810	71	74
925	54	59
990	56	63
1050	54	60
1360	57	61
1900	62	68
1970	67	69
2280	54	65
3400	57	68

reduced to each other. The result of the measurements is given above. (See table p. 422).

The results have also been represented graphically in two curves: fig. 6*a* for the lower, fig. 6*b* for the higher tensions. In the second diagram the tension is again expressed in kilovolts, in the first in volts.

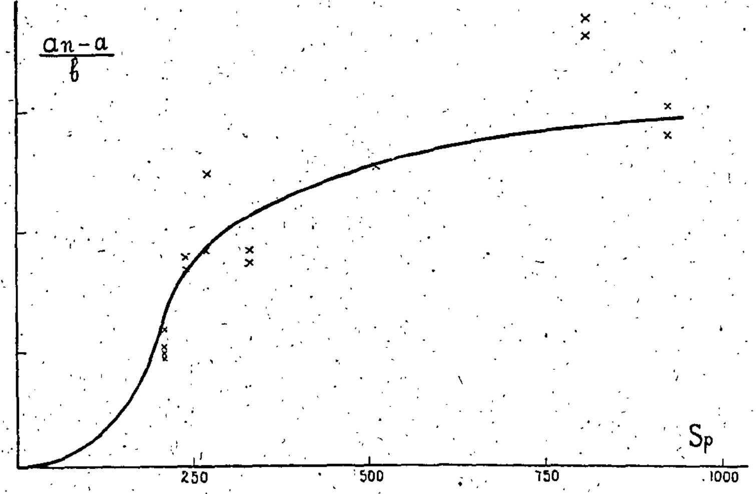

Fig. 6*a*.

In the region of the lower tensions the curve shows a point of inflexion, so that it is possible — VOIGT regards this as necessary — that by a first approximation the double refraction is proportional with the square of the field.

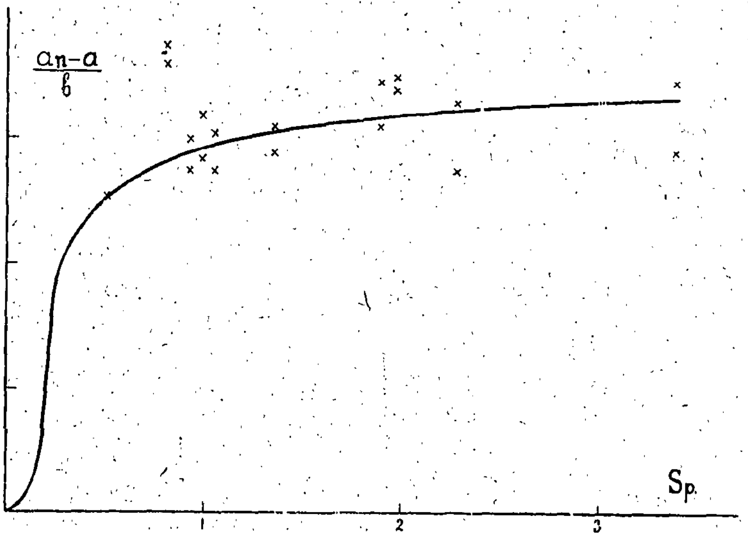

Fig. 6*b*.

The course of the curve makes it evident that also for a constant field the double refraction approaches asymptotically a maximal value.

Further the double refraction of the *β-modification* has been measured. This was done by means of a telescope with an ocular-micrometer. This modification was investigated in a constant field only. The researches were made in the following way. A cloud was blown into the condensator vessel. Then the place of the band, the field being not switched on, the zero position, was determined. Then the field was excited, successively the tensions V_1 and V_2, and the position of the band was read in these cases. As soon after each other as was possible this was repeated twice with the same cloud and finally the zero position was again determined. Here follows a set of observations.

