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SPECTRAL, ELECTROPHOTOMETRICAL AND RADAR RESEARCHES OF AURORAE AND AIRGLOW

V. I. Krasovskiy, Editor

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FOREWORD

The Institute of Physics of the Atmosphere of the Academy of Sciences of the USSR is the central organization charged with the responsibility of conducting spectral, electrophotometric, and radar research of aurorae and airglow. The Institute maintains three observation stations:

1) The Loparskaya Station (Φ = 63° 37', Λ = 126° 42')
2) The Roshchino Station (Φ = 56° 35', Λ = 116° 46')
3) The Zvenigorod Station (Φ = 51° 03', Λ = 120° 16')

Moreover, the Institute receives data from the Crimean and Abastumanskayan observatories and from a number of other stations in the Arctic.

The present collection of articles initiates the systematic publication of data received from the above observatories and stations in accordance with the International Geophysical Year program [1957 - 1958]. In addition to the authors of the articles presented herein, the entire staff of the Institute took part in the investigation. In particular, the cooperation of Ya. G. Birfel'd, M. L. Bragin, A. I. Grachev, A. B. Korotin, G. P. Sozin, and V. G. Trunov should be noted.

The authors express their gratitude to the staff of the Scientific Research Institute of Earth Magnetism and Wave Propagation of the Ministry of Communications of the USSR, and to the staff of its Murmansk Branch for the magnetic and ionospheric data.

CONTENTS

HYDROGEN EMISSION AND TWO TYPES OF AURORAL SPECTRA

by

Yu. I. Gal'perin

INTRODUCTION

During the past three years, systematic spectroscopic observations of aurorae have been made at the Loparskaya station, utilizing new equipment (Ref. 1).

The principal objective of this work has been the study of the properties of hydrogen emission in aurorae. More than 150 spectrograms were made which contain hydrogen lines, and in a number of cases this enabled determination of the profiles of the H_α, H_β, and H_γ lines in the magnetic zenith and at other magnetic coordinates. The method used enables us to simultaneously record a spectrum in the magnetic zenith and in any other desired direction, for example, on the magnetic horizon.

During the recording of one spectrum, the sighting at bright forms of aurorae was conducted in such a way that the angular distance of the point of sighting from the magnetic zenith did not change by more than $\pm 5°$.

Besides the study of the profiles of the hydrogen lines, traversing observations were made with the SP-47 spectrograph, 1:1, with a dispersion of approximately 200 A/mm and an exposure of one hour, for the detection of hydrogen emissions. The slit was divided into three parts. One part was directed toward the magnetic zenith, another to the north magnetic horizon, and the third was directed toward a white diffusion surface for the purpose of recording the mean glow from the entire heavens. Figure 1 shows the recorded forms of the spectra made by this spectrograph in the course of 8 hours of observation.

The photographic work was done on a D_H film, using A-12 developer. The calibration was accomplished on an individual piece of film by using a tube-type photometer illuminated by a white luminophor with exposures of 30 minutes and 2 hours. The film for calibration was exposed and developed together with the film for the spectrograph. The exposures were made at an identical temperature and at approximately the same time. The determination of the spectral sensitivity was accomplished from the spectra of the calibrated white luminophor and spectra of the moon.

Measurements were made on an MF-4 microphotometer using an antimony-cesium photosensitive element and a direct-current amplifier. The width of the slit of the microphotometer is 0.30 mm and the magnification is 20X.

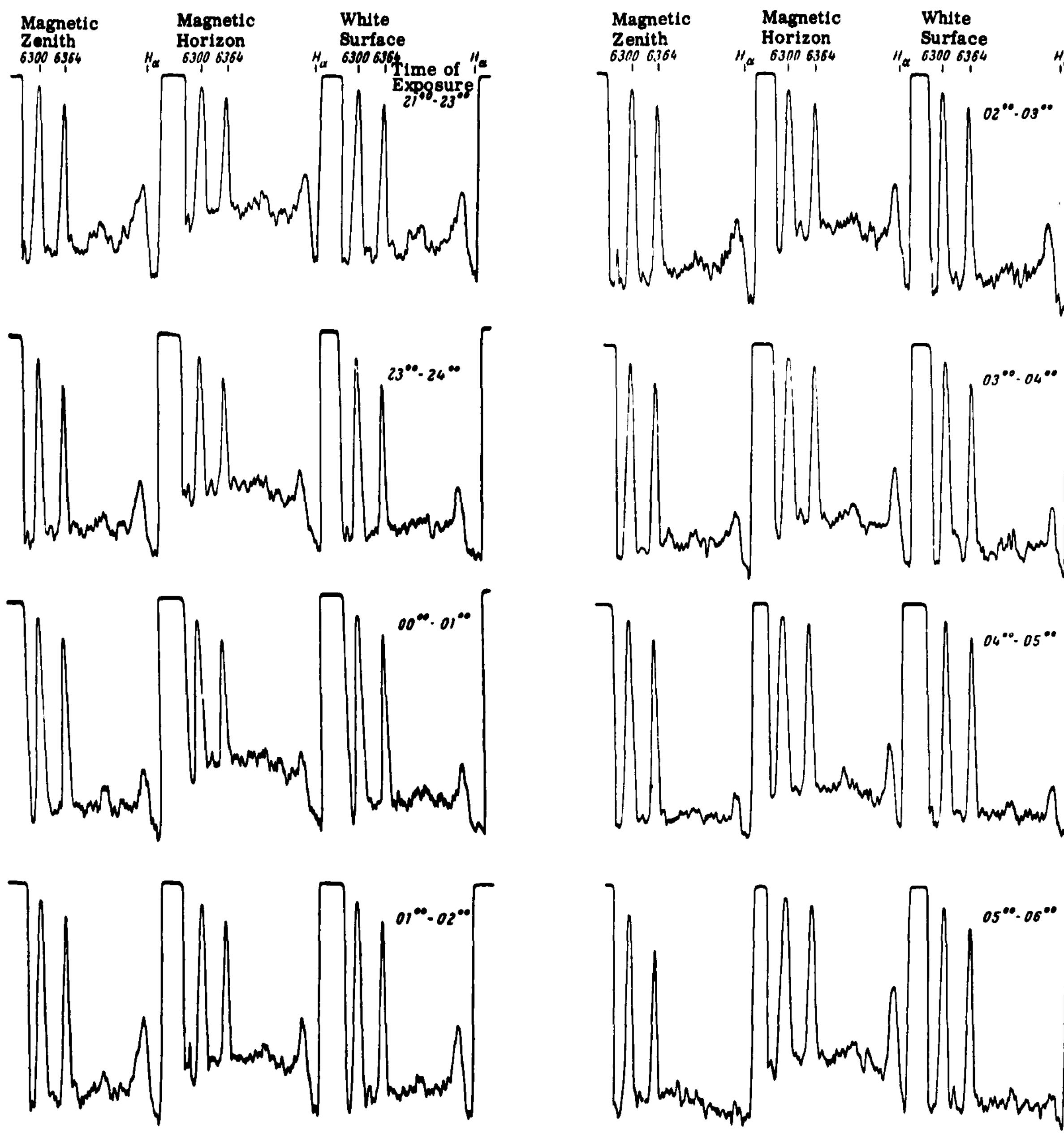
THE CHARACTER OF HYDROGEN GLOW AND TWO TYPES OF AURORAL SPECTRA

Formerly (Ref. 2) there were said to be two extreme types of auroral spectra: type A spectra, with relatively enhanced lines OI, NII, and [OI] λ 6300 A and attenuated molecular bands; and type B spectra, with relatively strong molecular bands 1PG N_2 and with a green line [OI] λ 5577 A. It was also stated that the hydrogen line H_α appears considerably more often in spectra of the first type than in the second. In Figure 2 are shown photographs of both types of spectra in the range of 5800 - 6660 A[1]. The first type of spectra is also characteristic of low-latitude aurorae where the band 1PG N_2 often is completely absent (Ref. 3). Data collected at the Loparskaya station indicates some correlation of the hydrogen emission with the allowed and forbidden lines OI and OII and a less noticeable correlation with the allowed and forbidden lines NI and NII in the first type of auroral spectrum.

Abundant data enable us to draw some preliminary conclusions about the character of the luminescence of hydrogen in aurorae. Hydrogen emission appears very often and is present in almost half of the spectrograms made. It appeared in a majority of the aurorae observed, at one stage or another of their development. The hydrogen lines were recorded at the time of homogeneous arcs HA, bands HB, and diffuse luminous surfaces DS as well as at the time of auroral forms with a ray-like structure, such as ray-like arcs RA and coronae C (for example, 24 - 25 March 1958, when minimum exposure amounted to 4 minutes). Most commonly, however, the hydrogen emission was observed at the time of quiet forms of aurorae without a ray-like structure, principally at the time of red forms of type A: RP; RR with enhanced lines λ 6300 - 6364 A; and also at the time of auroral luminescence in the south, especially in the form of a homogeneous arc HA.

The intensity of the H_α lines received from the magnetic zenith and from the white diffusion surface was usually identical. Evidently this demonstrates that the luminescence of hydrogen was diffused through a rather large surface occupying a considerable part of the heavens. To confirm this, instead of spectro-

[1]More detailed results, collected jointly with A. B. Korotin, will be published shortly.



a - Observations from 2140 on 16 February to 0200 17 February 1958.

b - Observations from 0200 to 0600 on 17 February 1958.

Fig. 1. Traces of 8 hours of observations with an SP-47 spectrograph. The traces at the left relate to the magnetic zenith; those in the middle, to the magnetic horizon; and those at the right, to a white surface.

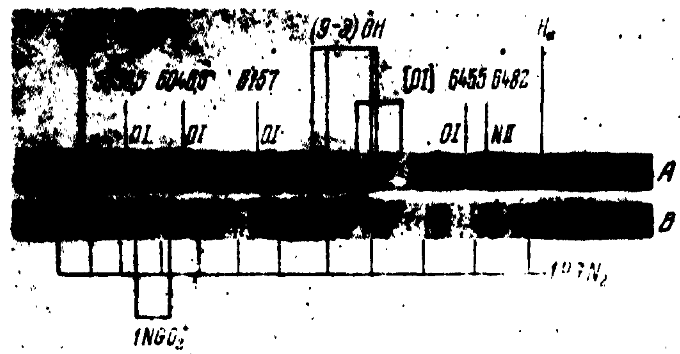


Fig. 2. Two types of spectra of aurorae. Upper - type A; lower - type B. The SP-48 spectrograph, dispersion approximately 85 A/mm.

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scopic examination of a white surface, one part of the slit - using a complete internal reflection prism - was pointed at the southern part of the sky at an angle approximately 20° above the horizon. Thus, the spectroscopic examination was made simultaneously to the north, to the zenith, and to the south. Usually, the H_α line was present simultaneously in all three spectra (for example, 27 - 28 March 1958), but the relative intensity of the hydrogen emission in different directions changed during the course of the night. These changes reflect the movement of regions emitting hydrogen lines through the heavens during the observation period of several hours. In Figure 1 it can be seen that the H_α emission is first distributed evenly through the sky and predominates in the north by the end of the night. The intensity of hydrogen emission was low: it rarely exceeded the mean intensity of luminescence of sodium at night (approximately 200 Rayleighs) and was usually considerably weaker. Sometimes, however, it was increased severalfold (for example, 24 - 25 March 1958). The intensity of hydrogen emission was not associated with the intensity of the aurorae. On some occasions, during an intense and prolonged emission of hydrogen, only a rather weak aurora made its appearance (16 - 17 February 1958, 24 - 25 March 1958). The intensity changed gradually, and usually the H_α line was discovered in a series of consecutive hourly exposures. In some cases, the hydrogen emission was observed over a period of up to nine days (18 - 28 January 1958), and very often for a period of two to three days in a row.

Gartlein (Ref. 4) has already noted that hydrogen emission has a tendency to appear during early stages of aurorae. A. Ye. Veller (Ref. 5) recorded the H_α line after a bright flare-up of an aurora. Present observations indicate that hydrogen emission appears at early, bright,[2] and concluding phases of aurorae. In a number of cases hydrogen emission and weak glow appeared simultaneously, but the hydrogen emission attained maximum intensity 1 to 2 hours before the flare-up of the auroral glow. Improved instruments and methods have enabled us to uncover a new basic result: sometimes the hydrogen emission begins before the appearance of any form of auroral glow, and 1 to 2 hours after its appearance there is a flare-up of an intense greenish-yellow aurora (for example, 21 - 22 November 1957, 11 - 12 December 1957, and others).

The SP-48 spectrograph enabled us to record very weak radiation that arises together with hydrogen emission before the appearance of visible forms of aurorae (Figure 3). The spectrum proved to be normal for type A with intensified (enhanced) allowed and forbidden lines NI, NII, and OI and with N_2^+.

Thus, there is reason to believe that the spectra of the high glow with atomic lines having high excitation potentials are empirically related to type A (Ref. 2), and that they are excited as a result of the direct collision of primary particles. The basic energy of the glow of bright aurorae is liberated only in the later stages of their development and is not necessarily associated with the presence of hydrogen emission.

SOME REMARKS ABOUT SPECTRA OF THE FIRST TYPE

The data that have been collected recently indicate that in spectra of type A the most intensively excited atomic lines are those shown in table 1.[3]

It is significant that these same lines NII λ 6482, 5680, and 5004 A were intensely excited in the experiments made by Fan and Meinel (Ref. 7) in the laboratory simulation of the excitation of aurorae with streams of fast protons and helium ions.

[2] The fact of the presence of H_α emissions at the time of bright flare-ups of aurorae and generally during the time there are intense 1PG N_2 bands, can be established only by means of an SP-48 spectrograph that possesses high resolving power.

[3] Omholt (Ref. 6) also noted enhancement with height of the lines λ 7319 - 7330 A [OII].

Table 1.

OI	OII	NI	NII
Å	Å	Å	Å
6300 } F	3726 } F	3466*F*	5755*F*
6364 }	3729 }	5200*F*	
4368	4317	4915 }	5004
5330	4347	4938? }	5011
5436	4415	8216	5666 }
5958	4857		5676 }
6046			5679 }
6157			5686 }
6455			5710 }
7774			6482
8446			

Fig. 3. Spectra for 11 - 12 December 1957, recorded in the complete absence of luminescence of aurora with exposure from 1845 hours to 2015 hours, at the magnetic horizon (upper) and magnetic zenith (lower).

