THE AURORAL SPECTRUM IN THE REGION OF LONG WAVES
RECENT RESULTS FROM THE AURORAL OBSERVATORY, TROMSØ

BY

L. VEGARD AND LEIV HARANG

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§ 1. The plan of observations.

As pointed out in previous communications on the auroral spectrum [1], great interest is attached to the further exploration of the auroral spectrum in the region of long waves, from say $\lambda = 4710$ to the limit of observable lines in the infra-red. Apart from the strong green line $\lambda = 5577{,}35$ and certain bands in infra-red most lines and bands in this region are very weak, from the most common aurorae of the greenish-yellow type. It is only in certain types with pronounced colour that some of the lines and bands in the visible long wave region may be enhanced. Thus it was found by one of us [2], that certain types of red-coloured aurorae show a line in the region 6309, with an intensity which may be comparable with that of the strong green line. In certain aurorae with a very greenish colour, the group of lines called «the second green line» probably appears somewhat enhanced, but as a rule the green lines and bands are so weak that they can only be seen spectroscopically from comparatively strong aurorae. Ths red lines are usually too weak to be seen in the spectroscope, even when the aurorae are very strong, as long as they are of the greenish-yellow type.

The spectrographic investigations in this region also meet with the difficulty that the plates have to be specially sensitized, and as yet we have found no sensitizer which gives a satisfactory sensitiveness for the whole region of long waves here considered.

The plates used for the exploration of this region may be referred to four types: —

1) Ordinary ortho-chromatic plates with a pronounced maximum of sensitiveness in the region 5400—5500.
2) Pan-chromatic plates with considerable sensitivety in the region 5400—6800.
3) The two types previously mentioned have usually a minimum intensity in green 5000 —5300, and for this region we have to use plates specially sensitized.
4) Plates sensitive to infra-red. The sensitive region may vary according to treatment. All the infra-red plates we have been using have a pronounced minimum of sensitiveness in the region 5000—6500.

On account of the weaknes of the lines, it is a matter of the highest importance to use photographic plates of the highest sensitivenes which is possible to obtain for the region considered, and during the last year hypersensitizing methods have been used with great advantage at the Auroral Observatory.

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[1] Compare e. g. L. Vegard, Handb. d. Exp. Phys. 25, 385, 1927. Nature March 1932, Z. S. f. Phys. 78, 567, 1932. Geophys. publ. IX No. 11 1932. Compare also a paper communicated to the Norw. Acad. March 13. 1933 to be published in Geophys. publ.

[2] L. Vegard, The origin of the red colouring of the aurorae of Jan. 26. 1926. Nature 117, 356, 1926.

In order to obtain spectrograms of the weak lines in green and red, we had at first to use spectrographs of high light power and small dispersion. A number of spectrograms from the red parts were obtained during the years 1923—1926[1] and the «second green line» and a few other lines were obtained in 1926 on a plate sensitized with pinaflavol.[1]

Bands from the infra-red part were obtained at the Tromsø Observatory in 1932 with two small glass spectrographs of high light power[2]. It is evident, however, that further investigations of the infra-red spectrum call for great interest.

During the winter 1931—32 a spectrogram was obtained on a panchromatic plate with a large glass spectrograph, and this spectrogram gave a number of lines and bands in the red part. The results obtained from this spectrogram were described by one of us (Vegard) in a paper published in Z. S. f. Phys. (78, 567, 1932) and in a more complete account which was recently communicated to the Norske Vid. Akad. and which will appear in Geophysiske Publikationer[3]. This plate showed some bands in red which were referred to the 1st. positive group of nitrogen and two lines (or bands) with wave-length 6303 and 6368. These two lines might also possibly be referred to the 1st. pos. gr. of nitrogren, but they call for particular interest because they also nearly coincide with the two oxygen lines ($^3P_2 - {}^1D_2$) and ($^3P_1 - {}^1D_2$), which from the interpretation of the green line given by Mc. Lennan would be expected to appear in the auroral spectrum.

The wave length differences between the two red auroral lines and the corresponding oxygen lines are not greater than may be accounted for by possible error of measurements. These lines call for particular interest, also for the reason that the red colouring of the aurorae was found to be due to the enhancement of a red line, probably identical with these lines. The fact that the spectrum of the red aurorae showed only one line, may be due to the small dispersion used at that time. It is obviously a matter of great importance to obtain more accurate wave length determinations of the two lines, in order to decide if they are identical with the oxygen lines mentioned.

As the dispersion of prism spectrographs diminishes rapidly with increasing wavelength, a grating spectrograph properly constructed might possibly be used with advantage for the analysis of the auroral spectrum in the region of long waves. For this reason a new grating spectrograph was constructed which combined a very considerable light power with a considerable dispersion in red and infra-red. Details regarding its construction were given in a paper recently published by one of us[3].

§ 2. The observational material to be dealt with in this paper.