	Zero position	Tension V_1	Tension V_2	Position band for tens. V_1	Position band for tens. V_2	Displacement band		Ratio of the displacements
						for tens. V_1	for tens. V_2	
Observed quantities	3¼	2100	730	5¼	4¼	2	1	1.9
								1.7
		2100	720	5	4¼	1¾	1	
								1.6
	3¼	2150	720	4¾	4	1½	¾	1.7
Mean values	3¼	2100	725	—	—	—	—	1.7

The last column has been derived from the two preceding ones by combining each time two successive values of one column with the value from the other column that has been observed between. For nearly equal tensions I made for each of a series of clouds such a set of observations. The mean of this series was

V_1	V_2	Ratio
2125	715	1.68

Also for other tensions series of observations were made. The mean values found from them have been arranged in this table.

V_1 in volts	V_2 in volts	Ratio double refraction
1460	640	1.45
2125	720	1.68
2670	700	1.77
3470	625	1.9

Fig. 7 gives the curve (abscissae in kilovolts) which has a similar form as the preceding one.

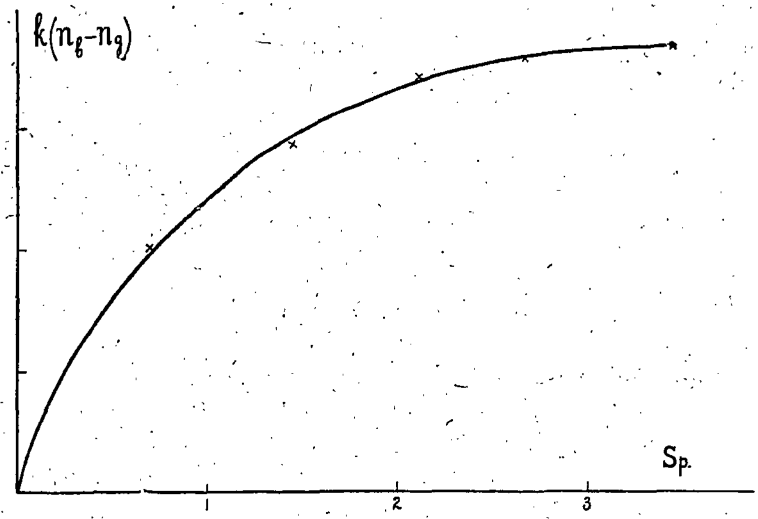

Fig. 7.

It was remarkable, that the double refraction of this modification is sometimes several times greater than that of the α-form. This may be caused by differences in density and difference in specific double refraction.

5. *Dispersion in the electric double refraction.* This occurs by no means always and if it does distinctly for the β-modification. It may be observed by the coloured edges of the black band of the bead, but for a more accurate investigation special decomposition was required. For this purpose an arrangement was used, much similar to that which Prof. Zeeman used formerly for his measurements of the Kerr-effect in liquid air[1].

In the telescope of the spectroscope an ocular micrometer had been fixed and by means of this the position of the black band could be read for the different colours. Some results have been given below.

Tension in volts	Zero-position	Place red	Place blue	Displacement red	Displacement blue
5500	5½	3	4	2½	1½
5500	4¾	3	4	1¾	¾

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[1] Zeeman, these Proceedings XIV, p. 650.

We see, that the dispersion may be very strong and that it is such that the rays with the greatest index of refraction show the smallest double refraction, which result is in contradiction with all that has been found till now on the electro-optic KERR-effect. Still it may be mentioned, that for the same mean double refraction the cloud showed a greater dispersion when it had stood for some time than when it had just been formed.

With the *a-modification* no definite result was reached. If however dispersion is shown by this too, then the rays of the greatest refractivity will also show the greatest double refraction.

6. *Experiments with other clouds.* Results similar to those found for ammonium chloride were reached with clouds of indigotine and ammonium-bromide and -iodide.

A remark of BLOCH [1]) on the properties of a cloud of *indigotine* in a magnetic field induced me to an investigation of this cloud. It was produced by heating the solid substance. For many experiments indigotine pur. cryst. of the "Pharm. Handelsvereeniging" was used. This heating however always caused decomposition, accompanied by formation of clouds [2]). A dry air current led over the heated substance carried the mixture to a condensator vessel, where it was proved to become double refracting and sometimes slightly dichroistic under the influence of an electric force, while the light was dispersed stronger in a perpendicular direction.

