Zeeman Effect of Neon Lines.

By

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§ **1.** *Introduction.*

The spectrum lines of neon, being characterised by their brightness and sharpness, are most suited for the study of Zeeman effect. An elaborate study on this subject hitherto published seems to be that of Lohmann(1), who has used an echelon grating of 32 plates and obtained many good photographs of the complex separations. Runge(2) founded his rule of the aliquot part on Lohmann's results.

In the measurement of the Zeeman effect, the accuracy in the determination of the strength of magnetic field is often questionable, as the strength of the field fluctuates even under the careful control of the electric current exciting the electromagnet, so that the reading of an ammeter cannot be much relied upon as a measure of the field strength.

The ballistic method, which consists in placing a proof coil in or out of the air gap of the electromagnet before and after each experiment, is more preferable, but it is still doubtful whether the strength of the magnetic field remains constant throughout the time of exposure of the photograph or not, especially during long exposure.

In the present experiment, the absolute determination of the strength of magnetic field was not attempted, but we adopted the separation of a standard line of which the amount of separation is well known as a measure of the field, and compared the separations of other lines referred to this standard line. In such cases, we can avoid the above difficulty by taking the photograph of the separations of many lines on a single plate, for in this case all the lines suffer the fluctuation of the field strength equally. A Rowland grating is suited for this purpose, but its resolving power is generally far inferior to that of an echelon grating.

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(1) Lohmann, Diss., Halle, (1907.)

(2) Runge, Phys ZS., **8**, (1907) p. 232.

For such spectrum as that of neon, which has a large number of bright lines in a comparatively narrow region between yellow and red, the use of horizontal echelon as used by Zeeman([1]) in his study of the dissymmetry of the Zeeman effect of the yellow mercury line (λ: 5790) seems to be of great convenience.

On the other hand, the use of a Fabry-Perot interferometer for the study of Zeeman effect has already been recommended by Zeeman and several other investigators; the principal advantage being the smallness of probable errors in the result. This method also allows us to measure the separations of many lines on a single plate.

Applying these two methods, we have taken in the present experiment two photographs simultaneously, for each stage of the strength of magnetic field.

The present experiment was confined to the transverse Zeeman effect only.

§ **2.** *Method of investigation.*

The arrangement is shown in Fig. 1.

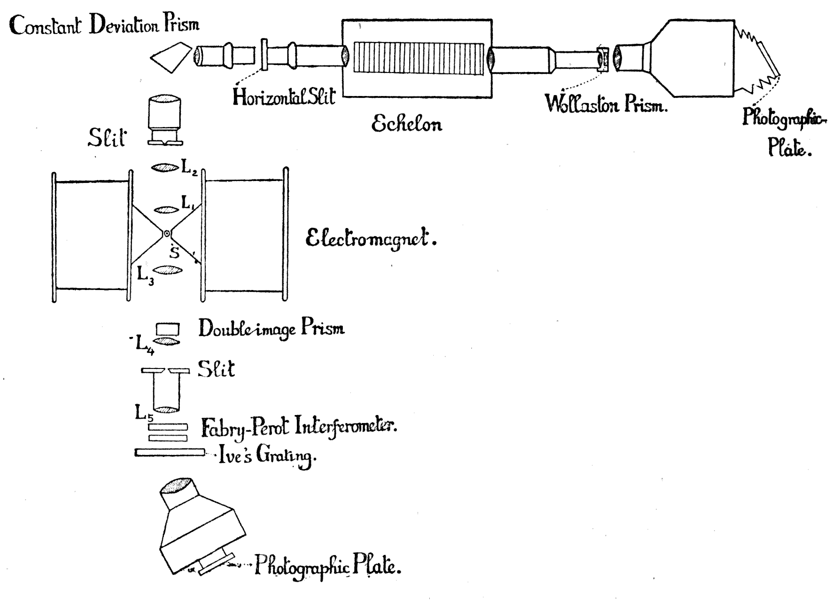


Fig. 1.

([1]) Zeeman, Archives Neerl. d. Sciences II, **14**, (1909) p. 267.

The source S was an ordinary Geissler tube filled with neon, placed vertically between conical poles of an electromagnet, having the vertical angle of 80°, the diam. of the end faces being 20 mm., and the air gap between the poles about 5 mm. The capillary of the Geissler tube was screened except a portion about 8 mm. long at the centre of the air gap.

The tube was excited by an induction coil, whose primary was run by an alternating current of 50 cycles per second. A spark gap of about $\frac{1}{2}$ mm. was placed parallel to the tube.

The light from S was concentrated by the two lenses L_1 and L_2 on the slit of a collimator, and after being dispersed by the constant deviation prism, was projected on a horizontal slit. It then traversed an echelon of 35 plates, made by Hilger, placed with its steps horizontal. The photograph was taken by an anastigmatic objective by Goerz. Sometimes a Wollaston prism was placed before the objective to separate the parallel and perpendicular components. To accomodate the difference of focal length for different wave lengths, the photographic plate was inclined about 30° to the axis of collimation.

On the other side of the electromagnet, the light from S was concentrated on a slit of the collimator by the two lenses L_3 and L_4. A double image prism was placed before the second lens L_4, so that the images due to the oscillations parallel and perpendicular to the magnetic field occupied the upper and lower half of the slit respectively.

After the light was made parallel by the achromatic lens L_5, it passed through a Fabry-Perot interferometer, which was of the sliding type and made by Hilger. Immediately behind the interferometer was placed an Ives' transparent grating, and the first order spectrum was photographed by a Zeiss's Tessar lens.

The echelon grating was placed in most cases with its front face almost normal to the incident ray. But as the angle between the direction of the diffraction maximum at the position of minimum deviation and that of the incident ray is not the same for light of different wave lengths, the intensity ratio of the consecutive orders showed considerable difference for some lines.