The observational material to be dealt with in this paper was obtained during the last winter season 1932—33, and consists of those spectrograms which were taken with the special object of investigating the long wave part of the auroral spectrum, with the exception of the strong green line. The latter line has been thoroughly studied by means of an interferometer method, and the results of these investigations will be discussed in a separate paper.

When visiting the Observatory in Oct. 1932 Vegard took with him the grating spectrograph which was then properly mounted, as described in the previous paper referred to. During his stay at Tromsø we had good weather conditions and much aurorae, and we succeeded in obtaining the following spectrograms: —

[1] Cfr. Geophys. Publ. IX No. 11, 1932.
[2] Nature March 1932.
[3] L. Vegard. Geoph. Publ. Vol. X No. 4, 1933.

a) With the grating spectrograph we obtained two spectra on pan-chromatic plates showing in addition to the strong green line, the two lines in red which nearly coincide with the oxygen lines mentioned. Reproductions of these spectrograms are shown on Pl. I Nos. 5 and 6. In the case of No. 5 the comparison spectrum is wanting, but we took a spectrum of neon under exactly the same conditions (same slit and temperature), and this can be utilised because we know very accurately the wave-length of the green auroral line which appears on the spectrogram.

With the small glass spectrograph built by one of us in 1922 and described in previous papers[1], we obtained the following spectrograms: —

b) One spectrogram (Pl. I No. 2) on Agfa infra-red plates (700—900 $\mu\mu$) showing a number of fairly strong bands in the infra-red. A neon comparison spectrum was taken under the same conditions, and this could be placed in the right position relative to the auroral spectrum by means of the well-known auroral lines in the blue and violet part.

c) In order to see whether the two red lines in the region 6300—6370 could be separated by means of the small spectrograph, we took a spectrogram on a pan-chromatic plate with a very narrow slit and good focussing of the instrument. A reproduction of the spectrogram is given on Pl. I No. 4. The two red lines appear well separated, and in addition a number of diffuse bands of the 1st. positive group appear.

d) In order to obtain the weak lines or bands in the green part, an exposure was made Oct. 26. and 27. with the small glass spectrograph on an isochromatic plate sensitized according to the Schmieschek process and treated with pinaflavol. In this case we used a fairly broad slit. The spectrogram, reproduced on Pl. I, No. 3, shows the «second green line» and two other green lines with considerable density. The second green line has also this time the appearance of a band.

The plates which were used for red and infra-red were hypersensitized. The sensitizing process used, was essentially the same as the one proposed by Schmieschek. The effect produced by the sensitizer depends greatly on the kind of photographic plates treated, and it is therefore very essential to select plates and sensitizer in the right way, so as to obtain the highest possible sensitiveness for the spectral region in question.

Although during the later part of the winter season the weather conditions were bad, some valuable spectrograms were obtained. A spectrogram on an infra-red plate (Agfa infra-red 700—900 $\mu\mu$) was obtained Nov. 1—4, with the same small glass spectrograph as used for the first infra-red spectrogram. A reproduction of the spectrogram is shown on Pl. I No. 1. On Dec. 15 another spectrogram, shown on Pl. I No. 9 was obtained on a hypersensitized pan-chromatic plate by means of the grating spectrograph.

By means of the new large glass spectrograph which was mentioned in the introduction and which was described in a previous paper[2], we obtained two spectrograms on hyper-sensitized pan chromatic plates on Nov. 22 (Pl. I No. 7) and a second one on Dec. 15. (Pl. I No. 8).

All spectrograms correspond to aurorae of the usual greenish yellow colour. Some red streamers and fringes might occur, but merely during short intervals of intense, rapidly changing aurorae. This colouring had probably very little effect on the spectral intensity distribution of our spectrograms, which were exposed for a great many hours and sometimes during several nights.

[1] Compare e. g. L. Vegard Geophys. Publ. IX No. 11, 1932.
[2] Geophys. Publ. X No. 4, 1933.

§ 3. Results from the spectrograms in infra-red.

The infra-red plates used for the present observations had two infra-red sensitivity maxima, one at 725 $\mu\mu$ and one at about 810 $\mu\mu$ with a quite pronounced minimum in between. The curve, D, Fig. 1 gives a rough impression of the infra-red sensitiveness of the plate Agfa (700—900 $\mu\mu$). The plate had thus a fairly high sensitivity in the region 700—900 $\mu\mu$, which is considerably more extensive towards shorter waves than the infra-red plates (Agfa 810), which were used for the first auroral spectrograms in infra-red. These plates had merely one intensity maximum at 810.

Owing to the extension of the high sensitive region towards shorter waves, we now obtained a number of new bands not observed on the first spectrograms. In fact we could distinguish 7 maxima. On account of the narrow slit and the good focussing of the spectrograph, the bands appeared with greater distinctness than on the first spectrograms, but even here the infra-red spectrum had the appearance of more or less diffuse bands with distinct maxima.