It has not yet been found out which substance it is that shows these properties. For a cloud of aniline, one of the products of decomposition, not any electro-optic effect could be detected.

Ammonium-bromide and -iodide showed just the same properties in the electric field as ammonium-chloride, also in this respect, that one and the same cloud, which at its formation was positively double refracting, after some time had become negative. If this change of sign is connected with the allotropy of those substances, this behaviour might have been expected for ammonium-*bromide*. For, as to their properties NH_4Cl and NH_4Br are very similar; they are enantiotropic, as has been proved by WALLACE [3]); for the points of transition SCHEFFER found: for NH_4Cl 184°,5 [4]) and for NH_4Br about 137° [5]).

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[1]) BLOCH, Loc. cit.

[2]) Thus BLOCH speaks of "fumées provenantes de la sublimation de l'indigotine".

[3]) WALLACE, Centralblatt für Mineralogie u.s.w. 1910 S. 33.

[4]) SCHEFFER, These proceedings, XVIII p 446 and 1498.

[5]) SCHEFFER, Handelingen 15de Ned. Natuur- en Geneesk. Congres te Amsterdam, pag. 242, Haarlem 1915.

Above these temperatures they crystallize into cubes, below them into the well-known skeleton form. If they are formed at ordinary temperature and undergo later a transformation, there are first formed cubes for them both (the β-modification, unstable at ordinary temperature). Later on a transformation into needles occurs (the α- or stable modification). Ammonium-iodide shows other properties; at ordinary temperature it crystallizes into cubes. SCHEFFER has proved however, that NH_4I is also dimorphous and enantiotropic, but that its point of transition lies near —16°. He had the kindness to tell me this result, which has not yet been published. At ordinary temperature NH_4I will therefore first exist as needles and then as cubes and from what has been said above, we might expect that the change of sign of the double refraction will have the opposite direction for NH_4I as for NH_4Cl and NH_4Br. This not being the case, we may conclude that the allotropy is of no influence in this question. I express still my thanks to Dr. SCHEFFER, who was so kind as to test the purity of the NH_4I.

7. *Some remarks on the explanation of these phenomena.* In my opinion the explanation may not be sought in the direction of the electro-optic KERR-effect. Firstly not because for ammonium-chloride the double refraction approaches a maximal value, while the KERR-effect always shows a quadratic dependence on the field and further because the small density of the cloud (generally less than 0,00005) would oblige us to ascribe to ammonium-chloride a constant of KERR of the order of $10^5 \times$ that of CS_2, which would be very improbable. I tried to find another explanation by assuming the particles to be directed by the field. Ammoniumchloride being regular in both modifications they should have then a stretched form. Microscopically however such a form could not be detected. Perhaps the particles were too small (5.10^{-5} cm. and smaller). Nor was an orientation observed microscopically. Besides the vivid BROWNIAN movement of the particles of the ammonium-chloride many of them were seen — in the case of an alternating field — to get into oscillation, as had formerly already been observed by COTTON and MOUTON [1]) and recently again by KRUYT [2]) in some colloidal solutions. Fall experiments with particles of ammoniumchloride have made it probable however that an electric field causes an orientation

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[1]) COTTON et MOUTON, Les ultramicroscopes. Les objets ultramicroscopiques. Paris 1906, pag. 154 and foll.

[2]) KRUYT, these Proceedings XVIII, p. 1625.

(Przibram[1]) and researches in the Amsterdam laboratory). This however does not yet explain the double refraction.

A comparison with the behaviour of the "liqueurs mixtes" in an electric, or of the iron of Bravais in a magnetic field is of no value, as in those cases the particles themselves are double refracting or at least are supposed to be so. For ammonium-chloride this is excluded. An explanation may be sought perhaps in the direction of O. Wiener's "double refraction of beads". [2]).