The absence of the forbidden lines λ 5755 A [NII] and 5200 A [NI] on the Fan and Meinel spectrograms, naturally, is explained by the great lifespan of their upper levels (0.90 second and 10^5 seconds according to Garstang (Ref. 8). The results given by Fan and Meinel indicated that the three mentioned NII lines are excited to a considerably greater extent by helium ions than by protons, whereas the opposite is true of the first negative system of N_2^+. The ratio of intensity of emissions λ 5004 A to λ 5228 A N_2^+ proved to be 1.3 at the time of excitation by protons, while excitation by helium ions gave a figure of about 10.

The measurement of spectra recorded at the Loparskaya station showed that in a majority of cases the value of the ratio fell within the limits 1.0 and 1.5. However, it sometimes varied within broad limits - from 0.35 in a spectrum of type B (strong aurora of type B) to 6.9 in a spectrum of type A (a striking red aurora of type A, 10 - 11 February 1958). Simultaneously with the emission of λ 5004 A, remaining NII emissions were intensified. Such a sharp increase in ratio in comparison with the usual possibly serves as an indicator of a significant increase in the concentration of helium ions in the primary stream.

The correlation of intensity of NII lines with hydrogen emission is insignificant. The allowed lines OI and OII in the visible field of the spectrum reveal some correlation with hydrogen emission. This correlation, however, is not always observed (see Figure 3).

The practically identical excitation of triple and quintuple terms of OI renders relatively improbable the excitation of corresponding emissions by a collision of an atom of oxygen in the normal state ^3P with a proton (Ref. 9). On the other hand, the experiments of Fan and Meinel deal with the collision of protons and oxygen molecules (since atomic oxygen easily recombines on the walls of a tube). The absence of OI lines on their spectrograms means that the effective cross sections of processes of excitation of corresponding emissions of OI as a result of collision of protons and molecules of O_2 are small in comparison with the same for the three indicated emissions of NII. However, in aurorae the intensities of OI and NII emissions are of the same order. Thus, the excitation of emissions of OI by the collision of a proton with an atom or molecule of oxygen is only slightly probable. There is also a series of objections (Ref. 9) against hypotheses concerning the excitation of OI emissions in aurorae by the impact of slow "thermal" electrons.

As will be demonstrated below, there is reason to suppose that hydrogen emission arises at heights that considerably exceed 100 to 110 km and that the small observed correlation of OI emission with hydrogen emission reflects only relatively the enhancement of the OI lines as the result of an increase of oxygen dissociation with height. If, however, the allowed emissions of OI in the visible part of the spectrum are excited by the impact of primary corpuscles, then it can be expected that such particles are neutral hydrogen atoms or "hard" electrons.

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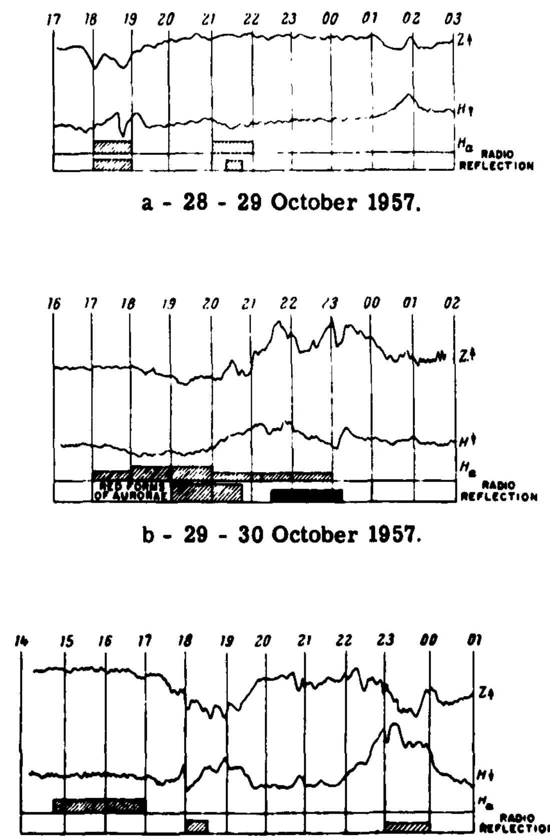
ASSOCIATION OF HYDROGEN EMISSION WITH VARIATIONS OF THE EARTH'S MAGNETIC FIELD AND RADIO SIGNAL REFLECTION FROM AURORAE

Some of the spectra were recorded during twenty-four magnetic storms. In twelve of them, hydrogen emission was determined to be present; in four of them it was not (one very large storm, two large, and one small). For the time being, no connection with "bays" has been discovered. The impression is created that hydrogen emission is weakly associated with the movement of the magnetic field at a given moment (Figure 4). There are many cases where it has been observed in a quiet magnetic field (for example, 16 - 17 October 1957). Sometimes, when there is a rather quiet magnetic field, one can observe a drift of the region of hydrogen emission through the heavens. In two cases of such a drift from the north to the south, the amplitude of the H-component slowly decreased, and in one case of drift northward the H-component increased slowly.

A correlation has been noted between the appearance of hydrogen emissions and radio signal reflection from aurorae. Examples are also shown in Figure 4. For comparison, use was made of traversing spectra (131 spectra) recorded by using an SP-47 spectrograph. At the time of these exposures at the Loparskaya station, Ya. G. Birfel'd and A. I. Grachev made observations of radio signal reflections from aurorae on a wavelength of 4 meters at a time interval of no less than 15 minutes (Ref. 10). Sixty-five percent of all spectra showed a coincidence in the time of appearance and disappearance of radio signal reflections and hydrogen emissions (Figure 4a); in 26 percent of the spectra, H_{α} lines were observed during the absence of radio reflections (Figure 4b). Only in 9 percent of the spectra was it absent at the time of radio reflections (Figure 4c), but part of these spectrograms (dispersion approximately 200 A/mm) strongly "blended" the intensive bands 1PG N_2 and therefore it is practically impossible to establish the absence of H_{α} lines.

In the group constituting 26 percent, there are several cases of observation of red forms of type A, whereas in Loparskaya hydrogen emissions without radio reflections are usually observed. To this group also belong cases of the appearance of H_{α} when there is a quiet magnetic field, when radio reflections are also usually not observed, and other cases. Evidently, the ionization created by the protons causes radio reflection from the aurorae, as has been assumed by several researchers (for example, Chapman (Ref. 11)); however, a disturbance of the earth's magnetic field is necessary for such observations. Therefore, the possibility is not excluded that radio reflection from aurorae, as well as hydrogen emission, is a direct indicator of the penetration of streams of corpuscles into the atmosphere. If this is correct, observations of radio reflections can serve as a very satisfactory indicator of the appearance of hydrogen corpuscles at any time of the day, especially when clouds render optical methods ineffective.



a - 28 - 29 October 1957.

b - 29 - 30 October 1957.

c - 17 - 18 December 1957.

Universal time.

Fig. 4. Examples of correlation of the variation of the magnetic field and radio reflections from aurorae with the appearance of H_{α} emissions. The deviation of 100 γ corresponds to 5.2 mm for Z and 3.6 mm for the H-constituent.

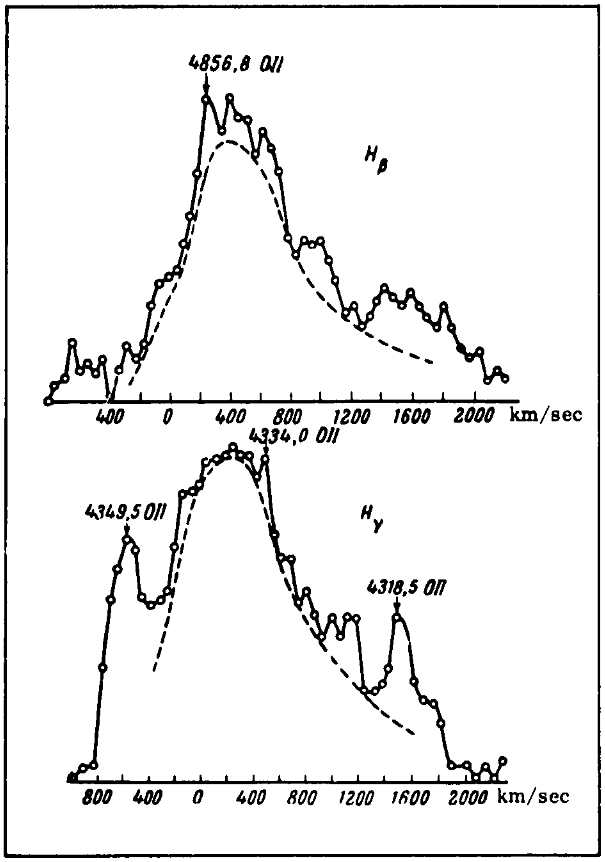


Fig. 5. Examples of profiles of H_β and H_γ, recorded in the magnetic zenith with dispersions of 88.5 and 94 A/mm respectively. The spectrogram was made with an exposure from 2140 hours on 16 February to 0600 hours on 17 February 1958. The intensity is plotted on the ordinate axis against the velocity in km/sec on the abscissa.

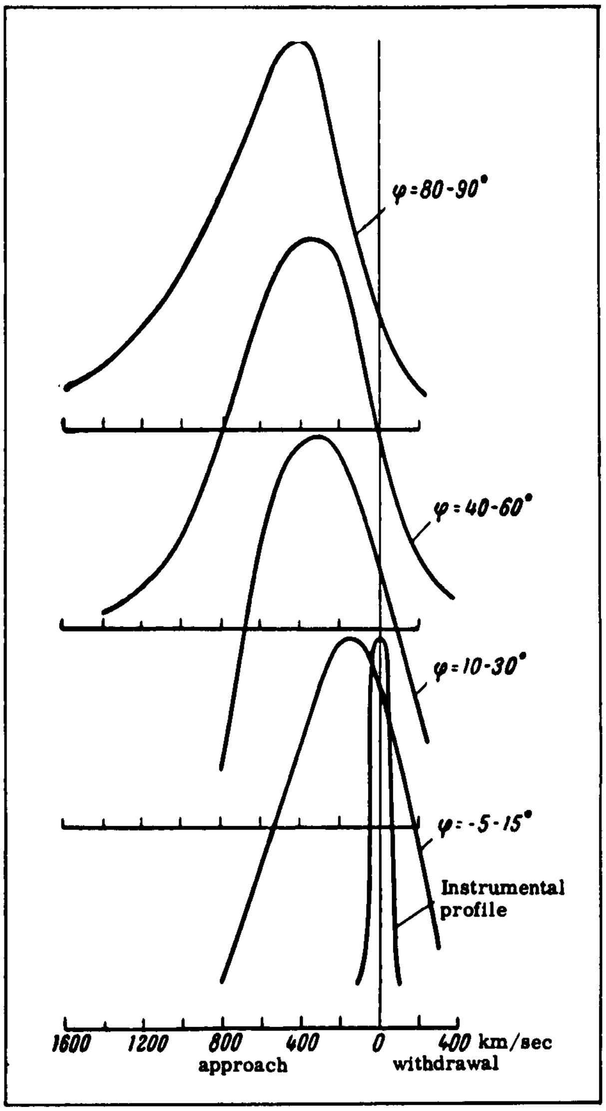


Fig. 6. Typical profiles of hydrogen lines at different φ distances from the magnetic horizon, freed from recurring "blends". In plotting, profiles for H_α and H_β were used (dispersions of 83.5 and 88 A/mm respectively).

PROFILES OF HYDROGEN LINES IN AURORAE

As a result of processing data, we have succeeded in obtaining a considerable number of profiles of the lines H_α, H_β, and H_γ with a dispersion of 80 - 95 A/mm[4] Their accuracy is lowered due to "blending". However, the combination of several traces enables us to expose recurring "blends". In addition, we occasionally succeeded in getting a relatively low "blending" of hydrogen lines. Profiles of hydrogen lines that are smoothed and freed from recurring "blending" are recorded at various distances from the magnetic horizon and are shown in Figure 6. Within the limits of error of measurement up to this time, we have not found notable differences among the profiles relating to identical φ. Thus, the wider scope of data confirms the result in Gal'perin (Ref. 12).

Chamberlain (Refs. 13, 14) has devised a theory concerning the hydrogen line profile in the magnetic zenith on the assumption of constancy in the modulus of entrance velocities of protons and an ionizing equilibrium along the path through the atmosphere. By selecting the distribution velocities according to direction, he simultaneously succeeded in explaining both the profile of the H_α line in the magnetic zenith and the variation of the intensity of hydrogen emission with height. However, Omholt (Ref. 15) soon demonstrated that this theory completely contradicts observed profiles of hydrogen lines on the magnetic horizon. Profiles in the magnetic zenith and on the horizon are two projections of one and the same distribution and

[4] The H_α profiles, recorded on the SP-47 spectrograph with a dispersion of 204 A/mm, will be published separately.

the theory should explain both profiles at the same time. B. A. Bagaryatskiy (Ref. 16) made calculations of the profile of H_α in the magnetic zenith under the same assumptions as Chamberlain (Ref. 14) but taking into consideration the spiral paths of protons in the earth's magnetic field. He demonstrated that such a refining of the theory for cases where there is no elastic or inelastic scattering of protons in the atmosphere cannot explain the "red drift" observed in the H_α profile.

I. S. Shklovskiy (Ref. 17) already pointed out in 1951 that the form of the profile of the H_α line in the magnetic zenith directly reflects the fact of dispersion of velocity of hydrogen corpuscles, since the form of the profile differs sharply from the variation of the effective cross-section of H_α excitation. Using this as a point of departure, it was demonstrated (Ref. 18) that the principal difficulty is the inability of the indicated theory to simultaneously explain the profiles of the hydrogen lines in the magnetic zenith and horizon. For the agreement of the observed profiles in these two directions with the expected variation of the effective cross-section of excitation, it proved necessary to assume the presence of dispersion of velocity for hydrogen corpuscles not only in direction but also in value: that is, to give up the basic assumption concerning the constancy of entrance velocities according to the modulus. The variation with velocity of the effective cross sections of overcharge and excitation by collision indicated that for the dispersion of velocity to exercise an influence on the kind of profile of hydrogen lines would require velocities on the order of 1,000 to 2,000 km/sec or less. However, if the reason for the small value of shift of the maximum in an observed profile of hydrogen emission is the dispersion of velocity of corpuscles, then the explanation of the observed constancy of the drift and of the whole profile (see also Ref. 12) constitutes a serious difficulty. One of the possible explanations of this effect is the following: in the course of an hourly exposure, the velocities of the corpuscles emitted may change repeatedly, and processing thus gives a profile that is averaged out for time.