The wave length values of the maxima were measured at the Physical Institute, Oslo. The results are given in Table I. The interpretation of the infra-red auroral spectrum will be given in a subsequent paragraph.

Table I.

Spectrograms taken on Agfa infra-red 700—900 μ with small, old glass spectrograph.

Oct. 20. 1932 Pl. I no. 2	Nov. 1.—4. 1932 Pl. I No. 1	Mean
8092,1 w	{ 8143,4 8035,4 } w	8143,4 8035,4 } 8091
7869,8 st.	7864,9 st.	7867,4
7723,6 st.	7730,5 st.	7727,0
7490,8 st.	7474,8 st.	7482,8
7360,9 m.	7343,3 m. d.	7352,1
7259,3 w.	7226,8 f (?)	7243,0

§ 4. The green and red lines obtained with the small glass spectrograph.

On the spectrogram Pl. I 4 obtained Oct. 24. 1932 on hypersensitized panchromatic plates, we measured in the yellow and red part, a number of lines and bands given in the 1st. column of Table II. The two lines in the region 6300—6370 now appear distinctly separated and we find the wave lengts $\lambda = 6293{,}1$ and $\lambda = 6361{,}4$.

On account of the small dispersion, the values of these and the other lines or bands appearing on the plate cannot claim any great accuracy. The error may amount to several Å units. The main interest of this spectrogram is attached to the fact that we find in the region 6300—6370 two distinctly separated lines, while earlier spectrograms taken with the same spectrograph *only showed one line.* Compare L. Vegard Geophys. Publ. IX No. 11 Plate I Nos. 9, 10, 12, 13, 14. For some of these spectrograms (e. g. Nos. 9, 10) the absence of a second line may be due to the use of a broader slit, but three of the earlier spectrograms (12, 13, 14) were taken with a slit so narrow that the second line ought to have appeared separated.

Table II.

Red and green auroral lines obtained with small, old glass spectrograph.

October 24. 1932. Panchromatic Plate. Pl. 1. No. 4.		October 30. 1932. Isochrom. plate treated with pinaflavol. Pl. 1. No. 3.
6596,5 d	6130,0 f	5751,1 f. d. (?)
6531,7 d	(6021,4) (?)	Green A. L. v. st.
6457,6 d	5980,1 f	5241,3 m. d. broad
6361,4 m	5891,0 f	5001,4 w
6293,1 st.	5833,1 f	4854,7 w
6185,0 f	Green A. L. v. st.	Then follow a number of lines and bands well-known from previous observations.

As is well known from previous investigations the red colour of certain aurorae (Vegard's type A)[1] is due to an enormous enhancement of a line near the stronger of the two lines here considered. In order to find the exact connection between these two lines and the one producing the red colour, and to find the cause of the enhancement, we shall have to wait for further observations of the spectrum of red aurorae of type A, which according to Vegard[2] may be expected to appear most frequently at sunspot maximum.

The spectrogram obtained Oct. 30. on isochromatic plates, treated with pinaflavol showed besides the lines in green also a number of lines in blue and violet which, however, are well known and have been more accurately measured previously. We therefore only give the weak lines in the region of long waves. These are shown in the second column of Table II.

The spectrum showed a faint line or band 5751 which has not been previously observed. The lines 5001 and 4854 have been observed and measured on several spectrograms[3] from previous years. The greatest interest is attached to the second green line. A spectrogram, showing this line with considerable density, was obtained in 1926[4]. It was then found that the «line» was too broad to be a single line. It might either be a narrow band or a group of lines. The single components were not separated. The very pronounced maximum gave the wave length 5239 Å. These results are confirmed by the present spectrogram, which also shows that the «second green line» has the appearance of a narrow band. The wave length of the maximum found from our spectrogram (5241) is also in close agreement with the value previously found, if we take into account the small dispersion and the diffuse character of the line.

§ 5. Lines and bands obtained with the grating spectrograph.

The spectrogram first obtained with the grating spectrograph Oct. 21. (Pl. I No. 5) showed the line near 6300 quite markedly, while the line near 6365 was very faint. The comparison spectrum, which was taken on a separate plate, was orientated relative to the

[1] L. Vegard Geophys. Publ. X No. 4, 1933
[2] Geophys. Publ. IX No. 11.
[3] Compare Geophys. Publ. IX No. 11 and X No. 4.
[4] L. Vegard Nature 119, 849, 1927.

auroral spectrum by means of the green auroral line. The position of this line relative to known lines of the comparison spectrum was determined by means of the spectrogram from Oct. 22.—26. (Pl. I No. 6).

Table III.
Lines and bands in red obtained with the grating spectrograph 1932.