This, however, did not cause much trouble, for the interpretation of the photographs was quite easy and the choice of the orientation for a certain line could at once be effected by a minute rotation of the echelon about a vertical axis. Owing to the great difference in intensity, all the lines could not be measured on a single plate, but in general it was possible to measure more than ten lines.

As Stansfield (1) remarked in his paper on the behavior of echelon spectroscope, the changes in the value of $d\lambda_{\text{max.}}$ arising from the deviation of the position of echelon from that of the minimum deviation are negligibly small.

To avoid the change of temperature, the echelon was enclosed in an wooden box lined with thick cork plates. One of the advantages of the method in using the Fabry-Perot interferometer was the great intensity of light. With a few minutes exposure, we could obtain a photograph sufficient for the measurement of most of the lines. But as remarked by Zeeman (2), difficulty arises from the proximity of neighbouring fringes. When the air-plate is thin, the fringes are widely apart, but the resolving power is small and each fringe appears very diffuse. As the thickness of the air-plate increases, each fringe becomes more sharply defined, but at the same time the neighbouring orders come nearer, so that the limit is immediately reached. The complexity may be avoided to a certain degree by separating the components due to parallel and perpendicular oscillations, and in some cases we could measure the separations of a sextet or those of the parallel component of some nonets or that of 12 components, but for the perpendicular components of the complex separations such as 12 or 15 components, the measurement was almost impossible.

When we compare the above two methods, we may conclude that for the complex separations an echelon spectroscope is indispensable, but for the accurate determination of the separation of the simple type such as a triplet or a quartet, a Fabry-Perot interferometer has the advantage of incurring small error of observation, as well as that of short exposure.

To determine the strength of the magnetic field, we have compared the separation of the bright yellow line of neon ($\lambda : 5853$) to the red helium line ($\lambda : 6678$) and also to the green mercury line ($\lambda : 5461$).

By the investigation of Paschen and Back (3), the red helium line is known as a normal triplet ($a = 4{\cdot}698 \times 10^{-5}$/gauss. cm. giving $\frac{e}{m} = 1{\cdot}771 \times 10^{7}$ E.M.U.), and by the investigations of Runge and Paschen (4),

(1) Stansfield, Phil. Mag, 18 (1909) p. 371.
(2) Zeeman, Researches in Magnetooptics, p. 112 1913.
(3) Paschen and Back, Ann. d. Phys. 39 (1912), p. 897.
(4) Runge and Paschen, Abh. d. Berliner Akad. 1902.

Nagaoka[1] and several others, the green mercury line is known as a nonet of the type $\left(\frac{a}{2}, a, \frac{3a}{3}, 2a.\right)$

The comparison was first made by taking the echelon photographs of the separation of the standard line immediately before and after photographing the separated yellow neon line. Since five minutes exposure was generally sufficient for each line, the comparison was finished within 15 to 20 minutes, including the time for exchanging the source of light. Afterwards we procured a tube containing both helium and neon, so that the comparison could be made on a single photograph.

The mean of the results of these comparisons gave the value $\frac{\delta\lambda}{H} = \pm 1{\cdot}66$ for the neon triplet ($\lambda : 5853$), while Lohmann obtained the value $\pm 1{\cdot}62$. This yellow line, being very intense and simple in separation, was well suited as a reference line in the neon spectrum.

In the present experiment the maximum field strength was about 18000 gauss; the above comparison was also made within this range.

For the photographic plate, we used the spectrum panchromatic plate of Wratten & Wainwright for the red lines, and the Agfa chromo-isolar plate for the green lines.

§ **3.** *Process of Reductions.*

The photographs were measured with a micrometer microscope, one division of the drum being equivalent to 1_μ.

With the photographs obtained by an echelon grating the measurement was quite simple. The separation of the reference line $\lambda : 5853$ being measured at first, the strength of the magnetic field was determined for that plate, and hence the separations of all the other lines could at once be calculated.

With a Fabry-Perot interferometer, we have

$$P\lambda = 2e\cos\theta, \quad\quad (1)$$

where P is the integer denoting the order of interference fringes for light of wave-length λ, when the thickness of the air plate is e, and 2θ the angle subtended by that fringe.

If we denote the focal length of the photographic objective by f, and the radius of the ring corresponding to θ by r, we have from (1)

(1) Nagaoka, Phys. ZS. **11** (1910), p. 789.

$$P\lambda = 2e\left(1 - \frac{r^2}{2f^2}\right), \dots\dots\dots\dots\dots\dots (2)$$

neglecting the higher powers of θ.

Let $\delta\lambda$ and δr be the small changes in λ and r respectively, caused by the magnetic field, then we can obtain from (2)

$$\delta\lambda = \frac{\lambda r\,\delta r}{f^2}. \dots\dots\dots\dots\dots\dots (3)$$

Thus by measuring r and δr for many rings, we obtained the values of $\delta\lambda$, the probable error of which was of the order $\pm 0{\cdot}1$ m. Å. U.

The strength of the magnetic field determined from two photographs taken simultaneously by the above two methods generally agreed within a few per cents.

§ **5.** *Result of Experiment.*

Out of 120 photographs taken by these two methods, we have selected a few typical ones and reproduced them in Figs. 1, 2 and 3 on Pl. XVI.

The number of lines measured in the present experiment was 28 in all, among which 21 lines were already measured by Lohmann. Of the seven new lines, two were at the red end, and five were in the yellow and green part of the spectrum.

When grouped by the number of components, we have

10	lines	of	3	components,
3	,,	,,	6	,, ,
11	,,	,,	9	,, ,
3	,,	,,	12	,, ,
1	,,	,,	15	,, .

The following table (Table I) shows the values of $\frac{\delta\lambda}{H}$ and $\frac{\delta\lambda}{\lambda^2 H}$ for different lines, most of the measurements being made on echelon photograms. The values obtained by Lohmann are also tabulated for the sake of comparison.

Table I.