When our work (Ref. 18) had already been set into type[5], we received Chamberlain's article (Ref. 19) in the September 1957 number of the Astrophysical Journal. In this article he came to similar conclusions about the dispersion of velocity. Approximate estimates enable him to roughly reckon the propagation of particles in the primary stream in velocity and direction as

$$N(\theta, v) = \text{const} \frac{\cos^2\theta}{v^2}$$

The profiles of the hydrogen lines at different places and at different times (Refs. 12, 20 - 24) are extremely similar. From the stated point of view, not one of these profiles permits the direct detection of an appreciable number of hydrogen corpuscles with velocities of $\geq$ 2,000 km/sec.

CONCERNING THE ENERGY OF PROTONS

In the review by Bates (Ref. 25), there are three principal contradictions pointed out which oppose the hypothesis of excitation of luminescence of aurorae by solar corpuscles. First, the velocity of protons, determined from the delay in onset of the magnetic storm in relation to phenomena of solar activity, proves to equal 1,000 to 2,000 km/sec. However, in order to penetrate deeply into the outer edge of luminescence of aurorae (approximately 105 to 110 km), hydrogen corpuscles must evidently possess initial velocities on the order of [illegible],500 to 6,500 km/sec. Gartlein and Sprague (Ref. 26) pointed out the possibility of fluctuations in the density of the polar atmosphere that will lead to a scattering in the indicated values. On the other hand, some facts give evidence that at least a considerable part of the hydrogen corpuscles have low velocities corresponding to retardation: 1) the described investigations of hydrogen line profiles; 2) the repeated recording of hydrogen lines during spectroscopic examination of high red forms of aurorae and the distribution of intensity of hydrogen emission with height in a homogeneous arc HA (Ref. 19); 3) difference between spectra directly excited by protons before glow and spectra of low bright forms of luminescence. Such slow corpuscles will begin to glow less at a great height, causing only a weak luminescence of the atomic lines OI, OII, NI, and NII and the band 1NG N_2^+. The brightest stage in the aurora, during which a considerable part of the emission is concentrated near the lower boundary, often begins only 1 to 2 hours after the beginning of hydrogen emission and has a different spectrum, indicative of supplementary processes of excitation.

A second contradiction involves the difference between the observed (Ref. 20) and theoretical profiles of the hydrogen line as recorded by Chamberlain (Ref. 14). Since the method of finding the velocity dispersion is based on the agreement of these profiles, this contradiction is disregarded.

The third contradiction is the deviation of the calculated and observed distributions of intensity with height of various emissions of aurorae and H_α. Unfortunately, former conclusions were based on a single spectrum recorded by Meinel at the time of an exceptionally strong aurora (Ref. 27). At the present time, we are making attempts at the spectroscopic examination of arcs and other forms of aurorae, so that the height of luminescence may be increased along the slit of the spectrograph. Among four spectrograms of arcs with H_α lines that were made by exposures lasting from 5 to 15 minutes, there is one in which the intensity of the H_α emission decreases very slowly along the arc. The distribution of intensity with height in other exposures also differs from Meinel's. Thus we must exercise some caution in dealing with results received before accumulating sufficient data from observations.

[5] A paper submitted to the Astronomical Journal of the Academy of Sciences of the USSR on 29 August 1957.

If we take into consideration that the initial velocities of corpuscles do not permit them to penetrate to the lower boundary of luminescence of the aurorae, then for the excitation of spectra of type B we should assume the acceleration of charged particles near the earth to an energy of several tens of thousands of electron volts. Such particles may be protons, helium nuclei, or electrons, whose role in the aurorae evidently has been established by Van Allen (Ref. 28) and Winckler and Peterson (Ref. 29). If such a mechanism of acceleration is absent, the excitation of the lower regions of the aurora with a resulting maximum of glow energy is possibly a secondary effect not associated directly with the penetration into the luminous region of hydrogen corpuscles that have been retarded at a great height[6].

CONCLUSIONS

1. Hydrogen emission exists in almost all observed aurorae at one stage or another of their development.
2. In some cases hydrogen emission appears before any visible forms of luminescence and during a magnetically quiet period. One or two hours later a strong aurora usually develops.
3. Simultaneously with the hydrogen emission, there is excited a spectrum that is of a type distinctive of high red aurorae of type A and also characteristic of low-latitude aurorae. It consists primarily of allowed and forbidden lines of OI, OII, NI, and NII and a N_2^+ band.
4. The profiles of the hydrogen lines indicate low velocities for the penetration of protons and, consequently, indicate that the lines become non-luminescent at great heights.
5. The spectra of the lower, greenish-yellow regions of the aurorae are evidently due to the influence of supplementary processes or to excitation by fast electrons.
6. A correlation of hydrogen emission with the degree of magnetic disturbance at a given moment is apparently lacking.
7. A notable connection has been established between the appearance of hydrogen emission and the appearance of radio reflections from the aurorae.
8. The assumption of dispersion of entrance velocities of corpuscles permits us to overcome a series of difficulties in Chamberlain's original theory; however, at the same time a new difficulty appears due to the observed constancy of the profile of the hydrogen lines in the magnetic zenith.

ABSTRACT[7]

The following are some results of the studies of auroral hydrogen emission obtained at the Northern Research Station at Loparskaya for the last three years.

The division of auroral spectra into two types is shown. The first one is high altitude luminescence of which permitted atomic lines with high exitation potentials are characteristic. The second one is natural to lower greenish aurorae and includes strong molecular bands.

It is shown that hydrogen emission begins sometimes before any visible aurorae forms appear and its intensity variation often precedes that of auroral luminescence by 1 - 2 hours. A feeble luminescence of the A - type ("atomic") appears together with hydrogen emission before auroral commencement.

Smoothed typical hydrogen profiles for different angular distances from the magnetic horizon are given.

It is pointed out that these profiles a detailed analysis of which is given in a special article testify that most auroral protons have initial velocities considerably less than 2000 km/sec.

Examples of H_β and H_γ profiles obtained in the magnetic zenith are shown.

Considerable correlation between hydrogen emission appearance and radio reflections from aurorae at 4m. wave length is established. The connection between hydrogen emission and the simultaneous variations of the Earth magnetic field can hardly be observed.

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[6] After completion of the research described herein, we learned the content of the report by Elvey (Ref. 30) at the Toronto conference of September 1957, in which it was also pointed out that the emission of hydrogen often precedes the development of the aurora by 1 to 4 hours and is rarely observed in the complete absence of auroral forms. Elvey confirmed the fact, which had already been noted by Stormer (Ref. 31), that variations in terrestrial currents may precede aurorae, and he pointed out the connection of these variations with hydrogen emission.

[7] The abstract appeared in English in the original Russian publication and is reprinted here with no change.

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OBSERVATION OF THE AURORA ON 10 - 11 FEBRUARY 1958 NEAR MOSCOW

by

A. V. Mironov, V. S. Prokudina, N. N. Shefov

On the night of 10 - 11 February and also on the evening of 11 February 1958, an intense aurora was observed near Moscow. A description of the aurora is given below as well as a discussion of the spectra that were recorded at the Zvenigorod station on the night of 10 - 11 February 1958.

DESCRIPTION OF THE AURORA

At 0545 Moscow legal time, over the northern part of the horizon, there was noted a diffuse red glow of the G_{kr} type. After a period of 3 to 5 minutes, this glow increased considerably in area and occupied the northern part of the sky at an elevation as great as approximately 60° and along the horizon for as much as 120°. The aurora resembled a bright glow. On a background of red diffused luminescence, brighter red spots were visible. In the period from 0610 to 0620, the brightness weakened without a substantial change in the area of luminescence. Between 0620 and 0627, the homogeneous field of illumination divided into individual red spots. The brightest, and that which shone the longest, was a red spot situated in the northeast at an angle of 30° above the horizon. It had an oval form, elongated vertically. At 0637 a ray-like arc, passing through the entire heavens from east to west, made its appearance for approximately 2 seconds. It consisted of short green rays with a height of about 1° situated at an angle to the direction of movement of the arc. At 0645 the red spots intensified and by 0705 the red luminescence began to disappear in the background of scattered sunlight.

The peculiarities of the described glow were the great brightness and the great area of luminescence and the briefness of the appearance of the ray-like arc in the zenith. Before this there was noted a significant increase in solar activity[1]. The glow was accompanied by a strong magnetic storm, which had begun suddenly at 0426 Moscow time on 11 February and ended at 2100 hours on 14 February. The active period continued from 0426 to 1700 on 11 February[2]. The

Fig. 1.

magnetogram for the beginning of the storm is shown in Figure 1. At Zvenigorod station, we recorded spectra of this aurora in the following regions: λ 3400 - 6600 A (dispersion approximately 85 A/mm), 8000 - 9400 A, 9800 - 11200 A (dispersion approximately 150 A/mm). The SP-48, SP-49, and SP-50 spectrographs (Ref. 1) were used for the above spectra, and in addition, a spectrum in the region of 3500 - 6600 A was made on a traverse spectrograph (dispersion 320 A/mm). The photography was accomplished in a northward direction at an angle of 30° above the horizon[3]. On one spectrograph, the SP-48, we simultaneously photographed the magnetic zenith and magnetic horizon in the region of λ 5500 - 6600 A. Spectra were recorded on plates of the D_H type that had first been hypersensitized. Since the aurora was observed at the night's end and in the early dawn, its spectrum is superimposed, in one case, on the spectrum of the night sky luminescence, and in the other case, on that of the dawn. The time of exposure of the night sky was from 1935 to 0600, and for the dawn it was from 0600 to 0650. In this article we show spectra with an exposure from 1935 to 0600 (on the night of 10 - 11 February).

[1] According to data from the NIZMIR (Scientific Research Institute of Terrestrial Magnetism, Ionosphere, and Radiowaves), February 8 witnessed three chromospheric flare-ups, February 9 - six flare ups with an intensity of 2 units and five flare-ups which occurred in the region of the center of the sun's disk, and February 10 witnessed three flare-ups of a 2 unit intensity.

[2] According to data from the NIZMIR, the maximum amplitudes of change in the magnetic field attained: Δ H - 916 γ, Δ Z - 1058 γ.

[3] At the beginning of the night period there was variable cloudiness. After 0230 the sky was clear. Transparency was average. The moon was in the last quarter. The moon rose at 0212.

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LISTING OF EMISSION LINES AND EVALUATION OF THEIR INTENSITIES

In the spectrum we find emissions characteristic of intensive low-latitude aurorae pertaining to the N_2^+, NI, NII, OI, and OII lines. Of special interest is the line λ = 10830 A, which cannot be identified for the time being, unless it represents emissions of HeI. The spectrograms and traces for the aurora are shown in Figures 2 - 7[4] . The measurement of wavelengths

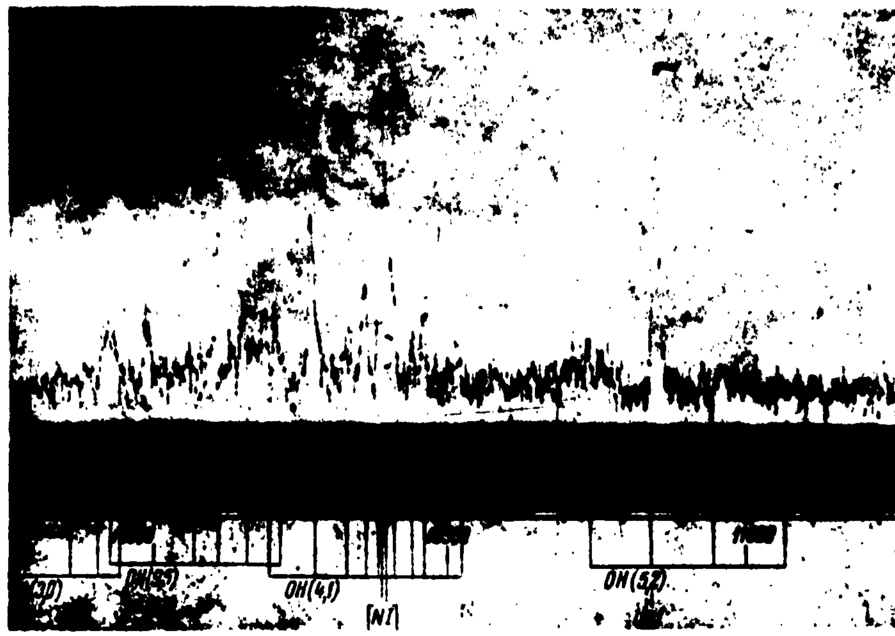

Fig. 2. Spectrum of glow in the region of λλ 9800 - 11200 A.

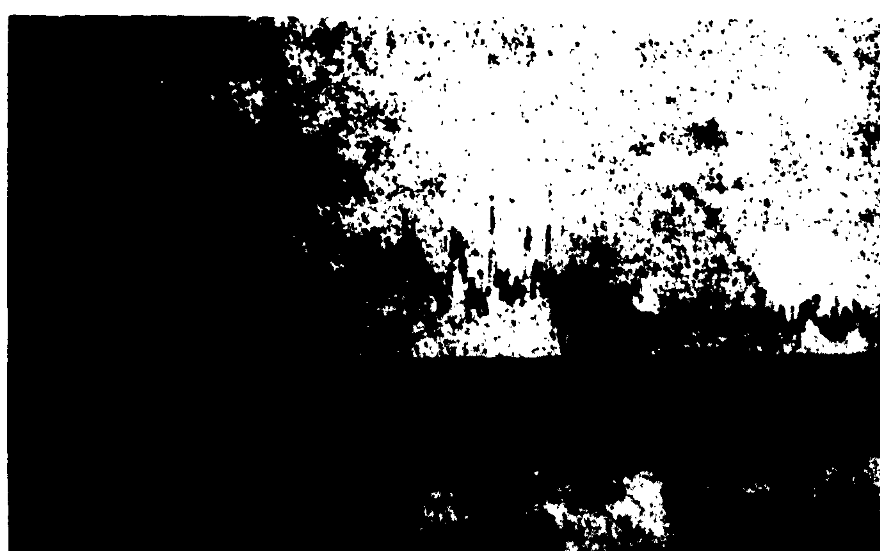

Fig. 3. Spectrum of glow in the region of λλ 8000 - 9400 A.