Spectr. Pl. I, 5 Oct. 21.	Spectr. Pl. I, 6 Oct. 22.—26.	Spectr. Pl. I, 9 Dec. 15.
	6599,2 w. d.	6608 f. d.
	6540,0 » »	
	6450,1 » »	
(6376) f. d.	6367,2 w	6368,2 f. d.
6297,8 w.	6300,6 m	6302,1 w. d.
5577 v. str.	5577 v. str.	5577 v. str.

The other two auroral spectrograms Pl. I No. 6 and No. 9 had Ne-comparison spectra placed in the ordinary way. The lines and bands measured on the three spectra from the grating spectrograph are given in Table III.

§ 6. Lines and bands observed with the large glass spectrograph.

The two spectograms taken by the large glass spectograph Nov. 22. and Dec. 15. showed the two lines near 6300 and 6365 quite distinctly, and in addition, some other red lines or bands also appeared. The lines and bands measured are given in Table IV.

Table IV.
Red and yellow auroral lines obtained with large glass spectrograph.

Spectr. Pl. I, 7 Nov. 22. 1932		Spectr. Pl. I, 8 Dec. 15. 1932
6758	B. max	
6689,7 / 6660,2	B. m	6676,7 d. B. max f.
6608,2 / 6577,4	B. m	6579,7 » » f.
6518,5	f. max	6507,8 f. d.
		6457,6 » »
6439,6	» »	
6397,9	f. d.	
6365,7	w.	6366,9 f.
6300,2	m. broad	6305,1 w
		6122 f. d.
6108	f?	6121,9 f. d.
6057,7	f.	
		5970,3 f.
		5866,5 f.
Green line v. st.		Green line v. st.

The spectrogram from Nov. 22. (Pl. I. 7) is particularly interesting, because it shows in addition to the two lines mentioned, some other lines in red, appearing almost equally sharply and distinctly.

We may especially call attention to the two lines for which we find an average wave-length of 6676 and 6592. Although they appear quite distinctly and sharply their breadth is greater than that of a single sharp line. On the original plate they give the impression of being doublets, and the wave-length found for each component is given in the first column of Table IV. Also the two lines near 6300 and 6365 appear to be broader than an ordinary sharp line of the same density, appearing in the comparison spectrum, but their doublet character is not so pronounced as to justify any measurement of each component. The wave-length values given in Table IV, therefore, correspond to the mean position of the line.

Comparing the two spectrograms (Pl. I, 7 and 8) we notice that although the lines 6300 and 6365 are almost equally dense on both, the bands 6676 and 6592 are much denser on the first spectrogram from Nov. 22. This shows that the intensity of the lines near 6300 and 6365 relative to that of the other red bands undergoes considerable variations.

The relative intensity and the character of the lines are denoted in the tables in the following way:

B	means	band	m	means	medium strength
d	—	diffuse	st.	—	strong
f	—	faint	v. st.	—	very strong.
w	—	weak			

The numbers given in Tables I, II, III, IV are the results of the measurements carried out at Oslo. In the case of the spectrograms Pl. I, 8 and 9 from Dec. 15. the two lines near 6300 and 6365 were also measured at the Tromsø Observatory (Harang). These measurements gave for the two lines the following average values: $\lambda = 6302$ and 6360.

As will be seen, the wave-length of the stronger of the two lines agrees well with the values given in the Tables for the same spectrograms.

§ 7. Summary and discussion of the results.

After having given the lines which appeared on each individual spectrogram in separate tables, we shall collect all the lines observed. For those lines which have been observed on several spectrograms, we take the mean value, if they may be supposed to be measured with about the same accuracy. As the grating spectrograph and the large glass spectrograph in the spectral region considered have a dispersion of the same order of magnitude, the wave-length values obtained are given equal weight, provided they are about equally well defined.

The red lines obtained with the small glass spectrograph correspond to a dispersion so much smaller than that of the two large spectrographs, that they are not used in the calculation of mean values. In this way we find for each line observed on more than one plate, an estimated mean value. The wave-length values obtained in this way from our present material are collected in the first column of Table V. In the second column we have indicated the spectrographs with which each line has been observed.

Although a considerable number of the lines given in Table V have previously[1] been observed and measured spectrographically, the results obtained from the spectrograms here described have essentially extended our knowledge regarding the auroral spectrum in the region of long waves. First of all we have observed several new bands in the infra-red, and in the red region we have been able to photograph a number of bands

[1] Cfr. L. Vegard. Geophys. Publ. IX Nos. 11 and L. Vegard, Z. S. f. Phys. 78, 567, 1932 and Geophys. Publ. X, No. 4.

Table V.

Lines and bands in the region of long waves.