λ in Å.U		$\pm \frac{\delta\lambda}{H} \cdot 10^5$	$\pm \frac{\delta\lambda}{\lambda^2 H} \cdot 10^{13}$	Type	Multiples of x	Exposure	Remarks
*7033	//	0	0	0		1^h	
		1·13	2·29	$\frac{a}{2}$	$x_1 = 2·372$		
	⊥	2·36	4·78	a	$2x_1 = 4·744$		
		3·52	7·13	$\frac{3a}{2}$	$3x_1 = 7·116$		
		4·72	9·53	$2a$	$4x_1 = 9·488$		
*6930	//	0	0	0		1^h	
		0·47	0·98	$\frac{2a}{10}$	$2x_2 = 0·948$		
	⊥	2·49	5·20	$\frac{11a}{10}$	$11x_2 = 5·214$		
		2·95	6·15	$\frac{13a}{10}$	$13x_2 = 6·162$		
		3·40	7·10	$\frac{15a}{10}$	$15x_2 = 7·110$		
6717	//	0 (0)	0 (0)	0		30^m	
	⊥	2·17 (2·13)	4·82 (4·70)	a		(45^m)	
6678	//	0 (0·)	0 (0)	0 [„]		40^m	
		0·53 (0·53)	1·19 (1·19)	$\frac{a}{4}$ [„]	$x_3 = 1·232$ [$x_1 = 1·165$]	(1^h 30^m)	
	⊥	2·21 (2·08)	4·97 (4·63)	a [„]	$4x_3 = 4·928$ [$4x_1 = 4·660$]		
		2·74 (2·60)	6·15 (5·82)	$\frac{5a}{4}$ [„]	$5x_3 = 6·160$ [$5x_1 = 5·825$]		
		3·29 (3·13)	7·40 (7·01)	$\frac{6a}{4}$ [„]	$6x_3 = 7·392$ [$6x_1 = 6·990$]		
6599	//	0·63 (0·59)	1·45 (1·37)	$\frac{4a}{13}$ [$\frac{2a}{7}$]	$4x_4 = 1·432$ [$2x_2 = 1·354$]	40^m	
	⊥	2·18 (2·06)	5·02 (4·73)	$\frac{14a}{13}$ [a]	$14x_4 = 5·012$ [$7x_2 = 4·739$]	(1^h 20^m)	
		2·79 (2·65)	6·42 (6·10)	$\frac{18a}{13}$ [$\frac{9a}{7}$]	$18x_4 = 6·444$ [$9x_2 = 6·093$]		
6533	//	0 (0)	0 (0)	0		30^m	
	⊥	1·36 (1·34)	3·19 (3·13)	$\frac{2a}{3}$		(40^m)	
6507	//	0 (0)	0 (0)	0 0		20^m	
		0·65 (0·66)	1·54 (1·56)	$\frac{5a}{15}$ [$\frac{4a}{12}$]	$5x_5 = 1·565$ [$4x_3 = 1·564$]	(25^m)	
	⊥	1·58 (1·50)	3·74 (3·53)	$\frac{12a}{15}$ [$\frac{9a}{12}$]	$12x_5 = 3·756$ [$9x_3 = 3·519$]		
		2·26 (2·16)	5·35 (5·09)	$\frac{17a}{15}$ [$\frac{13a}{12}$]	$17x_5 = 5·321$ [$13x_3 = 5·083$]		
		2·91 (2·72)	6·88 (6·65)	$\frac{22a}{15}$ [$\frac{17a}{12}$]	$22x_5 = 6·886$ [$17x_3 = 6·647$]		
6402	//	0 (0)	0 (0)	0 [„]		7^m	In Fig 1, this line is much overexposed. On some plates specially taken for this line we could measure 15 components distinctly.
		0·33 (0·32)	0·81 (0·78)	$\frac{a}{6}$ [„]	$x_6 = 0·785$ [$x_4 = 0·764$]	(10^m)	
		0·65 (0·63)	1·59 (1·54)	$\frac{2a}{6}$ [„]	$2x_6 = 1·570$ [$2x_4 = 1·528$]		
	⊥	1·92 (1·87)	4·70 (4·57)	a [„]	$6x_6 = 4·710$ [$6x_4 = 4·584$]		
		2·24 (2·19)	5·47 (5·34)	$\frac{7a}{6}$ [„]	$7x_6 = 5·495$ [$7x_4 = 5·348$]		
		2·57 (2·50)	6·28 (6·11)	$\frac{8a}{6}$ [„]	$8x_6 = 6·280$ [$8x_4 = 6·112$]		
		2·89 (2·82)	7·06 (6·88)	$\frac{9a}{6}$ [„]	$9d_6 = 7·065$ [$9x_4 = 6·876$]		
		3·21 (3·14)	7·85 (7·65)	$\frac{10a}{6}$ [„]	$10x_6 = 7·850$ [$10x_4 = 7·640$]		
6383	//	1·48 (1·38)	3·64 (3·38)	$\frac{10a}{13}$ [$\frac{8a}{11}$]	$10x_7 = 3·640$ [$x_5 = 3·33$]	7^m	The parallel and perpendicular components not superposed as in Lohmann's result.
	⊥	1·34 (1·38)	3·29 (3·38)	$\frac{9a}{13}$ [$\frac{8a}{11}$]	$9x_7 = 3·276$ [$x_5 = 3·33$]	(12^m)	
		2·81 (2·70)	6·90 (6·63)	$\frac{19a}{13}$ [$\frac{16a}{11}$]	$19x_7 = 6·916$ [$2x_5 = 6·66$]		
6335	//	0·70 (0·64)	1·75 (1·58)	$\frac{4a}{11}$ [„]	$x_8 = 1·750$ [$x_6 = 1·69$]	10^m	In Fig 1, two of the outermost components of consecutive orders are superposed.
		1·40 (1·35)	3·50 (3·36)	$\frac{8a}{11}$ [„]	$2x_8 = 3·500$ [$2x_6 = 3·38$]	(25^m)	
	⊥	1·40 (1·37)	3·50 (3·41)	$\frac{8a}{11}$ [„]	$2x_8 = 3·500$ [$2x_6 = 3·38$]		
		2·14 (2·04)	5·35 (5·09)	$\frac{12a}{11}$ [„]	$3x_8 = 5·250$ [$3x_6 = 5·07$]		
		2·83 (2·72)	7·07 (6·77)	$\frac{16a}{11}$ [„]	$4x_8 = 7·000$ [$4x_6 = 6·76$]		
		3·50 (3·39)	8·75 (8·45)	$\frac{20a}{11}$ [„]	$5x_8 = 8·750$ [$5x_6 = 8·45$]		