[4]In the spectrum there were rotational-pulsating bands of hydroxyl OH (v', v") and also lines for NaI and O_2 that pertained to the spectrum of luminescence of the night sky, which was exposed on this same photographic plate for a period of 10 hours.

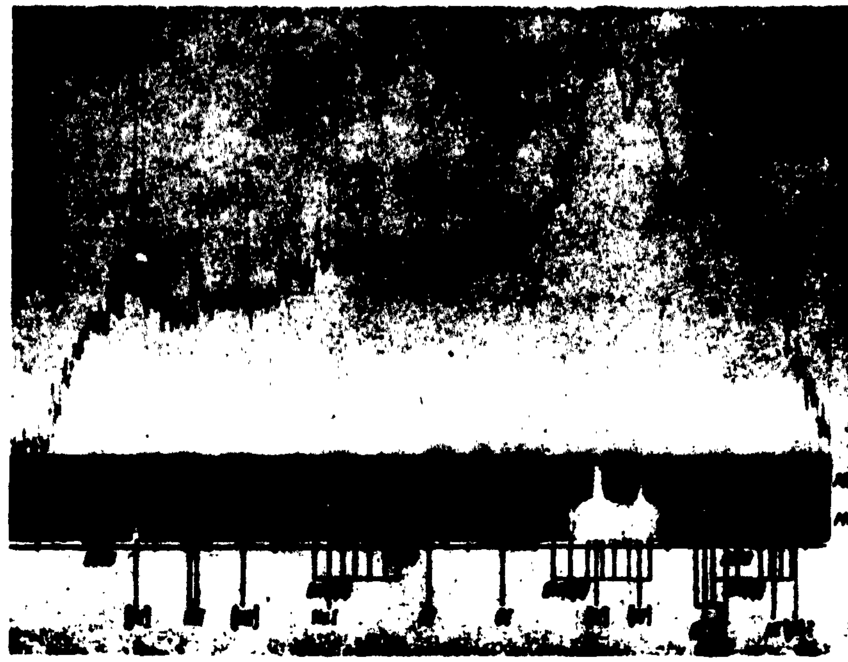

Fig. 4. Spectrum of glow in the region λλ 5500 - 6600 A.
MZ - spectrum of the magnetic zenith; MH - spectrum of the magnetic horizon.

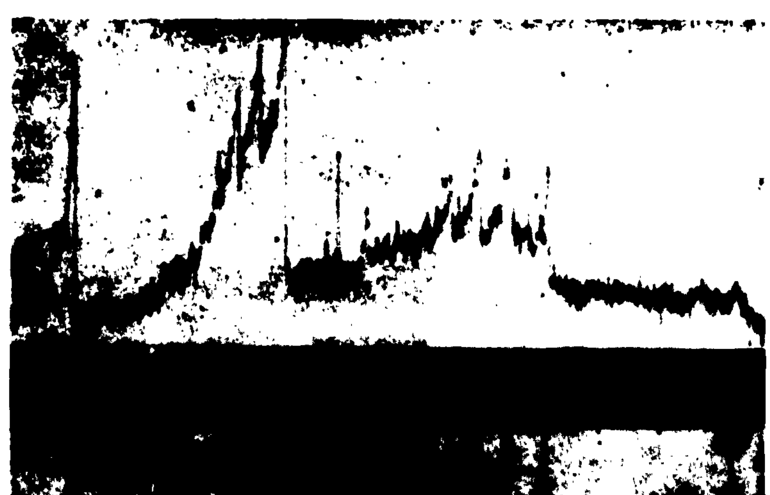

Fig. 5. Spectrum of glow in the region of λλ 3800 - 5000 A.

of emissions, their identification, and their intensities, are presented in the table 1 given below. Evaluation of the intensity was accomplished with a calibration tube and by using neutral filters. The accuracy with which the intensity was determined for each region was 20 percent; for some regions it was 40 percent. A characteristic peculiarity of the spectrum given was the absence of first and second positive systems of nitrogen, which are often observed in spectra of high-latitude aurorae (Ref. 2), and a clear definition of the atomic lines against the background.

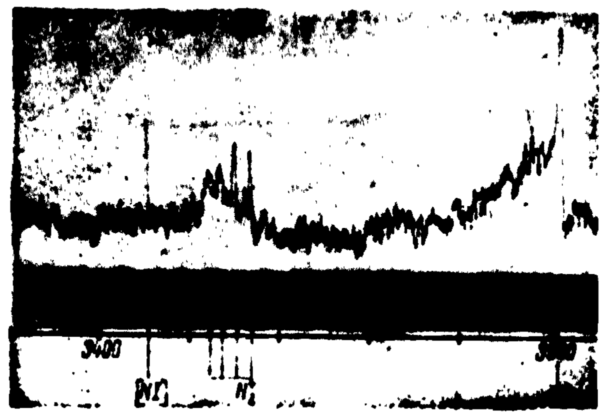

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Fig. 6. Spectrum of glow in the region of λλ 3300 - 4000 A.

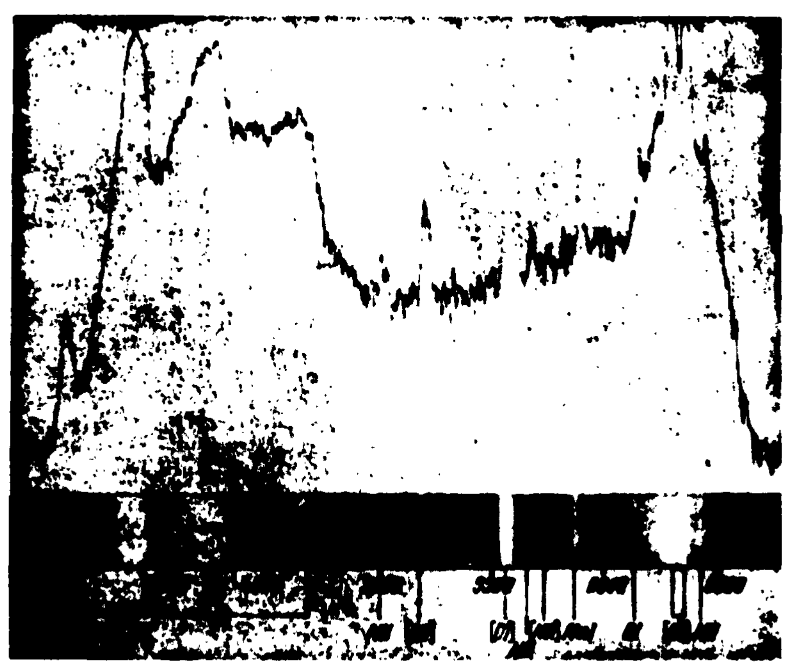


Fig. 7. Spectrum of glow in the region of λλ 3500 - 6600 A.

Table 1

λ measured	λ laboratory	Identification	Relative intensity	Notes
		Emissions of aurorae		
6300	6300	OI $2p^4\ ^3P - 2p^4\ ^1D$	Overexposed	
6364	6364	$2p^4\ ^3P - 2p^4\ ^1D$	" "	
5577	5577	$2p^4\ ^1D - 2p^4\ ^1S$	" "	
8446	8446	$3s\ ^3S - 3p\ ^3P$	34	
4367	4368	$3s\ ^3S - 4p\ ^3P$	6,2	Possilbe superimposition OII λ 4369Å
6455	6456	$3p\ ^5P - 5s\ ^5S$	4,2	
6158	6158	$3p\ ^5P - 4d\ ^5D$	3,3	
6048	6046	$3p\ ^3P - 6s\ ^3S$	0,96	
4415	4416	OII $3s\ ^2P - 3p\ ^2D$	2,8	
4318	4317	$3s\ ^4P - 3p\ ^4P$	Weak	
4350	4349		1,4	
4640	4642, 4649	$3s\ ^4P - 3p\ ^4D$		Blended
4592	4591, 4596	$3s'\ ^2D - 3p'\ ^2F$	Weak	
3466	3466	NI $2p^3\ ^4S - 2p^3\ ^2P$	28	
5200	5200	$2p^3\ ^4S - 2p^3\ ^2D$	9,1	
10398	10398	$2p^3\ ^2D - 2p^3\ ^2P$	230	
10407	10407	$2p^3\ ^2D - 2p^3\ ^2P$	120	
8680	8680	$3s\ ^4P - 3p\ ^4D$	7,7	
6482	6482	$3p\ ^4D - 4d\ ^4F$	1,7	Possible superimposition NII $3s^1P - 3p^1P$
6468	6468	$3p\ ^4D - 4d\ ^4D$		Blended with the branch R (6,1) OH
6441	6441	$3p\ ^4D - 4d\ ^4P$	2,4	
5679	5680	NII $3s\ ^3P - 3p\ ^3D$	3,3	
5664	5667		1,2	
5000	5005	$3p\ ^3D - 3d\ ^3F$	4,2	
5755	5755	$2p^2\ ^1D - 2p^2\ ^1S$	3,2	
6590	6584	$2p^2\ ^3P - 2p^2\ ^1D$	4,5	
10830±10	10830	HeI $2s\ ^3S - 2p\ ^3P$	360	
broadened	6562	HI H_α	~2	Faintly blended
3915	3914	N_2^+ 1*NG* 0,0	92	Measurements made on edges of band
4278	4878	0,1	40	
4237	4236	1,2	22	
4200	4199	2,3	16	
4168	4167	3,4	10	
4710	4709	0,2	6,0	
4653	4652	1,3	7,4	
4601	4600	2,4	5,1	
4553	4554	3,5	2,8	
3583	3582	1,0	21	
3565	3564	2,1	18	
3550	3549	3,2	13	
3535	3538	4,3	13	

Table 1 (Cont)

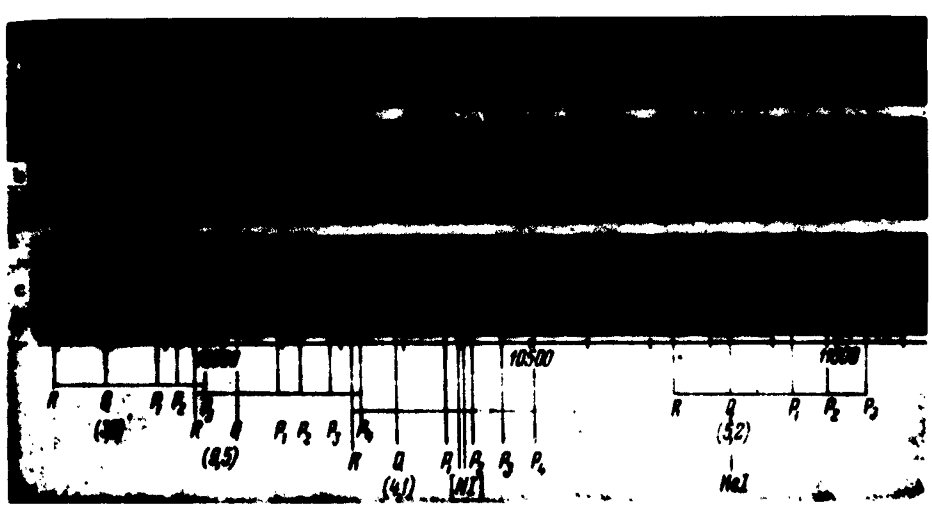
λ measured	λ laboratory	Identification	Relative intensity	Notes
		Emissions of the night sky		
5889	5890	Na I $3s\ ^2S - 3p\ ^2P$	7,8	
5896	5896		5,1	
5894	5890*	OH (8,2)	4,3	The λ value is indicated for the Q-branch intensity determined for whole band
6259	6257	OH (9,3)	7,1	
6498	6538	(6,1)	6,0	
8347	8347	(6,2)	80	
8829	8833	(7,3)	90	
10 028	10 010	(9,5)	290	
10 290	10 380	(4,1)	430	
10 830	10 830	(5,2)		
8645	8645	O_2 (0,1)	Weak	

* Values of λ for OH are given according Ref. 9.

ANALYSIS OF SOME EMISSIONS

Remarks on the Line λ 10830 A

Ordinarily, the spectrum of the night sky possesses a branch of the Q band (5, 2) OH λ 10830 A. In Figure 8 (a and c) are seen the R, Q, and P_1 branches of this band[5]. The intensity of the Q-branch in the night sky varies by a factor of 2.2, and the ratio Q/R, determined from the maximum of intensity, equals 3 on an average (it varies between the limits of 2 and 4, according to data derived from observations at the Zvenigorod station on 11 nights). In the spectrum of the aurora (Figure 8b), the line for λ 10830 A is enhanced in comparison with the R-branch by 9 times, that is, the ratio of the emission of λ 10830 A to the R-branch exceeds by three times the mean ratio between the Q- and R-branches in the night sky. Evidently the enhancement of the line λ 10830 A is not as-



a and c - spectra of the night sky for 27 - 28 January and 11 - 12 February 1958;
b - spectrum of glow for 10 - 11 February 1958.

Fig. 8. Comparison of spectra of glow and the night sky in the region λλ 9800 - 11200 A.

[5] The sensitivity of the image converter in this region decreases because the P_2 and P_3 lines of the OH band are only faintly visible.

sociated with the Q-branch of the band (5.2) OH, since from the R-branch of the band (5.2) and other bands OH (4.1), (9.5), (6.1), (9.3), and (8.2) it may be concluded that the emission of hydroxyl in this spectrum is weaker than on other nights. It may be assumed that in the line λ 10830 A there is present an emission associated with aurorae and caused by the radiation of HeI (transition $2\ ^3S - 2\ ^3P$ with $E = 20.87$ electron volts).

The drawing of the contour of the line λ 10830 A was accomplished by taking into consideration the contour of the Q-branch of the (5.2) band (Figure 9). The intensity of the Q-branch was determined from the measured intensity of the R-branch and the mean ratio between the R- and Q-branches for the night sky.

The half-width of the contour of the line λ 10830 A coincides with the instrument contour and is 9 A (for the middle of the spectrum the instrument contour has $\Delta\lambda = 6$ A).

Only one such spectrum is available at this time. Observations in this field have been made since the end of January 1958, and during this period no similar spectra have been recorded.