λ	Spectrogr.	1st. pos. gr. $n' - n''$	$n' - n''$	Other origin
8143,4	S. P.	5— 4		
8035,4	»	6— 5		
7867,4	»	7— 6		
7727,0	»	8— 7	or (2— 0)	
7482,8	»	(10 — 9)	» 4— 2	
7352,1	»	(11—10)	» 5— 3	
7243,0	»	*(12—11)*	» 6— 4	
6758,0	L. P.	4— 1	» 11— 9	
6690	»	5— 2		
6660	»		12—10	
6608	» Gt.	6— 3		
6577	» S. P.		13—11	
6536	Gt. & S. P.	7— 4		
6513	L. P.	(7— 4)		
6455	L. P., S. P., Gt.	8— 5		
6440	L. P.	(8— 5)		
6398	»		*15—13*	OI ($^3P_0 - {}^1D_2$)
6367,0	» & Gt.	9— 6		OI ($^3P_1 - {}^1D_2$)
6302,0	» »	10— 7		OI ($^3P_2 - {}^1D_2$)
6185	S. P.	12— 9		
6126	» & L. P.		5— 1	
6108	L. P.	13—10		
6058	»		6— 2	
5975	» & S. P.	15—12		
5891	S. P.		9— 5	
5867	L. P.	*17—14*		
5833	S. P.		10— 6	
(5751)	»		12— 8	
5577,35	» S. P.			OI ($^1D_2 - {}^1S_0$ or N_1
5241	»	15—10		or N_2
5001	»	16—11		N (5002,7) or Nebul.
4855	»			OII or N.

S. P. means small prism spectrograph.
L. P. — large prism spectrograph.
Gt. — grating spectrograph.

and lines with instruments of larger dispersion, and in this way have been able to measure the individual bands with greater accuracy. In previous papers we only described one spectrogram in the red part taken with the large glass spectrograph[1]. All previous spectrograms in this region were taken with the small glass spectrographs.

As will appear from the previous papers referred to, most weak lines and bands in the yellow, red and infra-red region were referred to the 1st. positive group of nitrogen. The correctness of this interpretation has been confirmed by the more detailed and extensive analysis given in this paper on the basis of the improved observational material. In the third column of Table V we give those lines which may be referred to the 1st.

[1] L. Vegard, Z. S. f. Phys. 78, 567, 1932 and Geophys. Publ. X No. 4.

positive group of nitrogen. For each such line we give the vibrational quant numbers of the transition which results in the band considered.

Thus, $n' - n''$ means a transition from and the upper level with vibrational quant number n', towards a lower state with quaut number n''.

The wave-length values of the heads (or maxima) belonging to the 1st. positive group, corresponding to a large number of vibrational transitions are given in Table XII of a paper previously published by one of us[1].

As is well known, a band of the 1st. positive group corresponding to a certain vibrational transition ($n' - n''$) consists of several components, separated from each other by frequency intervals of about 20 cm^{-1}. The heads given in the previous paper Table XII, correspond to that component which has the longest wave.

On account of the molecular rotation, each component is developed into rotational band series. With the dispersion here used, the individual components will not be separated. The value we measure will therefore be a kind of mean value for the various components. As a consequence, the values found from our measurements must be displaced towards shorter waves as compared with the corresponding values given in Table XII of the previous paper. This is also found to be the case.

From Table V we notice that the bands belonging to the 1st. positive group arrange themselves into sequences. Beginning with the longest waves, we see that the first infra-red bands belong to the sequence $n' - n'' = 1$. The band 7727 corresponds to the transition (8—7) of this sequence, but it might also be interpreted as the 2—0 transition of the sequence $n' - n'' = 2$. This latter sequence now seems to be the more prominent as we pass towards shorter waves, and it can be followed far into the red region. In the infra-red part, members of each sequence follow continually, with the exception that the band corresponding to the transition 9—8 (or 3—1) is missing. This may be due to the intensity distribution of the emitted bands. It might e. g. mean that the first four infra-red bands belong to the sequence $n' - n'' = 1$, and that the intensity of this sequence suddenly diminishes with increasing quant numbers. On the other hand, the bands of the sequence $n' - n'' = 2$ are still very weak, and first the transition 4—2 gives marked

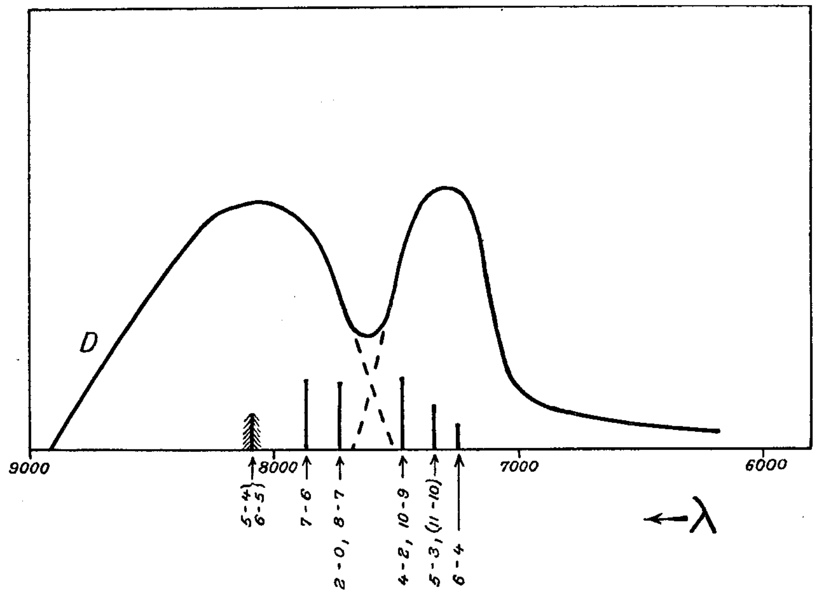

Fig. 1.