II. The influence of the electric field on the intensity of the transmitted and the dispersed light.

8. *Introduction and method of observation.* Some of these phenomena have already formerly been observed (see **1**). In this investigation three directions occur: the direction of the incident light (L), that of the electric field (V) and that, in which the observations are made (W). With respect to each other these directions can have different positions. By fixing these by means of the system of coordinates PQR (see fig. 8) we obtain the cases of the next table.

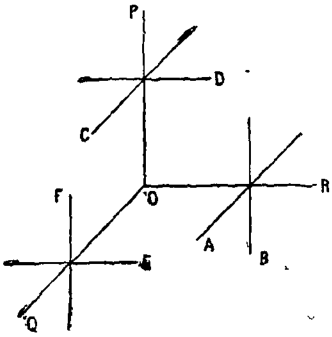

Fig 8.

Number	L	V	W
I	R	Q	P
II	R	Q	Q
III	R	Q	R
IV	R	R	P
V	R	R	R

Moreover we may still distinguish the cases in which the incident light is unpolarized or polarized in one of the "principal directions". Also the state of polarization of the transmitted or of the dispersed light may be investigated.

The observations were made microscopically or with the naked eye. For the first method small condensator vessels were constructed with condensator plates of 15 × 15 mm at a distance of ± 7 mm; for the other a large condensator was used, the plates of which

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[1] Przibram, Phys. Zs. **11**, 630, 1910.

[2] O Wiener, Leipz. Ber. **91**, 113, 1909, **63**, 256, 1910.

had a distance of ± 10.5 mm and which was placed in a box of cardboard, which had been filled with a cloud. All the experiments described in this chapter were made with ammonium-chloride and in an alternating field.

9. *Summary of the observed phenomena.* The following may serve as an interpretation for the tables below, in which the results have been collected; the letters in the second and third columns indicate, that oscillations of the direction denoted by it (see fig. 8) are transmitted. If a letter has been omitted, there is no polarizer or analyzer. The intensity of the field has been given in volts per cm.

It is easily seen that with these three numbers the cases are exhausted. For a polarizer e. g. B cannot give anything new.

The numbers 20 and 21 clearly show the dichroistic character of ammonium-chloride. Formerly Prof. ZEEMAN and the author[1]) had

CASE I.

L // R, V // Q, W // P.

Method of observation: microscopically.

Number	Polarizer	Analyzer	Intensity of the field	Phenomena at the switching on of the field.
1	—	—	5400	Strong increase of intensity.
2	—	C	5400	Idem.
3	—	D	5600	Weak incr. of int. Without field cloud blue and not intense.
4	A	—	5600	Strong incr. of int.
5	A	C	5600	Idem.
6	A	D	5600	Without field some particles visible. At the switching on of the field they vanish or become weaker. At the vanishing they reappear. Another time general decrease of intensity under influence of the field.
7	B	—	5600	Moderate but observable incr. of int.
8	B	C	5600	The particles disappear or the int. diminishes. Without field very weak.
9	B	D	5600	Nearly as 7.

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[1]) ZEEMAN and HOOGENBOOM, Communication II.

CASE II.

L // R, V // Q, W // Q.

Method of observation: directly with the naked eye

Number	Polarizer	Analyzer	Intensity of the field	Phenomena at the switching on of the field.
10	—	—	3900	Decrease of intensity
11	—	E	»	» » »
12	—	F	»	» » »
13	A	—	»	» » »
14	A	E	»	» » »
15	A	F	»	No influence of the field observed (without field very weak)
16	B	—	»	Decrease of intensity.
17	B	F	»	» » »
18	B	E	»	The dispersed light, hardly existing without, seems to vanish quite under influence of the field.

CASE III.

L // R, V // Q, W // R.

Method of observation as II.

Number	Polarizer	Analyzer	Intensity of the field	Phenomena at the switching on of the field.
19	—	—	3800	Decrease of intensity.
20	—	A	»	» » »
21	—	B	»	» » » But less than for 20.

already concluded from the sense of the "rotation of the plane of polarization", that the oscillations parallel to the electric force are absorbed stronger than those perpendicular to it.