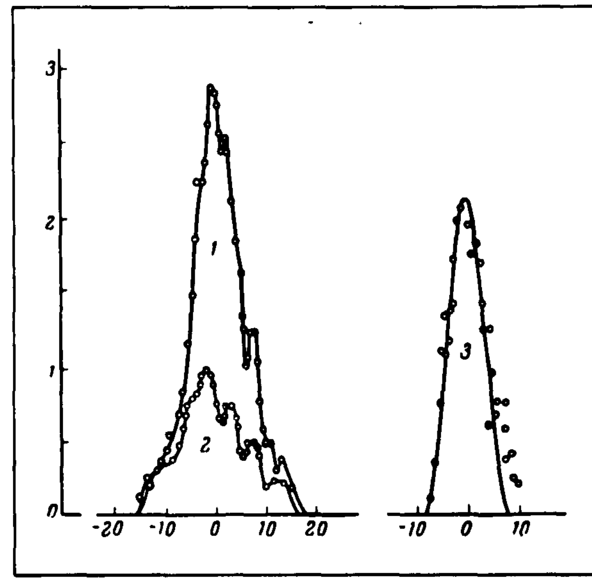


Fig. 9. Contour of emission of λ 10830 A.
1 - contour of emission of λ 10830 A in the spectrum of 10 - 11 February 1958;
2 - contour of branch Q averaged out for observations over 11 nights;
3 - contour of emission of HeI (found by the difference between 1 and 2).

Remarks on Emissions Near λ 10400 A

NI lines are usually observed in the spectrum of a low-latitude aurora. In the case at hand, the [NI] lines λ 10398 A $^2D_{5/2} - {}^2P_{3/2}$ and λ 10407 A $^2D_{3/2} - {}^2P_{1/2}$ merit attention[6]. The experimental ratio of intensities of doublet components is 1.84, which coincides with a theoretical 1.80 calculated from the relative strengths of lines (Ref. 3)[7]. The line λ 3466 A, having an original level identical with the infrared doublet of λ 10398 A - 10407 A, is weaker than the total intensity of [NI] λ 10400 A by a factor of 16 (Ref. 8). The measured value of the ratio (12) characterizes the precision of curves of spectral sensitivity of different spectrographs.

The molecular band (0.0) 1PG N_2 λ 10420 A was not found in the auroral spectrum. (At the given dispersion it might have been possible to distinguish this band between the lines for OH and NI.)

ABSTRACT[8]

The results of treatement of the auroral spectrograms in the regions 3400 - 6600, 8000 - 9400, 9800 - 11200 A obtained on 10 - 11 of February, 1958 at the Zvenigorod station are reported.

Strong enhancement of the emission at λ 10830 A is registered as compared to the usual intensity of the Q-branch of the OH (5,2) band. This enhancement is apparently due to the appearance of the HeI emission.

[6]The third component of the multiplier $^2D_{3/2} - {}^2P_{3/2}$ was not considered due to its insignificant intensity.

[7]The existence of emissions near λ 10400 A has also been noted in References 4 - 7.

[8]The abstract appeared in English in the original Russian publication and is reprinted here with no change.

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INTENSITY OF SOME EMISSIONS OF THE TWILIGHT AND NIGHT SKY

by

N. N. Shefov

During 1957, a study of the twilight and night sky was made at the Zvenigorod station. The SP-48 spectrograph was used to obtain spectra for the visible region and the SP-50 spectrograph with image converter was used for the infrared region (Ref. 1). The spectrographs were sighted to the north at an angle of 30° above the horizon. In the photograph, a D_H type plate that had first been hypersensitized was used. The length of the exposure was the maximum possible and was limited by the duration of the astronomical night. As a reference source, an incandescent lamp with a temperature of 2750° K was used for the infrared region, and a luminophor calibrated by this lamp was used for the visible region. The transparency of the atmosphere was not determined but a visual separation of nights was made according to their transparency.

CONTINUUM IN EMISSION IN THE NIGHT SKY

The existence of continuous emission in the spectrum of luminescence of the night sky was discovered a lo g time ago and has been studied by many researchers (Ref. 2-5). The determination of the intensity of the continuum was made only in the green-red region of the spectrum. For processing we selected spectra of nights near the new moon that had good transparency. There proved to be only four such nights. The distribution of intensity (in Rayleighs/A) of the continuum for these nights, reduced to the zenith, is shown in Figure 1. In Table 1 are shown the intensities of the lines λ 6300, 6364, 5890, 5896, and 5577 A for these same nights; the mean intensity of the continuous spectrum for the interval λ 5200 - 6600 A is about 3 Rayleighs/A. The relative accuracy is 10-15 percent while the absolute accuracy is about 20 percent.

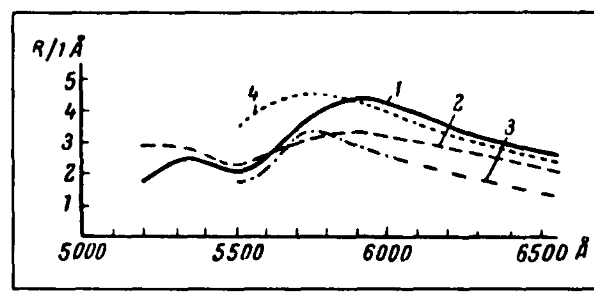

Fig. 1. 1) 31 March - 1 April 1957; 2) 4 - 5 April 1957; 3) 22 - 23 October 1957; 4) 19 - 20 November 1957.

Table 1

Date	5577	5890 5896	6300 6364	Remarks concerning the state of the earth's magnetic field
31 March - 1 April 1957	580	420	820	Strong disturbance
4 April - 5 April 1957	300	230	720	Moderate disturbance
22 Oct. - 23 Oct. 1957	790	180	420	Moderate disturbance
19 Nov. - 20 Nov. 1957	650	170	330	Moderate disturbance

Table 2

Author	Atmospheric constituent Rayleighs/Å	Extra-atmospheric constituent Rayleighs/Å
D. Barbier, J. Dufay, D. Williams (Ref. 3)	0,8 λ 5180 Å	0,5—1,6 λ 5180 Å
K. K. Chuvayev (Ref. 4)	0,2—0,9 λ 5300 Å	0,5 λ 5300 Å
P. St. Amand (Ref. 5)	1,0 λ 5300 Å	0,4—2,0 λ 5577 Å
According to Figure 1	2,5 λ 5300 Å	

For comparison, Table 2 shows the intensities of the continuum according to data from various researchers, converted to Rayleighs/A. In the last line is given the mean intensity dependent on atmospheric and extra-atmospheric constituents, in accordance with Figure 1.

The received intensity in a continuous spectrum apparently can be caused only by its atmospheric constituent and possibly arises as a result of a reaction between NO and O: $NO + O \longrightarrow NO_2 + h\nu$. The distribution of energy thus established is similar to that which corresponds to the indicated process (Ref. 6).

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EMISSIONS OF THE TWILIGHT SKY IN THE VIOLET REGION OF THE SPECTRUM

An attempt to discover a continuous emission in the spectrum of the twilight sky in the violet region was made using an SP-48 spectrograph in the summer of 1957. The survey began with the sinking of the sun to 10° above the horizon and ended when the sun had again reached 10°. The presence of a continuous emission was determined by comparison of residual intensities of Fraunhofer lines in the twilight spectrum and in the solar spectrum received by day using the same spectrograph under the same conditions. The only region investigated was that of λ 3900 - 4700 A. If $r = I_\lambda/I_0$ and $r' = I'_\lambda/I'_0$ are the residual intensities for the given line in the solar and twilight spectra and ΔI is the intensity of the atmospheric emission, then

$$\Delta I = I'_0 \cdot \frac{r' - r}{1 - r},$$

where I'_0 is the intensity of the scattered light of the sun for a continuous spectrum near the given line. As the result of preliminary processing of 28 lines, an emission in the twilight spectrum was distinguished that has several maxima. The distribution of the emission through the spectrum is shown in Figure 2. The given curve was derived by means of processing 8 twilight spectra. All the spectra showed a coincidence of maxima. The mean relative accuracy of the separate measurements is about 15 percent. The total intensity of this emission in the given spectral interval is on the order of 0.5 ergs/cm² sec. Since these are preliminary results, further research is needed for a final clarification of the problem of twilight emission in the violet region.

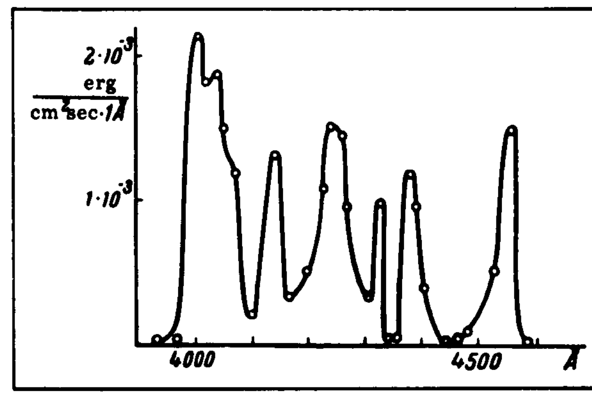

Fig. 2.

ABSOLUTE INTENSITIES OF THE MAIN EMISSIONS OF THE NIGHT SKY

Spectra by which the intensities of the emission of the night sky were determined apply to the period January - April. For the determination of absolute intensities, only clear nights were used, and the spectra

Table 3

Index	λ	I_{av}	Mean deviation		I (according to Roach-Ref. 7)	I_{max}	I_{min}	Number of measurements
			$\pm\Delta I$	%				
[OI]	5577	560	220	39	250	1100	174	14
NaI	5890	203	90	44	240	427	54	20
	5896							
[OI]	6300	590	270	45	150	1100	184	20
	6364							
H_α	6562	17	5	29	—	27	12	14
(8,2)	5890	91	34	37	60	163	61	20
(5,0)	6170	48	15	31	10	81	16	11
(9,3)	6257	138	35	25	170	308	94	20
(6,1)	6500	96	25	26	60	320	62	20
(6,2)	8347	980	300	30	820	3000	660	9
(7,3)	8833	1750	400	23	1940	5470	1120	9

obtained . cloudy weather served as auxiliary data. As a result, the intensities of the following emissions were observed: [OI], λ 5577 A, 6300 A, 6364 A, NaI λ 5890, 5896 A, H_α λ 6562 A, and the OH bands (8. 2), (5. 0), (9. 3), (6. 1), (6. 2), and (7. 3).

In Table 3 are shown the mean absolute intensities in Rayleighs, relating to the zenith; mean deviations from the mean value for intensity in Rayleighs and in percentages; the values of these intensities according to Roach (Ref. 7), received by him on the basis of theoretical calculations by Shklovskiy (Ref. 8); maximum and minimum intensities; and the number of measurements for a given emission. From this table it follows that the mean values for the green and red lines considerably exceed the values indicated by Roach. It is necessary to note that the night sky in this period possessed high activity, especially at the end of March. This is seen in Figure 3 which gives the variations of the indicated emissions in units of mean values in the course of the period of observations, and also variations of the earth's magnetic field (Ref. 9). The intensity of the Na line agrees with the maximum winter value.

H_α emission, which was observed on a number of nights, had a half-width identical with the instrument contour (3. 3 A) and a mean intensity of 17 Rayleighs. The character of variations of its intensity in the course of the period of observations resembles the variations of other emissions of the night sky and is one of the arguments for its origination in the earth's atmosphere rather than in interstellar space. V. S. Prokudina devotes an article (Ref. 10) especially to the problem of H_α.

From Table 3 it is also seen that the intensities of the OH bands differ from the calculated values (Ref. 11). Transitions from upper levels are less intense, and transitions from lower levels are more intense, than those indicated by Roach.

In addition, it follows from Table 4 that even rare maximum values of ratios of different bands do not as a rule attain the values indicated by Roach. The ratio of the intensities of bands (6. 2) and (6. 1) should give a direct ratio of probabilities of transitions. The received value is very close to the theoretical value calculated for a case of linear dipole moment (Ref. 8)and significantly differs from the theoretical, calculated by taking into consideration the quadratic term of the expansion (Ref. 11). The mean deviation of 14 percent also characterizes the precision of determination of intensities. The ratios of the other bands differ from the theoretical. This difference may be caused by deviation from the assumed populations of the levels and from the assumed probabilities of transition.

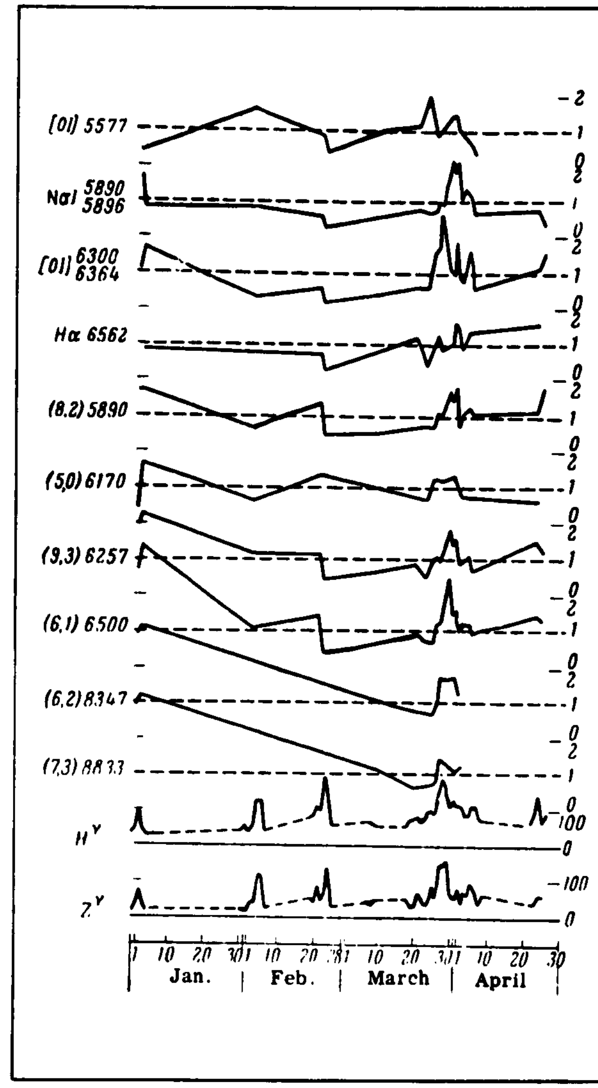

Fig. 3.

In any case these ratios are closer to the calculated values for a case of linear dipole moment.

The ratio of the intensity of the components of the Na doublet in Table 4 is given without taking into consideration their blending with the branch Q (8. 2). The consideration of this effect changes the result by no more than 20 percent.