Table I (Continued)

λ in Å. U		$\pm \frac{\delta\lambda}{H}\cdot 10^5$	$\pm \frac{\delta\lambda}{\lambda^2 H}\cdot 10^{13}$	Type	Multiples of x	Exposure	Remarks
6305	//	0 (0)	0 (0)	0 [„]			
		0·47 (0·44)	1·18 (1·10)	$\frac{a}{4}$ [„]	x_9 = 1·156 [x_7 = 1·115]		
	⊥	1·85 (1·78)	4·66 (4·48)	a [„]	$4x_9$ = 4·624 [$4x_7$ = 4·460]	$1^h 20^m$	
		2·29 (2·32)	5·76 (5·58)	$\frac{5a}{4}$ [„]	$5x_9$ = 5·780 [$5x_7$ = 5·575]	(2^h)	
		2·74 (2·75)	6·90 (6·67)	$\frac{6a}{4}$ [„]	$6x_9$ = 6·936 [$6x_7$ = 6·690]		
6267	//	0 (0)	0 (0)	0		20^m	
	⊥	1·85 (1·73)	4·72 (4·40)	a		(30^m)	
6217	//	0 (0)	0 (0)	0 [„]			
		1·50 (1·51)	3·89 (3·90)	$\frac{5a}{6}$ [„]	$5x_{10}$ = 3·940 [$5x_8$ = 3·910]		
	⊥	1·23 (1·21)	3·19 (3·13)	$\frac{4a}{6}$ [„]	$4x_{10}$ = 3·152 [$4x_8$ = 3·128]	40^m	
		2·75 (2·72)	7·13 (7·04)	$\frac{9a}{6}$ [„]	$9x_{10}$ = 7·092 [$9x_8$ = 7·038]	(1^h)	
		4·24 (4·23)	11·00 (10·95)	$\frac{14a}{6}$ [„]	$14x_{10}$ = 11·032 [$14x_8$ = 10·948]		
6164	//	0 (0)	0 (0)	0		20^m	
	⊥	2·45 (2·31)	6·45 (6·07)	$\frac{4a}{3}$		(30^m)	
6143	//	0·48 (0·44)	1·27 (1·17)	$\frac{3a}{12}$ [„]	$3x_{11}$ = 1·227 [$3x_9$ = 1·218]		In Fig 1, the outermost components of consecutive orders are superposed.
		0·94 (0·92)	2·50 (2·45)	$\frac{6a}{12}$ [„]	$6x_{11}$ = 2·454 [$6x_9$ = 2·436]		
	⊥	1·67 (1·57)	4·43 (4·41)	$\frac{11a}{12}$ [„]	$11x_{11}$ = 4·499 [$11x_9$ = 4·466]	15^m	
		2·15 (2·04)	5·70 (5·66)	$\frac{14a}{12}$ [„]	$14x_{11}$ = 5·726 [$14x_9$ = 5·684]	(20^m)	
		2·62 (2·51)	6·95 (6·91)	$\frac{17a}{12}$ [„]	$17x_{11}$ = 6·953 [$17x_9$ = 6·902]		
		3·08 (2·96)	8·17 (8·15)	$\frac{20a}{12}$ [„]	$20x_{11}$ = 8·180 [$20x_9$ = 8·120]		
6096	//	0 (0)	0 (0)	0 [0]		11^m	
		0·30 (0·32)	0·81 (0·86)	$\frac{a}{7}$ [$\frac{2a}{11}$]	x_{12} = 0·672 [$2x_{10}$ = 0·854]	(30^m)	
	⊥	1·98 (1·74)	5·33 (4·68)	$\frac{8a}{7}$ [a]	$8x_{12}$ = 5·376 [$11x_{10}$ = 4·697]	11^m	
		2·21 (2·06)	5·96 (5·54)	$\frac{9a}{7}$ [$\frac{13a}{11}$]	$9x_{12}$ = 6·048 [$13x_{10}$ = 5·551]	(25^m)	
		2·49 (2·38)	6·71 (6·41)	$\frac{10a}{7}$ [$\frac{15a}{11}$]	$10x_{12}$ = 6·720 [$15x_{10}$ = 6·405]		
6075	//	0 (0)	0 (0)	0		11^m	
	⊥	2·54 (2·52)	6·90 (6·80)	$\frac{3a}{2}$		(25^m)	
6030	//	0·19 (0·26)	0·51 (0·68)	$\frac{a}{10}$ [$\frac{2a}{13}$]	x_{13} = 0·475 [$2x_{11}$ = 0·690]	1^h	Great deviations from Lohmann, see p. 285.
	⊥	2·25 (0·97)	6·18 (2·42)	$\frac{13a}{10}$ [$\frac{7a}{13}$]	$13x_{13}$ = 6·175 [$7x_{11}$ = 2·415]	($1^h 30^m$)	
		2·40 (1·13)	6·60 (3·10)	$\frac{14a}{10}$ [$\frac{9a}{13}$]	$14x_{13}$ = 6·650 [$9x_{11}$ = 3·105]		
5976	//	0 (0)	0 (0)	0 [0]			
		0·84 (0·83)	2·36 (2·34)	$\frac{a}{2}$ [„]	x_{14} = 2·350 [x_{12} = 2·335]		
	⊥	1·67 (1·67)	4·68 (4·67)	a [„]	$2x_{14}$ = 4·700 [$2x_{12}$ = 4·670]	$1^h 20^m$	
		2·53 (2·50)	7·10 (7·00)	$\frac{3a}{2}$ [„]	$3x_{14}$ = 7·050 [$3x_{12}$ = 7·005]	(2^h)	
		3·34 (3·33)	9·36 (9·34)	$2a$ [„]	$4x_{14}$ = 9·400 [$4x_{12}$ = 9·340]		
5945	//	0·39 (0·29)	1·11 (0·83)	$\frac{2a}{10}$ [$\frac{a}{5}$]	$2x_{15}$ = 0·946 [x_{13} = 0·936]		
		0·68 (0·65)	1·93 (1·83)	$\frac{4a}{10}$ [$\frac{2a}{5}$]	$4x_{15}$ = 1·892 [$2x_{13}$ = 1·872]		
	⊥	1·83 (1·62)	5·19 (4·58)	$\frac{11a}{10}$ [a]	$11x_{15}$ = 5·203 [$5x_{13}$ = 4·680]	40^m	
		2·16 (1·97)	6·12 (5·58)	$\frac{13a}{10}$ [$\frac{6a}{5}$]	$13x_{15}$ = 6·149 [$6x_{13}$ = 5·616]	(35^m)	
		2·52 (2·32)	7·13 (6·58)	$\frac{15a}{10}$ [$\frac{7a}{5}$]	$15x_{15}$ = 7·095 [$7x_{13}$ = 6·552]		
		2·94 (3·68)	8·32 (7·58)	$\frac{18a}{10}$ [$\frac{8a}{5}$]	$18x_{15}$ = 8·514 [$8x_{13}$ = 7·488]		