CASE IV.

L // R, V // R, W // P.

Method of observation as in II.

Number	Polarizer	Analyzer	Intensity of the field	Phenomena at the switching on of the field.
22	—	—	3600	Decrease of intensity.
23	—	C	"	" "
24	—	D	"	" "
25	A	—	"	" "
26	A	C	"	" "
27	A	D	"	" " 1)
28	B	—	"	" "
29	B	D	"	" "
30	B	C	"	" " 2)

CASE V.

L // V // W // R.

Method of observation as in II, but the distance between the condensator plates was 2 cm.

In this case the use of polarizer and analyzer has no sense as all directions perpendicular to the direction of observation are equivalent.

Number	Intensity of the field	Phenomena at the switching on of the field
31	3750	Increase of intensity

10. *Dispersion phenomena.* Only the dispersion in the dichroism was investigated. The same arrangement as for the dispersion in the double refraction was used. In this way was found, that the difference in absorption for vibrations parallel with and perpendicular to the field (according to nrs. 20 and 21 a positive quantity) increase, when the wavelength decreases.

11. *Possible explanation of the phenomena.* Voigt 3) has shown, how the electric dichroism can be explained by taking into consideration the absorption in Langevin's orientation theory; further that in a region of absorption the absorption power must undergo an influence of the field for *natural* light too. The occurrence

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1) Without field the intensity of light less than for 26.

2) " " " " " " " " " 29

3) Voigt, Gött. Nachr. 1912, 577; Graetz, Handbuch der Elektrizität und des Magnetismus 1, 338, 1914.

of both phenomena in ammonium-chloride may not be considered however as a statement of these results. For VOIGT[1]) finds the connexion

$$\frac{n_1\varkappa_1 - n\varkappa}{n_2\varkappa_2 - n\varkappa} = -2,$$

where $n\varkappa$ is the absorption coefficient outside the field, $n_1\varkappa_1$ and $n_2\varkappa_2$ the absorption coefficients for the ordinary and the extraordinary rays. For ammonium-chloride it has been found here however, that the vibrations along both of the principal directions are absorbed stronger, so that the above fraction is *positive*.

A plausible representation of these phenomena may be obtained however by the assumption of an orientation of the somewhat elongated particles of the ammonium-chloride.

The phenomena of Case I (see 9) are analogous to phenomena of this kind: fine lines on glass or corrosion figures on crystals are seen clearly, when the length direction of the lines or figures is perpendicular to the plane through the incident ray and the line of observation[2]). In Case II the eye has the most disadvantageous position to receive light of the orientated particles. In Case IV the incident light has a disadvantageous direction for the deflexion. Case V is easily derived from IV. The dispersion only cannot be explained by the orientation. For in the case of a slit-width below a wavelength, we should expect just the opposite from what has been observed.

Finally I wish to express my indebtedness to Prof. ZEEMAN for his encouragement and powerful assistance in this research.

Amsterdam, June 1916.

Chemistry. — *"The Interpretation of the Röntgenograms and Röntgenspectra of Crystals".* By PROF. A. SMITS and DR. F. E. C. SCHEFFER. (Communicated by Prof. J. D. VAN DER WAALS).

(Communicated in the Meeting of June 24, 1916.)

1. LAUE's researches [3]) and those by W. H. and W. L. BRAGG [4]) about the diffraction of Röntgenrays by crystals have given rise to a view about the arrangement of the atoms in the solid substance, which, though sufficiently in agreement with the *physical properties* of the substance, cannot be reconciled with our *chemical ideas.*

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[1]) Loc. cit. p. 585.

[2]) Compare COTTON et MOUTON, Les ultramicroscopes, les objets ultramicroscopiques. Paris 1906, p. 167.

[3]) Sitzungsber. d. Bayer. Akad. d. Wiss., Juni 1912.

[4]) Proc. Cambridge Phil. Soc. 17 (1912) I, 43.