Table 4

Emissions	Measured ratio	Mean deviation		Theoretical deviation according to Shklovskiy	Theoretical ratio according to Heaps and Herzberg		Max ratio	Min ratio
		±Δ	%		linear dipole moment	square dipole moment		
$\frac{D_2}{D_1}$ Na*	1,56	0,17	11	—	—	--	1,96	1,21
$\frac{[OI]_{red}}{[OI]_{gr'n}}$	0,6	0,22	40	—	--	—	4,67	0,21
$\frac{(6,2)}{(6,1)}$	11,0	1,5	14	13,3	13,8	57,4	15,8	8,7
$\frac{(7,3)}{(6,2)}$	1,65	0,22	13	2,37	1,88	2,31	2,03	1,10
$\frac{(9,3)}{(8,2)}$	1,63	0,35	21	2,84	5,37	--	2,58	1,04
$\frac{(9,3)}{(6,1)}$	1,31	0,19	14	2,84	3,48	--	2,13	1,04
$\frac{(8,2)}{(6,1)}$	0,86	0,18	21	1,00	0,65	0,20	1,32	0,49
$\frac{(6,1)}{(5,0)}$	2,63	0,9	29	6	5,25	7,30	4,5	1,03

* without considering Q (8.2).

ABSTRACT[1]

Some results of observations of night airglow and twilight emissions at the Zvenigorod station are reported. The continuum intensity distribution is measured in green and red spectral regions. Its similarity with one corresponding to the process $NO + O \longrightarrow NO_2 + h\nu$ is stated.

Twilight continuous emission was studied in the violet spectral region. Its intensity was measured by comparing residual intensities of the Fraunhoffer lines in the twilight spectra with those in the solar spectrum. The total intensity of this emission attains to 0.5 erg. cm^{-2} . sec^{-1} .

Absolute intensities of the main night airglow emissions were measured. It is stated that relative OH band intensities are in closer agreement with the computations for linear dipole momentum.

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[1] The abstract appeared in English in the original Russian publication and is reprinted here with no change.

ELECTROPHOTOMETRIC MEASUREMENTS IN THE AURORAL ZONE

by

N. V. Dzhordzhio

INTRODUCTION

Beginning in September 1957, at the Loparskaya station, electrophotometric observations were made of the night sky and aurorae on each moonless and cloudless night in accordance with the program of the International Geophysical Year. This program provided for observations in the zenith and in reference sectors of aurorae. Measurements in the zenith were made hourly on zonal time in five regions of the spectrum (λ 4278, 5300, 5577, 5893, 6300 A). The intensities of bright forms of aurorae were measured in three regions of the spectrum (λ 4278, 6300, 5577 A).

In the observations, use was made of an electrophotometer which we devised jointly with the Design Office of the Institute of Earth Physics (designer V. G. Shifman). A diagramatic sketch of the photometer is shown in Figure 1. As an entrance lens, use was made of part of a KZS-11 objective (D = 250 mm, F = 500 mm). Then a dispersion lens O_2 was inserted (D = 55 mm, F = 110 mm), the interference filter F (φ) was inserted, and a condensing lens O_3 (D = 55 mm, F = 110 mm). This system of lenses, with a relatively large entrance opening, insured a decrease in the angular aperture of the light beam in the interference filter. The Fabry lens O_4 projected the entrance objective onto the surface of a photocathode. A reading was taken from the scale of an M-95 type galvanometer with a sensitivity of $\gamma = 2 \cdot 10^{-9}$ a/division.

The sensitivity of the apparatus proved to be adequate for the measurement of lines in the night sky without supplementary amplification. The constancy of the integral sensitivity of the photometer was checked by using a luminophor. The transparency of the atmosphere was checked by changes in the brightness of the stars Vega and Capella, whose extra-atmospheric brightness was determined in graduations of the M-95 instrument. The angle of vision of the photometer at the time of observation of the night sky and glow was 12.56 sq. degrees; in observing the stars it was 0.04 sq. degree.

The calibration of the photometer in absolute units was done according to Capella on nights with good and stable transparency in accordance with Bouguer and also independently according to Vega. The results of both calibrations differed by a total of several percent. However, before comparision of the photometer with Roach's standard instrument (Ref. 1), the cited brightness in absolute units should only be regarded as preliminary.

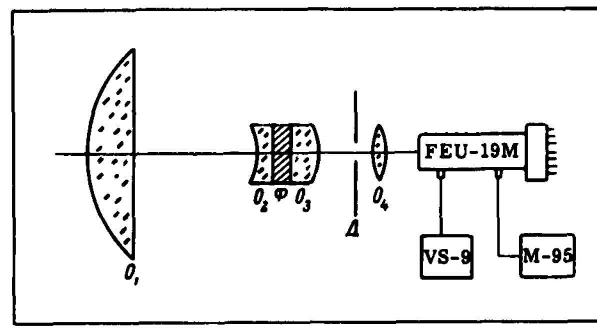


Fig. 1.

PRINCIPAL RESULTS OF OBSERVATIONS

Systematic electrophotometric observations at the Loparskaya station have shown that the intensity of luminescence of the night sky in northern latitudes is approximately 1.5 to 2.0 times greater than in the middle latitudes. In Table 1 comparative data are given for the mean values of the intensity of emission of the night sky according to observations at the Loparskaya and Zvenigorod stations (according to measurements made by V. M. Morozov and A. D. Bolyunova). The sensitivity of the photometers at these two stations was compared. In the north the sky was considered to be a purely night sky when no luminescence was visible to the eye and the band (0.1) 1NG N_2^+ (λ 4278 A) gave a relatively low reading ($\leq$ 40 Rayleighs). The continuous background was measured through a filter of λ 5300 A and was considered as distributed through the spectrum as in stars of spectral class G_2. The superimposition of OH bands on the main emissions was not considered.

The high intensity of luminescence of the night sky is evidently explained by the weakly diffused luminescence that is almost constantly present in the north. Thus, in the season of observations September 1957 - March 1958, there was no pure night sky but rather some transitional state from a night sky to aurorae, since aurorae appeared even on those nights during which the luminescence in the initial hours was regarded as purely night glow.

Table 1

Time of observation	Wavelength A	Mean value of intensity, in Rayleighs	
		Loparskaya station	Zvenigorod station
November 1957	5577	314	183
	5893	190	140
	6300	340	86
December 1957	5577	280	101
	5893	180	80
	6300	190	70

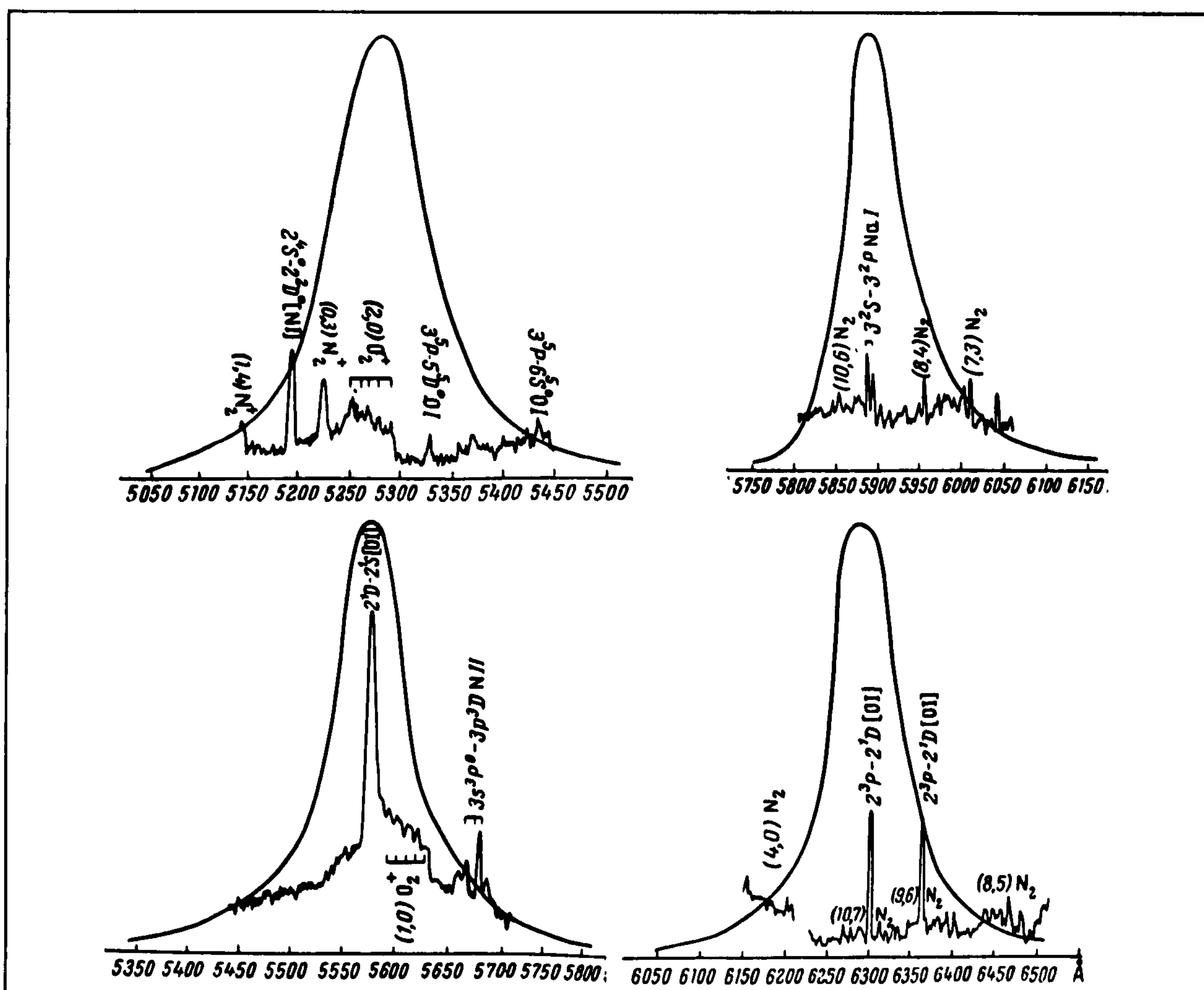


Fig. 2. Transmission Curves of Interference Light Filters 5300, 5577, 5893, and 6300 A and Traces of Auroral Spectra in the Corresponding Fields.

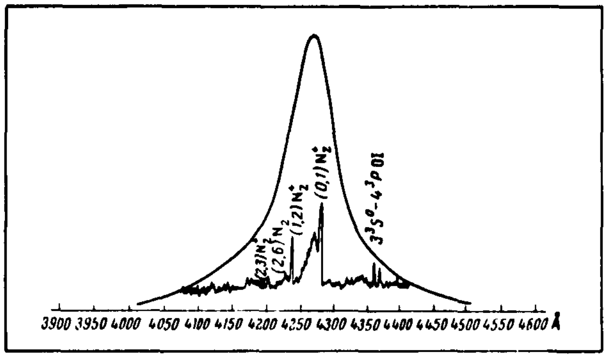


Fig. 3. Transmission curve for the filter λ 4278 A and corresponding trace of auroral spectrum.

Spectroscopic investigations have shown that the spectrum regions λ 5300, 5577, 5893, 6300 A in aurorae are blended by intense emission. In Figures 2 and 3 are shown the transmission curves of interference filters[1] and the emissions of aurorae penetrating through these filters (blackening traces were made by Petrie and Small (Ref. 2).

As can be seen, bands (10.6) and (8.4) of the first positive system of N_2 noticeably blend λ 5893 A (in bright forms of aurorae they can exceed λ 5893 A), the filter λ 5300 A transmits the intense bands (2.0) 1NG O_2^+ and (0.3) 1NG N_2^+. The picture was so obscured that it was decided not to measure the luminescence of the bright auroral forms with these two filters. The red oxygen line λ 6300 A in the aurora is blended by the (10.7) and (9.6) bands of the first positive nitrogen system N_2, and the green oxygen line λ 5577 A, by the band (1.0) 1NG O_2^+. The emission of λ 4278 A is relatively free from blends. In respect to the continuous background in the auroral spectrum, the situation is still less known than it is for the night sky. From spectroscopic observations made at Loparskaya (by Yu. I. Gal'perin and A. B. Korotin), it is known that the intensity of the continuous background changes noticeably in the green and red parts of the spectrum of the aurorae (in a series of 1-hour exposures).

Electrophotometrically the problem of the influence of a continuous background in aurorae is a difficult one since in the spectral region from λ 4000 to λ 6500 A it is almost impossible to find a band 150 A wide that is relatively free from emissions. The least blended region of the auroral spectrum is the interval from λ 4450 A to λ 4600 A. Evidently the measurement of luminescence in this interval together with spectroscopic observations can be used for the calculation of the continuous background in the auroral spectrum.

[1] The lack of symmetry in the transmission curves of the interference filters is explained by the influence of colored pieces of glass glued on the filters for the purpose of suppressing secondary transmission maxima. (Filters were measured in a parallel beam of light. Special measurements showed that the use of filters in the optical layout of the photometer causes a shift of the transmission maximum by 20 to 30 A in the short-wave region and an insignificant broadening of the transmission band.)

For the time being, no data are available concerning the continuous background in aurorae, and the processing of data has been conducted without taking into consideration the continuous background and extraneous emissions penetrating through the filter. The only measure taken was the correction of the reading for atmospheric absorption and for apparent increase of intensity of luminescence on the horizon.

Figure 4 is a graph showing the behavior of the main emissions in an ordinary aurora of a greenish-white color. On the graph it can be seen that for each large flare-out of λ 5577 A there is a corresponding flare-out of λ 4278 A whereas the red oxygen line λ 6300 A acts differently. The mean values of ratios (200 measurements) for aurorae of a greenish white color are

$$\frac{I_{4278}}{I_{5577}} = 0.33; \qquad \frac{I_{6300}}{I_{5577}} = 0.19.$$

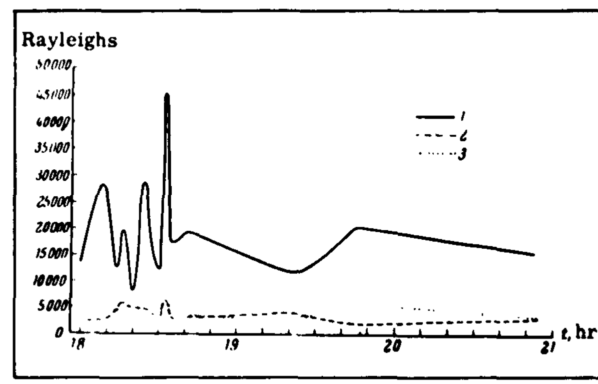


Fig. 4. Aurora of a greenish-white color 13 December 1957. Variation with time of main emissions in a homogeneous arc. (1 - λ 5577 A; 2 - λ 6300 A; 3 - λ 4278 A.)