Table I (Continued)

λ in Å.U		$\pm \frac{\delta\lambda}{H} \cdot 10^5$	$\pm \frac{\delta\lambda}{\lambda^2 H} \cdot 10^{13}$	Type	Multiples of x	Exposure	Remarks
5882	//	0	0 (0)	0 [,,]		40m (1h)	Lohmann estimated the separation for this line.
	//	0·27 (0·27)	0·78 (0·77)	$\frac{2a}{12}$ [,,]	$2x_{16}=$ 0·768 [$2x_{14}=$0·752]		
	⊥	2·26 (2·83)	6·53 (6·38)	$\frac{17a}{12}$ [,,]	$17x_{16}=$ 6·528 [$17x_{14}=$6·392]		
	⊥	2·52 (3·19)	7·30 (7·14)	$\frac{19a}{12}$ [,,]	$19x_{16}=$ 7·296 [$19x_{14}=$7·144]		
	⊥	2·78 (3·46)	8·04 (7·92)	$\frac{21a}{12}$ [,,]	$21x_{16}=$ 8·064 [$21x_{14}=$7·896]		
5853	//	0 (0)	0 (0)	0		5m (12m)	
	⊥	1·66 (1·62)	4·84 (4·74)	a			
*5820	//	0	0	0		3h	
	⊥	1·51	4·47	a			
*5765	//	0	0	0		3h	
	⊥	1·75	5·27	$\frac{9a}{8}$			
*5690	//	0·	0	0		3h	
	//	0·73	2·26	$\frac{a}{2}$	$x_{17}=$ 2·388		
	⊥	1·58	4·88	a	$2x_{17}=$ 4·776		
	⊥	2·34	7·24	$\frac{3a}{2}$	$3x_{17}=$ 7·194		
	⊥	3·07	9·50	$2a$	$4x_{17}=$ 9·582		
*5563	//	0 (0)	0	0		3h	
	⊥	1·64	5·30	$\frac{9a}{8}$			
5401	//	0 (0)	0 (0)	0		1h (1h 25m)	
	⊥	2·03 (1·90)	6·97 (6·50)	$\frac{3a}{2}$			
*5331	//	0	0	0		3h	
	//	0·89	3·14	$\frac{4a}{6}$	$4x_{18}=$ 3·200		
	⊥	2·28	8·05	$\frac{10a}{6}$	$10x_{18}=$ 8·000		
	⊥	3·20	11·20	$\frac{14a}{6}$	$14x_{18}=$11·200		
	⊥	4·09	14·40	$\frac{18a}{6}$	$18x_{18}=$14·400		

Remarks :