[1] L. Vegard Geophys. Publ. X, No. 4.

intensity. This would mean that the transitions which on Table V are put into brackets do not essentially effect the intensity of the corresponding auroral band.

The absence of a band corresponding to transitions (9—8) or (3—1) may also partly be accounted for by the fact that the sensitivity of the photographic plate has a pronounced minimum just where these bands are situated. This will be seen from Fig. 1, where the curve roughly drawn indicates the way in which the sensitiveness varies with the wave-length.

The bands observed are given in Fig. 1 as vertical lines, the length of which indicates the relative density on the plate. We notice that the band (9—8) or (3—1) would coincide with the minimum intensity.

Between the infra-red band of shortest wave-length (7243) and the nearest red line (6758), there is a gap of about 500 Å, where no auroral bands or lines are observed, but this may only be due to the fact that both the infra-red and the pan-chromatic plates, as yet used, are very insensitive in the neighbourhood of 7000 Å. In fact we should expect bands of the sequence $n' - n'' = 2$ to appear in this region of the auroral spectrum.

In the region between the red band 6758 and the yellow band 5867, we have a large number of bands belonging to the sequence $n' - n'' = 3$. In the region of long waves a few bands belonging to the sequence $n' - n'' = 4$ set in.

As pointed out in a previous paper[1], the two red lines, for which we now find the wave-length 6302 and 6367, may be referred to the transitions 10—7 and 9—6 of the sequence $n' - n'' = 3$ of the 1st. positive group of nitrogen, but they also nearly coincide with the oxygen lines 0I ($^3P_2 - {}^1D_2$) and 0I ($^3P_1 - {}^1D_2$) respectively. The wave-length of these two oxygen lines was measured by Paschen and found to be 6300 and 6364. The difference between the wave-length of these lines and that of the corresponding auroral lines is 2 Å and 3 Å respectively. The wave-length values found for these auroral lines from various spectrograms showed variations of this magnitude, so the difference is not greater than might be accounted for by errors of measurement. It is of interest to notice that the auroral line 6398, which may be referred to 1 PG (15—13), nearly coincides with the third component of the oxygen triplet 0I ($^3P_0 - {}^1D_2$).

We may, however, give several arguments in favour of the view that the lines are to be referred to the first positive group of nitrogren. We notice from Table V that if the two lines 6302 and 6367 are referred to the first positive group, all bands of the sequence $n' - n'' = 3$ would appear in the auroral spectrum from $n' = 4$ to $n' = 13$. If the two lines 6302 and 6367 were referred to oxygen, the bands 9—6 and 10—7 would disappear, and there would be a sudden gap in the sequence of bands. We also found that the lines 6302 and 6367 are broader than a sharp line of the same density would be.

We have also to consider the possibility that the oxygen lines are present, and fall in the region of the two bands belonging to the first positive group. In order to decide the question as to the true interpretation of the lines 6302 and 6367, we shall have to wait for further observations. On the one hand we hope to obtain more intense spectrograms which may give more accurate wave-length values. We also intend to use an interferomenter method for an accurate determination of the red line, the enhancement of which produce the red coloured aurorae of type A. We further hope that accurate measurements of the relative intensity of the two lines may give us valuable information regarding their origin. Some preliminary measurements in this direction have been made, and will be dealt with in the following paragraph.

The possible interpretations of the strong green lines and that of the second green line were discussed by one of us in previous papers, and especially in a recent paper published in the Geophysical Publications[1].

[1] Geoph. Publ. X No. 4.

§ 8. On the relative intensity ot the lines 6302 and 6367.

In the case of the two spectrograms from Dec. 15, 1932 Pl. I, Nos. 8 and 9 taken with the large glass spectrograph and the grating spectrograph respectively, an intensity scale was photographed on each plate by means of an «intensity step grating» from Zeiss. On the grating spectrogram the densities of the two red lines 6302 and 6367 were too small for intensity measurements. The spectrogram from the glass spectrograph, however, gave the two lines with a density so marked that a determination of the relative intensity of the two lines might be attempted. But even in this case we cannot claim any great accuracy.

First of all, they produce a very small deflection on the photometer curve, and secondly the relative intensities to be derived by means of the intensity curve depend very much on the threshold effect, which is difficult to determine very accurately.