At the Loparskaya station during this season there were often aurorae of type A of a reddish color. Table 2 shows the minimum, maximum, and mean values of ratios of intensities of the emissions $\frac{I_{6300}}{I_{5577}}$ and $\frac{I_{4278}}{I_{5577}}$ in different forms of red aurorae.

The mean ratio $\frac{I_{6300}}{I_{5577}}$ in homogeneous forms proved to be only half that of ray-like forms, and diffuse forms lie in between these two. The mean ratio $\frac{I_{4278}}{I_{5577}}$ in homogeneous and diffuse forms remains approximately identical, but in ray-like forms it increases a little.

We have also succeeded in tracing the dynamics of development of red rays. Figure 5 illustrates the behavior of different emissions in the red rays that were observed on 27 November 1957 in the east, 45° above the horizon. As can be seen, in this case any enhancement of the red oxygen line λ 6300 A was accompanied by a weakening of λ 4278 and 5577 A, and vice versa.

Table 2

Forms of aurorae	I_{6300}/I_{5577}				I_{4278}/I_{5577}			
	Minimum	Maximum	Mean	Number of observa-tions	Minimum	Maximum	Mean	Number of observa-tions
Homogeneous . . .	0,23	1,14	0,7	8	0,24	0,63	0,34	9
Ray-like	0,22	5,5	1,9	32	0,15	1,5	0,41	30
Diffuse . . .	0,62	2,0	1,14	7	0,21	0,54	0,31	6

F
7
6

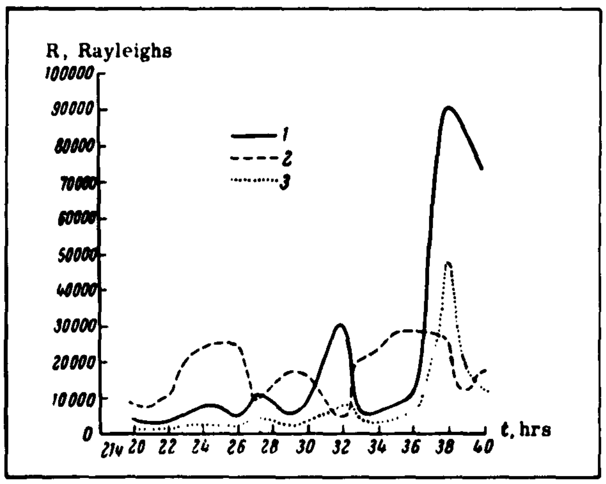


Fig. 5. Course of development of red rays 27 November 1957. (1 - λ 5577A; 2 - λ 6300A; 3 - λ 4278A.)

In accordance with the program of the IGY, the study of reference sectors of aurorae was also provided for. In the bright forms of aurorae and near them, a great number of bright and faint points were measured. On the basis of this data, it is possible to determine in which part of the emission is concentrated the predominant part of the auroral energy: in the bright forms of aurorae or in the faint diffusion background surrounding them.

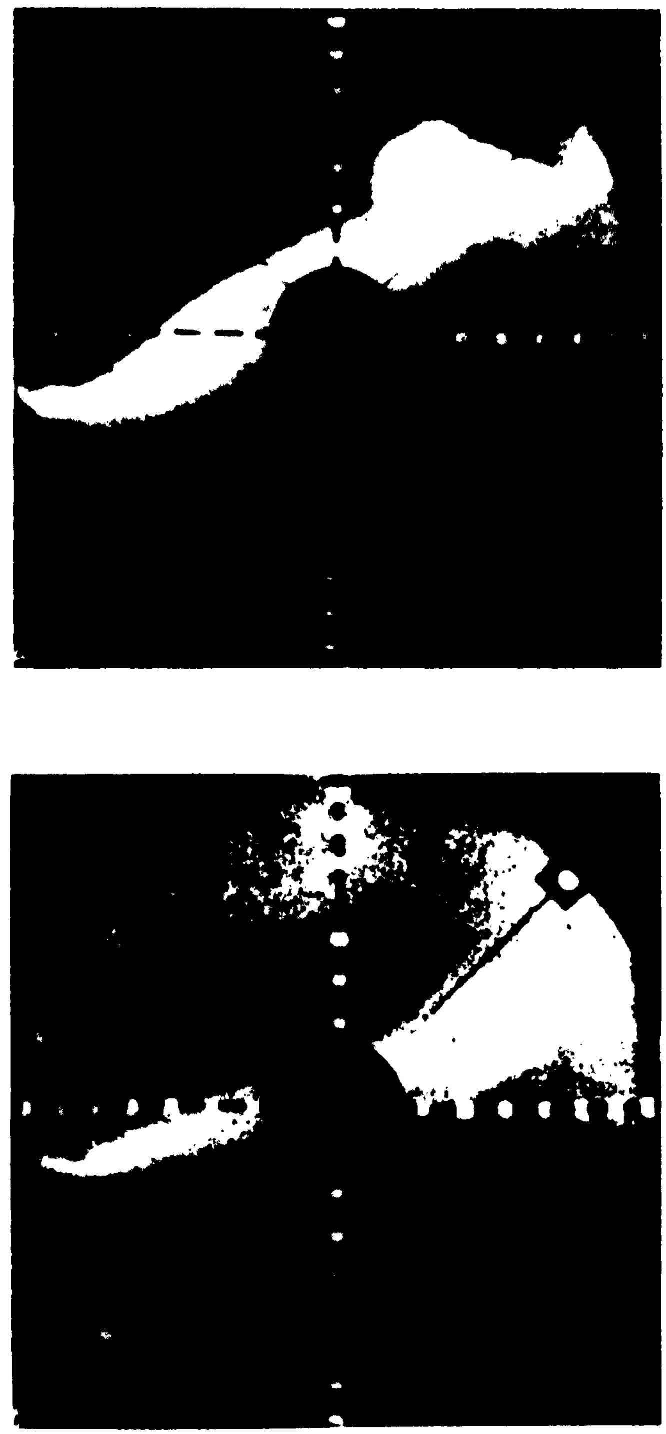
The fact is that with an intensification of aurorae, the background surrounding them sometimes increases and sometimes does not. Pictures of aurorae made by M. L. Bragin with wide-angle 180° cameras have enabled us to determine the area of the luminescent formations. Simultaneous electrophotometric measurements have given the value for intensity (in Rayleighs) of aurorae and diffuse forms surrounding the bright formations. The total ratio of intensity of luminescence of aurorae and background was calculated.

Table 3

Form of luminescence	aurora/background	Form of luminescence	aurora/background
HB - II	0,7	RA — II	0,4
HB II	1,3	HA — II	0,2
HB - II	0,5	HB — III	0,5
HB II	0,3	RA — II	0,1
RB - II	0,3	RA — II	0,9
HA - II	1,1	RB — II	1,1
HA — II	1,4	RB — II	0,5
HA · II	0,4	RB — II	0,4
D — III	1,0	RB — II	0,3
HB — II	0,2	HA — II	1,9
RA — II	0,4	HA — II	1,3
HB — II	0,3	HA — I	0,1
HB — II	0,2	HB — I	0,2
D — II	0,3	HA — I	0,5
D — II	7,3	HA — II	0,1
D — III	0,8	RA — II	2,0
HB — IV	15,0	RA — II	1,4
HB — IV	14,0	HB — I	0,4
HB — II	4,4	HB — II	3,6
RA — I	0,2	HB — II	2,2
HA — II	0,6	HA — I	1
HA — II	0,4	HA — I	1,2
HA — I	0,1	HA — II	2,2
HA — II	0,4	HA — II	0,9
RB — III	4,4		
RB — II	2,2		

Table 3 shows the results of these calculations. As can be seen, in a majority of cases during aurorae the greater part of the energy of luminescence is concentrated in the background and only in the brightest forms of aurorae does the energy of luminescence exceed the energy of the background. In Figures 6 and 7 are shown the most characteristic photographs. Figures 6a and 7a show bright forms of aurorae whose flux exceeds the flux from the background, while in Figures 6b and 7b the reverse is true.

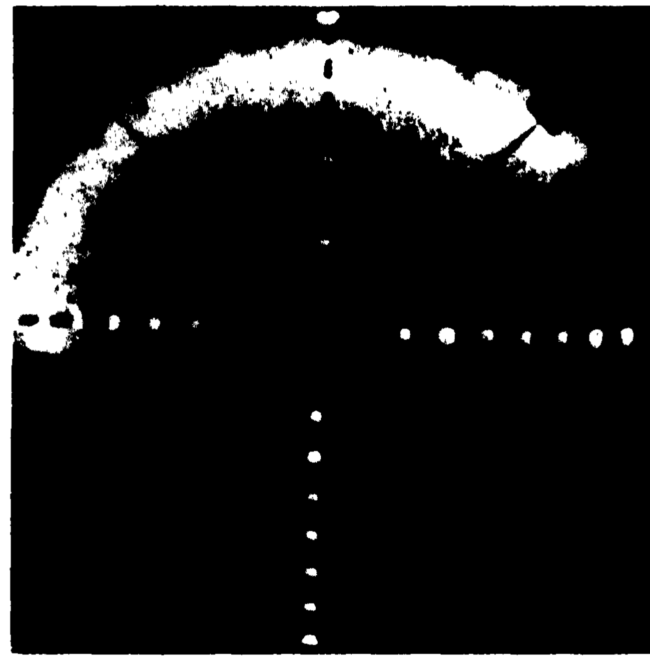
In addition to determinations of the absolute brightness of the various formations, an electrophotometric

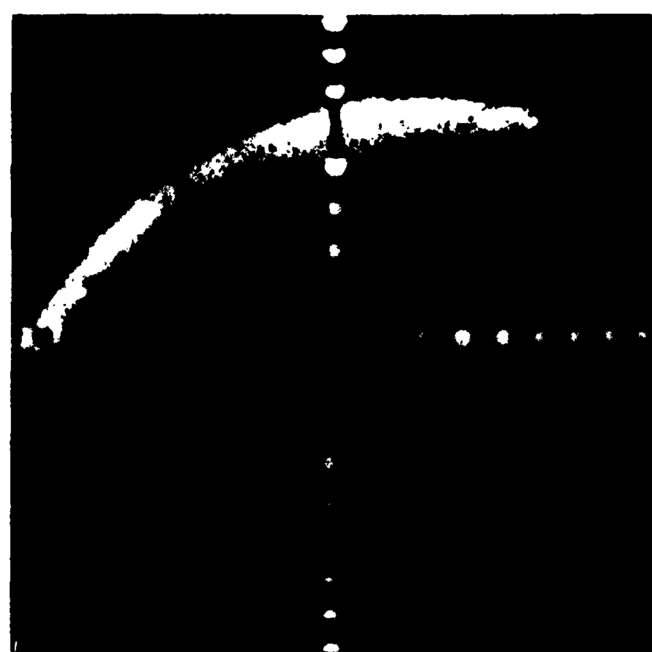


a - 15 January 1958, 2235 hours, HB-II, aurora/background 2.2;
b - 15 January 1958, 2210 hours, HB-I, aurora/background 0.4.

Fig. 6.

F
7
6





a - 14 December 1957, 2240 hours, PA-II, aurora/background 1.4;
b - 14 December 1957, 2352 hours, HA-I, aurora/background 0.4.

Fig. 7.

study of changes in intensity of rapid forms of aurorae was also made at Loparskaya. Very often, especially after the development of bright forms of aurorae, luminescent spots appeared throughout the entire sky. Their intensity changed rhythmically.

For the purpose of studying the relationships among pulsating spots, observations were carried out in which three photometers were aimed at different spots and the recording of each was made on a separate circuit of a type POB-12 oscillograph. Figure 8 shows a case in which three photometers, with filters for λ 3914 and 4278 A and without a filter (all multipliers of type FEU-19M), were aimed at three pulsating spots. One spot was in the north at an angle of 38°, another in the west at an angle of 36°, and a third was in the zenith. The clearly visible periodicity of pulsations was such that T ~ 6 seconds. Figure 9 shows recordings from spots whose pulsations first coincide in phase and are then directly opposed. The character of simultaneous pulsations of N_2 emission in different spots often is still more confused despite individual cases of coincidence. For the time being, therefore, it is difficult to draw conclusions about pulsations of different spots as related to one another.

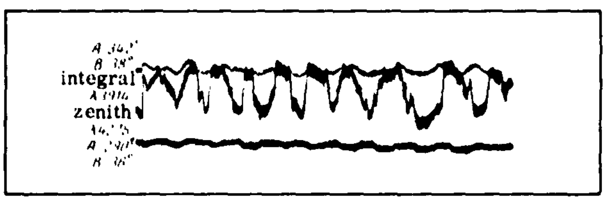


Fig. 8. Pulsating Spots 24 February 1958.

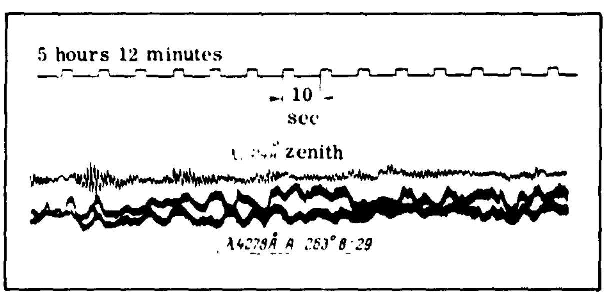


Fig. 9. Pulsating Spots 23 February 1958.

Figure 10 shows recordings for 23 February 1958 when all three photometers were aimed at a pulsating zone in the zenith. All three oscillograph circuits were synchronized. The ratio (a - b)/a (depth of modulation) characterizing the relative value of change in number of molecules of N_2^+ in the excited state $^2\Sigma_u$ proved to be 0.6.