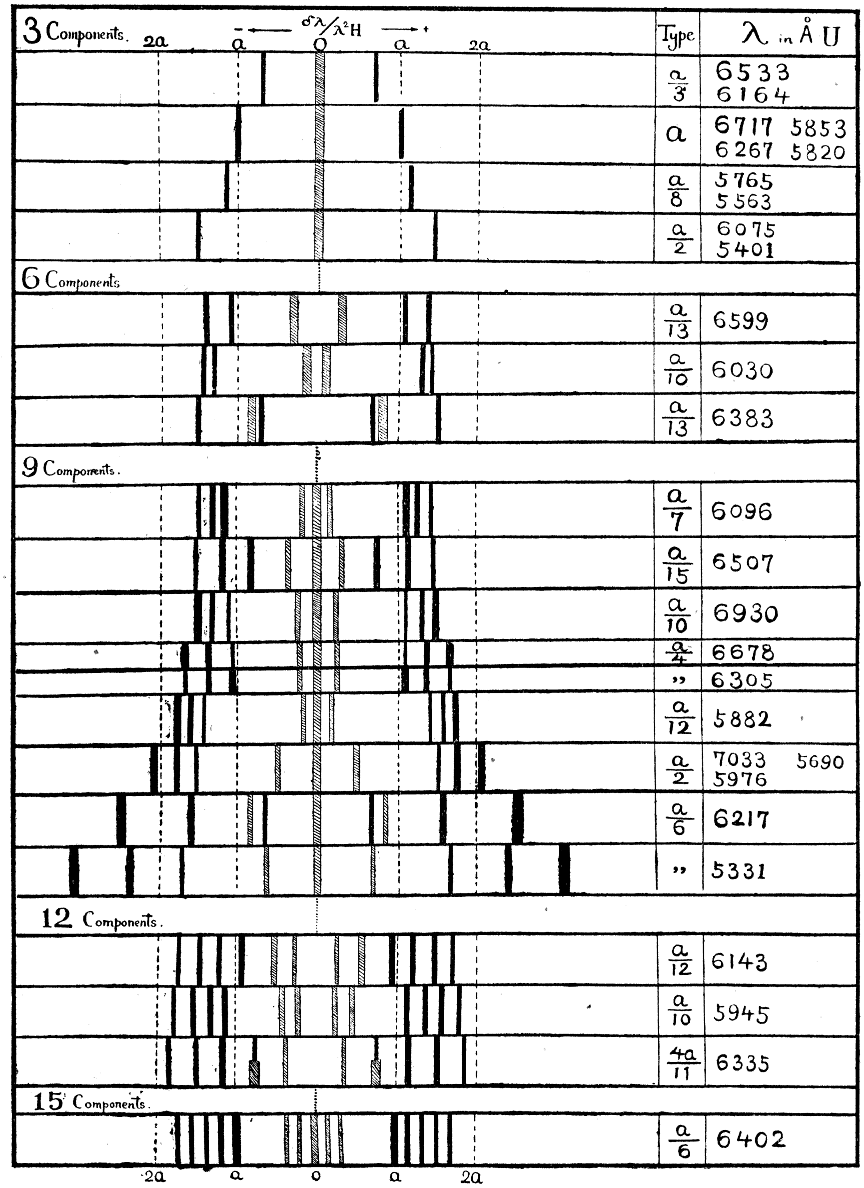
The lines marked by an asterisk in the first column are measured for the first time.
The numbers in brackets are the values given by Lohmann.
The numbers in square brackets [ ] are those given by Runge.

The values of $\frac{\delta\lambda}{H}$ agree tolerably well with those given by Lohmann, but as remarked in the table, the discrepancies are in some cases not small.

The line λ: 6030 shows the greatest deviation, but since the photographic reproduction of Lohmann for this line is quite similar to that of ours, (Figs. 23, 39 in Tafel II, and Fig. 6 in Tafel III in Lohmann's paper); perhaps some may be misprints.

The fourth column of Table I gives the multiples of aliquot parts of the normal distance a, and the fifth column, those of x calculated after the method of Runge [1], the results of Runge being given for comparison.

(1) Runge, *loc cit.*



Different Types:

$$\left(a, \frac{a}{2}, \frac{a}{3}, \frac{a}{4}, \frac{a}{6}, \frac{a}{7}, \frac{a}{8}, \frac{a}{10}, \frac{a}{11}, \frac{a}{12}, \frac{a}{13}, \frac{a}{15}.\right)$$

Fig. 2.

For the lines λ: 6599, 6507, 6383, 6096, 6030 and 5945 the assigned types are different from those given by Runge, the discrepancies naturally arising from the difference of our results of $\frac{\delta\lambda}{H}$ compared to those of Lohmann. It must, however, be remarked that these deviations from Runge's results occur mostly for the types having large denominators, and obviously Runge's rule loses its convincing power as the denominator becomes large, so that we are rather inclined to believe that in such cases the application of Runge's rule is not so conclusive as in the cases of small denominators.

To illustrate the distribution of intensity among the components, we have drawn Fig. 2, in which the distance between the components are measured in the scale of $\frac{\delta\lambda}{\lambda^2 H}$, the shaded and full lines representing the parallel and perpendicular components respectively.

As Lohmann has already shown, there are two different kinds of intensity distribution in the perpendicular components of nonets; thus, for instance, the lines λ : 6678 and λ : 6305 are of the same type of separation, but their intensity distribution are quite different; that of 6305 is normal, while that of 6678 is of inverse order.

After Runge has given the types $\frac{a}{2}, \frac{a}{3}, \frac{a}{4}, \frac{a}{5}, \frac{a}{6}, \frac{a}{7}, \frac{a}{11}, \frac{a}{12}$, Jack ([1]) found in the spectra of tungsten and molybdenum the types $\frac{a}{8}, \frac{a}{9}, \frac{a}{10}, \frac{a}{13}, \frac{a}{14}, \frac{a}{21}$ in addition to Runge's types. The different types which appeared in our results are given in the lower part of Fig. 2.

Beside the 28 lines here described, we could ascertain at least the nature of separations of 6 rather faint lines in the green part. But these, together with the photographic reproductions of newly measured lines and more detailed numerical data, will be reserved for a more exhaustive paper.

According to our results, the three sextets retained the following common property which appeared also in the Lohmann's result, but as different types. Writing p and s for the parallel and perpendicular components, we have

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([1]) Jack, Ann. d. Phys. **28** (1909) p. 1032.

λ	p	s_1	s_2
6599	$\frac{4}{13}a$	$\frac{14}{13}a$	$\frac{18}{13}a$
6383	$\frac{10}{13}a$	$\frac{9}{13}a$	$\frac{19}{13}a$
6030	$\frac{1}{10}a$	$\frac{13}{10}a$	$\frac{14}{10}a$

thus the sum of p and s_1 is equal to s_2, or in other words the change in the frequency of parallel component from its initial value is equal to the difference of frequencies of the two perpendicular components of the same sign.

The remark by Lohmann, that in all cases of separations the number of components is multiples of 3, remained true in our case also.

In some nonets, we noticed that the three perpendicular components were not at equal distance in the scale of $\frac{\delta\lambda}{\lambda^2 H}$, but the distance from the component of medium intensity was smaller for the stronger component than for the fainter component. This is well shown in the cases of two lines 6096 and 6930.