The determination of the relative intensity of the two lines from this plate may therefore merely be regarded as a first attempt in this direction. We intend in future to take spectra with intensity scales more suitable for accurate measurements.

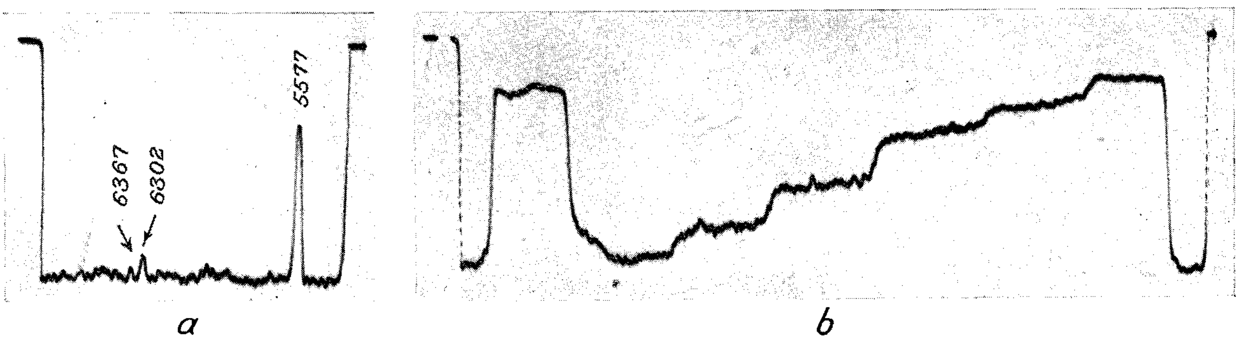

Fig. 2.

The photometer curve of the auroral spectrogram (Pl. I 8) is shown in Fig. 2 (a). We notice the strong green line and the two maxima corresponding to the two red lines. Fig. 2 (b) shows the photometer curve of our intensity scale. Assuming that the sensitiveness of the photographic plate is not essentially different for the two lines considered, the measured deflections (Fig. 2 a) of the two lines and the intensity scale Fig. 2 (b) lead to the following result:

$$\frac{I_{6302}}{I_{6367}} = 1{,}65.$$

From the spectrogram obtained with the grating spectrograph and from the photometric curves, it would seem as if the intensity relation $\frac{I_{6302}}{I_{6367}}$ is considerably smaller. This would mean that the relative intensity is not constant. As the lines on spectrogram Pl. I, 9 are very weak and the background of the plate somewhat foggy, we do not venture to draw any definite conclusions as to the reality of this apparent change of relative intensity.

The experimental intensity relation found, might now be compared with that which we should expect theoretically if the lines were emitted from oxygen. But before entering into further considerations in this direction, we shall have to wait for further results of our intensity measurements.

In conclusion, we wish to express our sincere thanks to Mr. S. Stensholt at the Physical Institute, Oslo, for most valuable assistance in connection with the measurements of the spectrograms, and the calculation work for the wave-length determinations.

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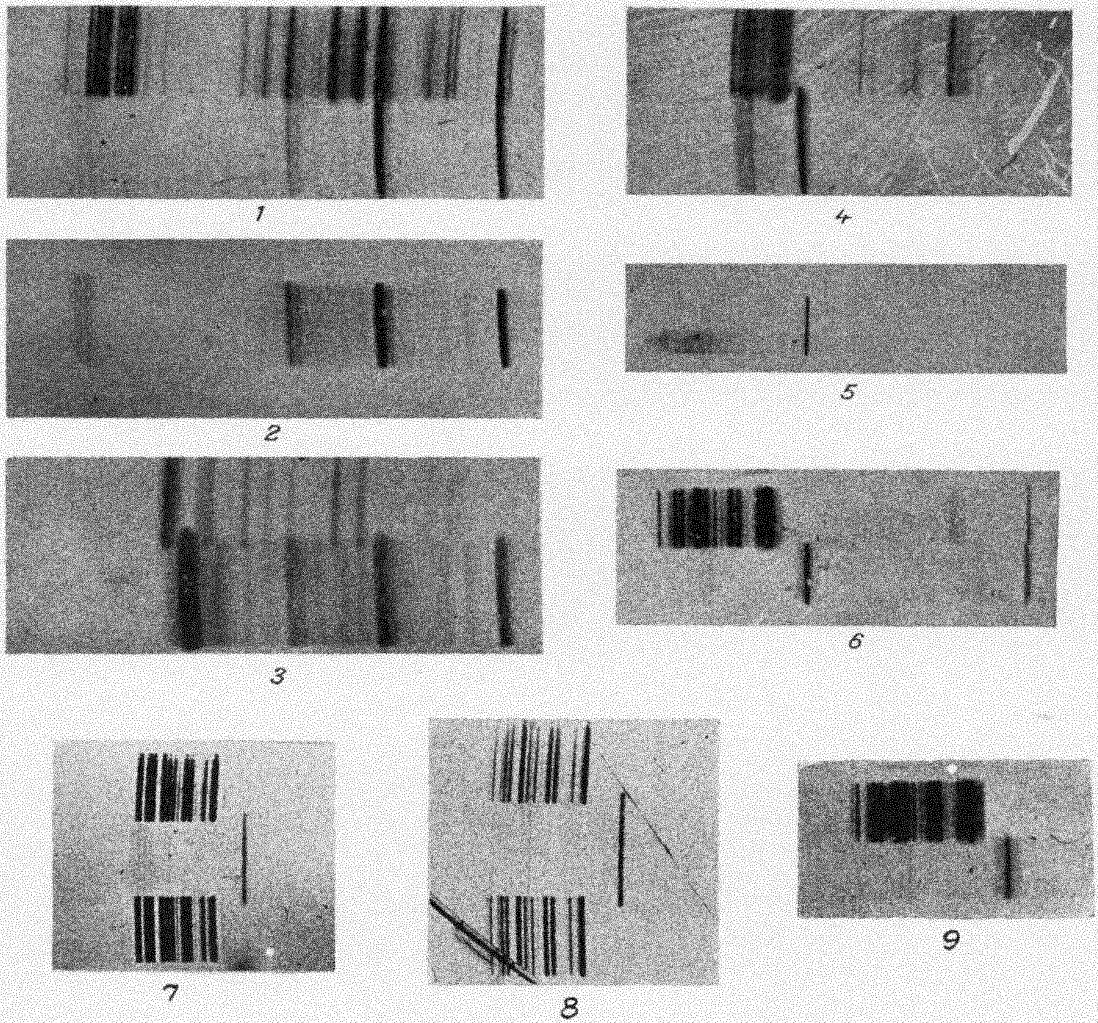


Plate I.

Explanation of Plate I.

1. Spectrum on the infra-red plate (Agfa 700—900 μμ) from Nov. 4. 1932.
2. Spectrum on the infra-red plate (Agfa 700—900 μμ) from Oct. 15.—20. 1932.
3. Spectrum on isochromatic plate sensitized according to the Schmieschek process and treated with pinaflavol from Oct. 30. 1932.
4. Spectrum on panchromatic plate from Oct. 24. 1932.
5. Spectrum on panchromatic plate from Oct. 21. 1932.
6. Spectrum on panchromatic plate from Oct. 22.—26. 1932.
7. and 8. spectra taken on panchromatic plates with large glass spectrograph. Nov. 22. and Dec. 15. respectively.
9. Spectrum on panchromatic plate taken with grating spectrograph Dec. 15. 1932.

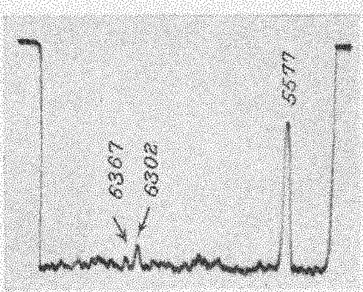
Nos. 1—4 were taken with the small glass spectrograph. Nos. 5 and 6 taken with grating spectrograph. Neon-lamp used for comparison spectrum.

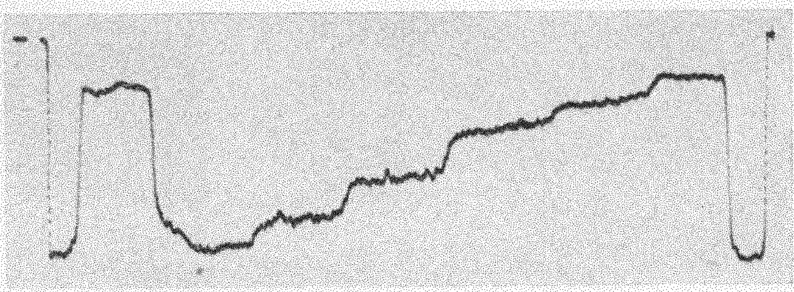
§ 8. On the relative intensity ot the lines 6302 and 6367.

In the case of the two spectrograms from Dec. 15, 1932 Pl. I, Nos. 8 and 9 taken with the large glass spectrograph and the grating spectrograph respectively, an intensity scale was photographed on each plate by means of an «intensity step grating» from Zeiss. On the grating spectrogram the densities of the two red lines 6302 and 6367 were too small for intensity measurements. The spectrogram from the glass spectrograph, however, gave the two lines with a density so marked that a determination of the relative intensity of the two lines might be attempted. But even in this case we cannot claim any great accuracy.

First of all, they produce a very small deflection on the photometer curve, and secondly the relative intensities to be derived by means of the intensity curve depend very much on the threshold effect, which is difficult to determine very accurately.

The determination of the relative intensity of the two lines from this plate may therefore merely be regarded as a first attempt in this direction. We intend in future to take spectra with intensity scales more suitable for accurate measurements.





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