Lastly, a few words may be added about the relation between the lines. The series of lines in the spectrum of neon were found by Rossi (1) for the lines beginning at yellow and green part, but for the bright red lines we have no series formula.

According to Watson (2) there is a regularity of constant frequency difference in these red lines as well as in the violet lines. The following table (Table II) shows the Watson's regularity for red lines.

Table II.

Quadruplets											
$10^8/\lambda_1=\nu_1$	λ_1	Separation	$\nu_2-\nu_1$	λ_2	Sep.	$\nu_3-\nu_1$	λ_3	Sep.	$\nu_4-\nu_1$	λ_4	Sep.
14232·22	7024·38	—	1070·33	6533·08	3	1429·78	6383·14	6	1847·20	6217·44	9
14883·08	6717·22	3	1069·97	6266·69	3	1429·34	6128·63	6	1846·62	5975·76	9
15149·28	6599·18	6	1070·24	6163·73	3	1429·41	6030·20	6	1846·95	5882·06	9
Common property with respect to Zeeman effect.					Triplet			Sextet			Nonet
									Intensity distribution normal.		

(1) Rossi, Phil. Mag. 26 (1913) p. 981.

(2) Watson, Proc. Camb. Phil. Soc. **16** (1911) p. 130.

Triplets.								
$10^8/\lambda_1 = \nu_1$	λ_1	Sep.	$\nu_2 - \nu_1$	λ_2	Sep.	$\nu_3 - \nu_1$	λ_3	Sep.
13934·95	7174·25	—	1429·67	6506·69	9	1846·96	6334·65	12
14426·56	6929·78	9	1429·64	6304·97	9	1846·89	6143·31	12
14969·37	6678·50	9	1429·40	6096·36	9	1846·85	5945·02	12
Common property with respect to Zeeman effect.		Nonet			Nonet			12 components
	Intensity distribution inverse.			Intensity distribution normal.				

Examining the groupings of Watson from the point of view as regards magnetic separations, we notice certain regularities in this respect.

As written in the above table, the separations of the corresponding terms of the quadruplet and triplet are quite analogous except in a few cases. Perhaps the most interesting feature is that, not only the separations, but also the intensity distribution of nonets is again similar throughout each column. We believe that these are not due to mere chance.

It is doubtful if the bright lines 7033, 6402, 6074, 5853, which are not included in the groups above described, may have some relation among themselves.

According to Merton (1), neon emits the spectra rich in violet lines and quite different from the ordinary one in case of jar and spark-gap discharge. In some of the photographs obtained by Fabry-Perot interferometer, we also noticed a great number of strong lines in the violet region. We hope to investigate further if the Zeeman effect of these lines are again so complicated or not.

§ 6. *Summary.*

1. Transverse Zeeman effect of 28 neon lines was studied simultaneously by two different methods, i.e. by using an horizontal echelon, and by using a Fabry-Perot interferometer crossed with a plane grating.

2. Most of the results agreed with the previous work of Lohmann, but for some lines the results were not in good agreement, necessiating the change of types assigned by Runge.

3. Beside the lines investigated by Lohmann, seven new lines were photographed and measured, these are

(1) Merton, Proc. Roy. Soc A. **89** (1914) p. 447.

λ (by Watson [1])	Separation	Type
7032·65	9	$\frac{a}{2}$
6929·78	9	$\frac{a}{10}$
5820·29	3	a
5764·55	3	$\frac{a}{8}$
5689·96	9	$\frac{a}{2}$
5562·90	3	$\frac{a}{8}$
5330·90	9	$\frac{a}{6}$

4. The regularity in the constant frequency difference between many red lines is accompanied at the same time by the regularity in the separations and intensity distributions of magnetically separated lines.

In conclusion we wish to express our best thanks to Prof. Nagaoka for many useful suggestions during the progress of this experiment.

Deformation of Rocksalt Crystal.

By

T. Terada.

[Read June 6, 1914.]

Recently K. Kleinhanns published a brief note on the plastic deformation of rocksalt [2]. As it seemed very interesting to see how

(1) Watson, Proc. Roy. Soc. A. **81** (1908) p. 181.
(2) Kleinhauns, Phys. ZS. **15** (1914), p. 362.

Zeeman Effect of Neon Lines (pp. 277—290)

Fig. 1. (by Horizontal Echelon) { H = 10500 gauss; Magnification : 10; Exposure : 40 m.

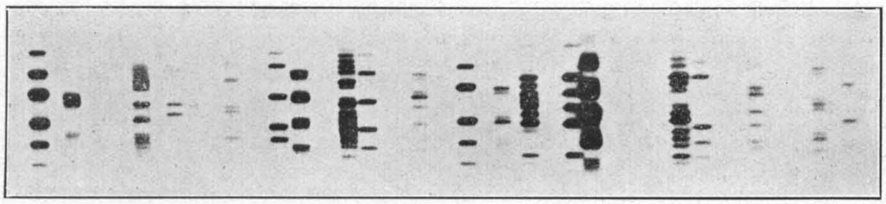
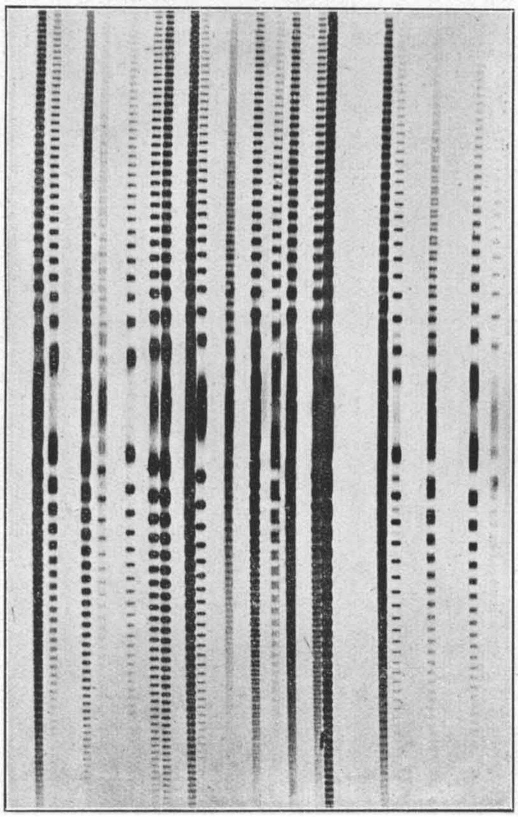
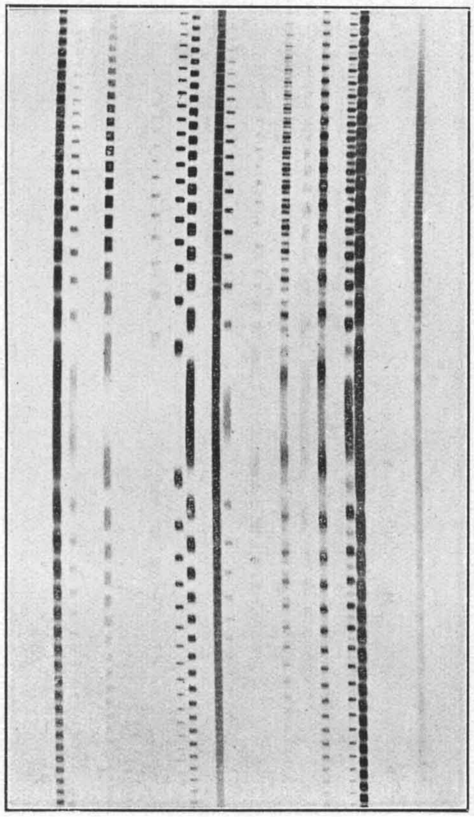


Fig. 2. (by Fabry-Perot Interferometer)



H = 8720 gauss.
Magnification : 7
Exposure : 7 m.
Air plate : 9·4928 mm.

Fig. 3. (do)



H = 14100 gauss.
Magnification : 7
Exposure : 2 m.
Air plate : 4·6371 mm.

T. Takamine & K. Yamada.

Fig. 1. Deformation of Rock Salt Crystal (pp. 290—291)

Fig. 2. On the Molecular Structure of Common Alum (pp. 292—296)

Fig. 3, 4. On the Spectrum of X Rays obtained by Means of Lamellar or Fibrous Substances (pp. 296—298).

Fig. 1.

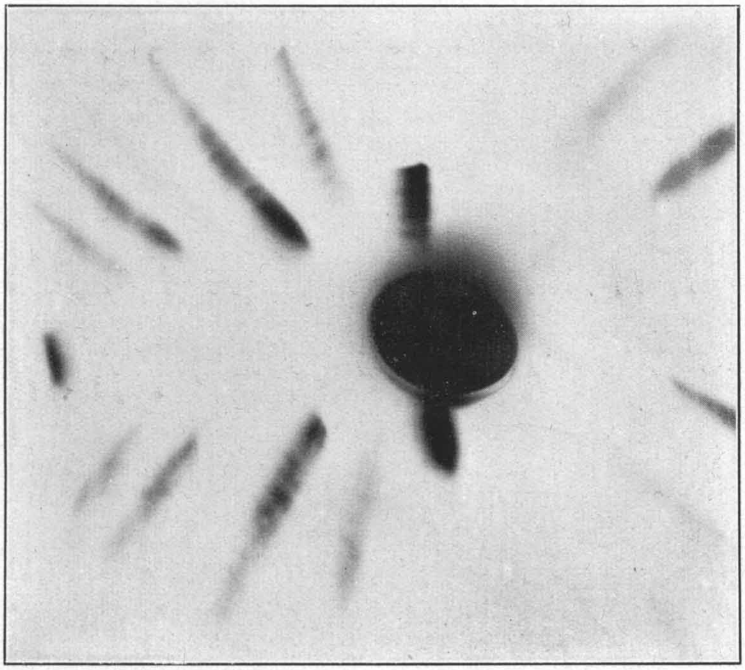


Fig. 2.

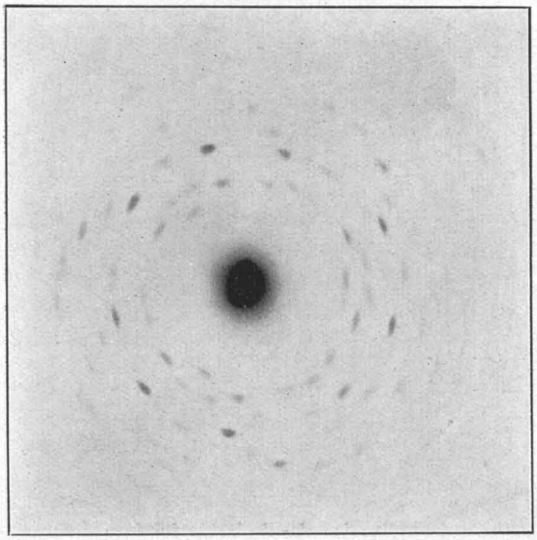


Fig. 4.

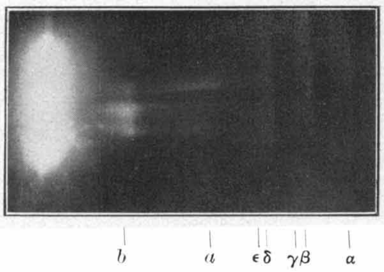
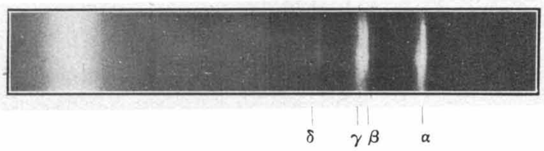


Fig. 3.



T. Terada.
S. Nishikawa.