Figure 11 corresponds to a case when two photometers with λ 5577 and 3914 A filters are aimed at one pulsating spot in the zenith. As can be seen, the pulsations of λ 5577 A duplicate the corresponding fluctuations of intensity of λ 3914 A and lag behind them

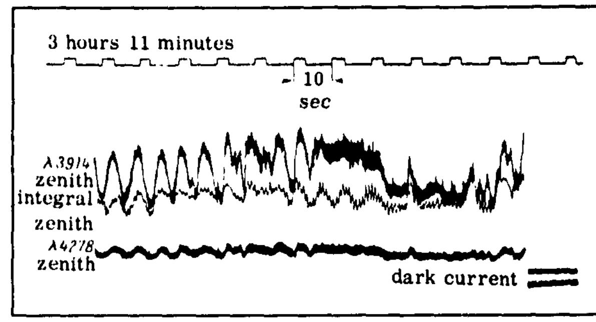


Fig. 10. Pulsating Band, 23 February 1958.

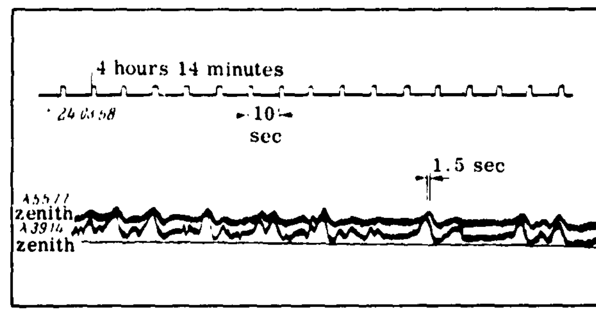


Fig. 11. Variations of Intensity of Emissions λ 5577 and 3914 A in Pulsating Spots.

by approximately 1.5 seconds. Ashburn (Ref. 3), making analagous measurements, obtained a lag between λ 5577 A and λ 3914 A of approximately 0.5 second. With Omholt (Ref. 4) the time interval between the maxima of λ 5577 and 4278 A lay in the range of 0.5 to 2 seconds.

Besides a study of pulsating spots, a study was also made of wave-like movements of the luminescent formations which are sometimes observed in our latitudes. Yu. I. Gal'perin was the first to devote his attention to them. He made visual determinations of the speed of movement of the waves (approximately 3 to 4 km/sec for heights of 100 km).

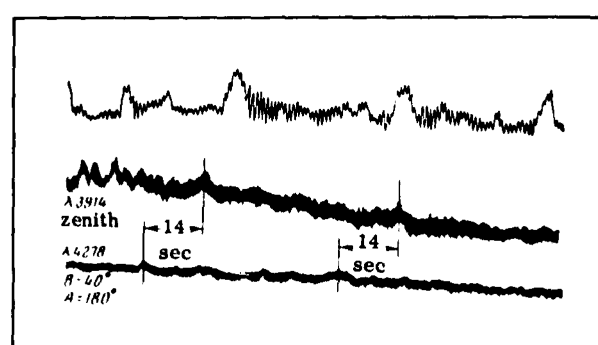


Fig. 12. Waves Recorded by Two Photometers on 23 February 1958.

In 1958 an attempt was made to study this phenomenon quantitatively. The work was done by using three electrophotometers situated in echelon along the path travelled by the waves. A series of appearances of such waves was recorded. The oscillogram of observations for 23 February 1958 is shown in Figure 12. The lag time was determined from the displacement between the flare-outs. We can obtain the velocity of propagation of the waves by knowing the angle between the photometers and assuming that the height of luminescence is 100 km. In our case it proved to be 9 km/sec. Such waves constitute relatively rare phenomena and the record received is not sufficiently clear; therefore the velocity of 9 km/sec should be looked upon as a preliminary result. We hope to continue the study of these waves in the future.

ABSTRACT[2]

At the Loparskaya station the electrophotometrical measurements of the night airglow and auroral emissions were carried under the IGY programme. Intensity of the airglow emissions of Loparskaya ($\varphi = 69°$) are 1, 5 - 2 times that in Zvenigorod ($\varphi = 56°$). The mean ratios of the main emissions in different auroral forms were obtained from a large quantity of measurements. The intensity changes of λ 6300 A in the red rays RR are in the opposite sense than of the λ 5577 and 4278 A. It is shown that the main part of the radiated energy is emitted not in the bright auroral forms but in the diffuse background around them in the most of auroras. The short period emission intensity variations in auroras were studied. The period of the pulsations is of order of some seconds. The spatial velocity of the wavelike intensity changes is of some kilometers per second.

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[2] The abstract appeared in English in the original Russian publication and is repringed here with no change

AN ATTEMPT AT INTERFEROMETRICAL STUDY OF AURORAL EMISSION LINES

by

T. M. Mulyarchik

During the winter of 1957 - 1958 at the Loparskaya station, observations were made using two Fabry-Perot interferometers. Both interferometers had glass plates with a diameter of 60 mm. Their precision in preparation was $\lambda/75$. The plates had multilayered dielectric coatings applied at the State Optical Institute. The coefficient of reflection for both plates of the first interferometer is given below.

λ 5577	5890	6300
R 94%	94.5%	95%

Observations were made with a quartz intermediary ring with a thickness of 32 mm so that the field of dispersion of the interferometer was 0.05 A. The interferometer, placed in an airtight chamber, was thermostatically controlled with a precision of 0.05°. Individual emissions of aurorae were separated out by the interference filters. The relative opening of the apparatus was 1:3. Photography was made on hypersensitized D_H plates, usually with exposures of 1 to 2 hours. Before the beginning of the main exposure and after its completion on the plate with a 30 minute exposure, interference rings were impressed from a low pressure krypton gas discharge tube. The width of the instrument contour was 0.01 A.

Interference rings for the lines λ 5577 and 6300 A were received at the time of various forms of aurorae. Preliminary estimates of the half-width of the green line λ 5577 A from ten pictures enable us to evaluate the upper boundary of kinetic temperature of emitting atoms of oxygen in the state $^1S_0$ at 400° K. For the red line [OI] λ 6300 A we find a temperature on the order of 1000° K. The pictures obtained at the time of an intense aurora of 10 - 11 February 1958 yielded different results. In the first two pictures, recorded at the time of a homogeneous arc and ray-like forms of a greenish-yellow color, clear rings are visible. The measurement of their half-width shows that the temperature of emitting atoms is on the order of 1000° K. In the third picture, recorded at the time of exceptionally intense red forms of type A (defined by emissions of λ 6300 - 6364 A), with the same exposure as in the two preceding cases, the interference picture of the λ 6300 A line is blurred, the background between the rings is very much enhanced, and the rings themselves are faint and washed out. Evidently this is the result of a strong broadening of the line due to an increase in the kinetic temperature. For this the temperature of the emitting atoms should exceed 2500° K.

A second apparatus consisted of an interferometer with multilayered dielectric coatings, designed for the infrared region of the spectrum, and including chambers with image converters. The space between the plates was 6 mm, the coefficient of reflection for λ 8500 was R = 94%, and the relative opening of the apparatus was 1:2.8. For determining the instrument contour after the main exposure, interference rings were impressed from the krypton gas discharge tube. With this apparatus we succeeded in obtaining interference rings for the line λ 8446 A, clearly divided into two components.

ABSTRACT[1]

At the Loparskaya station the fringes of the oxygen emissions λ 5577, 6300 and 8446 A were obtained. Preliminary estimates of the green line's width give upper limit for the kinetic temperature of emmiting atoms as 400° K. The temperature for red line is of order of 1000° K. Indications have been obtained to strong widening of λ 6300 A line in bright red aurora of A-type.

[1] The abstract appeared in English in the original Russian publication and is reprinted here with no change.

ON THE OBSERVATIONS OF THE LINE λ 6562 Å IN THE SPECTRUM OF THE NIGHT SKY

by

V. S. Prokudina

During 1957 - 1958 at the Zvenigorod station, a line with the wavelength λ 6562 $\pm$2 A[1] was discovered among lines of the hydroxyl band (6.1) (λ 6465 - 6600 A) between the components P_2 and p_3 of the rotational structure, in spectra obtained at times of good transparency. In Figure 1 are shown examples of spectra and traces pertaining to observations made in 1958. In 1957 a survey was made northward at an angle of 30° above the horizon and in 1958 a survey was made in the magnetic zenith and the magnetic horizon.[2] According to estimates for 1957 (March - April), this emission line is comparable with P_1 and P_2 with OH lines (6.1) and is approximately 3 to 8 times weaker than OI λ 6364 A. Since the measured length of the wave within the limits of error coincides with H_α, it may be assumed that the emission belongs to neutral hydrogen.

It is well known that a hydrogen emission appears in aurorae. The H_α line that is recorded at the time of an intensive low-latitude aurora has a broad contour (Figure 2). However, in the present case the width of the line coincides with the widths of the instrument contour. Disturbances of the earth's magnetic field are no more than moderate: changes in Z_γ on the days of observation were usually $\Delta Z \sim$ 30-60 γ. H_γ underwent almost no change at all. It is well known that during intensive low-latitude aurorae ΔZ is 300 to 500 γ; ΔH is 300 to 700 γ.

However, the connection between small disturbances of the magnetic field and change in intensity of emission of λ 6562 A does possibly exist. The lines NI λ 5200 A and N_2^+ 4278 A, which were sometimes observed on these days, were weaker in comparison with the usual low-latitude aurorae by 3 to 8 times for NI and 4 to 10 times for N_2^+, respectively. Thus, the appearance of narrow emission with a wavelength of λ 6562 A can not be associated with a typical low-latitude aurora.

Observations in 1958 revealed the existence of this emission in the direction of the magnetic zenith with a weakening of intensity, apparently due to a decrease in the optical thickness.

When sweeping to the north, the Milky Way fell into the spectrograph's field of vision; however, NII lines, typical for diffuse gaseous nebulae, were not detected.

If this emission actually belongs to hydrogen, then the study of the possibility of excitation of this line in the upper atmosphere or in interplanetary space is of considerable interest.

ABSTRACT[3]

Registration of a narrow spectral line at λ 6562 A in the night airglow spectrum is reported.

[1] The wavelength for OH P_2 is λ6554 A; p_3 - λ6569 A; P - λ6578 A.

[2] When the angle of the sun's dip is greater than 18°.

[3] The abstract appeared in English in the original Russian publication and is reprinted here with no change.

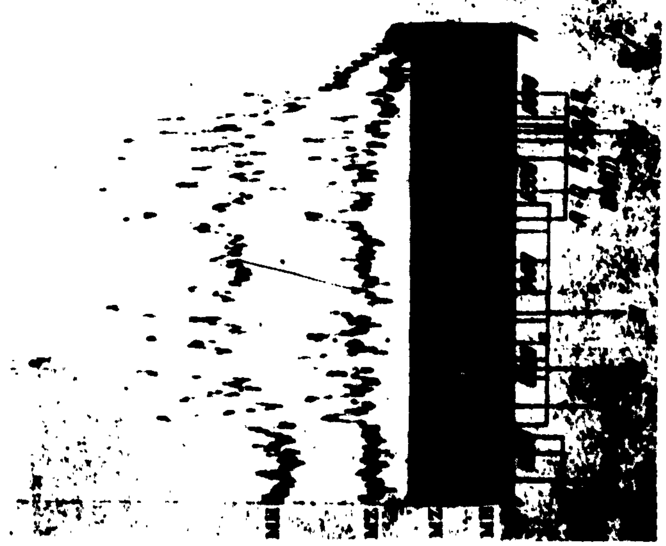
Fig. 1a.

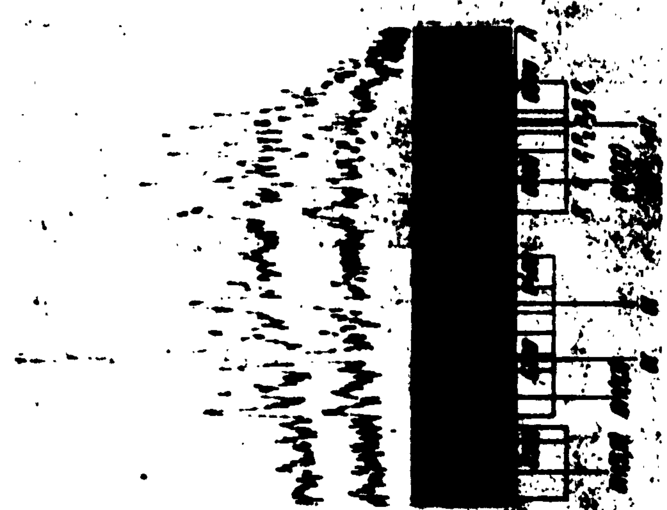
Fig. 1b.

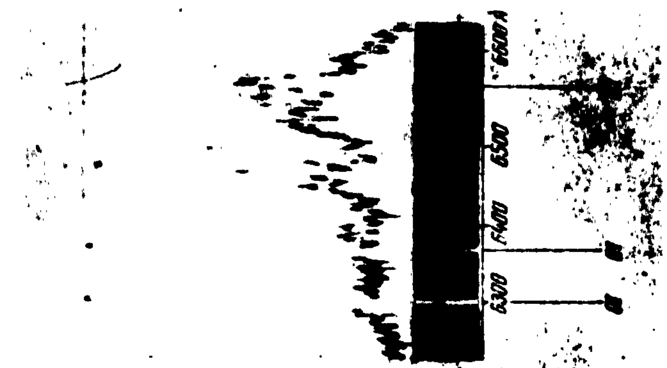

Fig. 2.

SOME RESULTS OF SPECTROSCOPIC INVESTIGATIONS OF AURORAL AND NIGHT GLOW SPECTRA

by

F. K. Shuyskaya

At the Roshchino station, an IGY program of spectroscopic observations is being carried out using the SP-48 and SP-49 spectrographs. Descriptions of the instruments and the method for producing and processing spectrograms are set forth in Refs. 1 - 4 .

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From the beginning of the International Geophysical Year through March 1958, five spectrograms were recorded showing H_α emissions at the time of aurorae of types HA, R, F, and RP. One spectrogram was recorded while sighting at the magnetic zenith and the others while sighting at the magnetic horizon. The hydrogen emission in all the spectrograms, with one exception relating to the magnetic horizon, is strongly blended with the first positive system of molecular nitrogen. The intensity of H_α in no case exceeds the intensity of the adjoining zones 1PG N_2 . Investigation of the H_α profile in the zenith has demonstrated that the displacement of the maximum corresponds to a velocity of +360 km/sec. In the violet direction from the maximum, the emission is traced to a velocity of approximately -600 km/sec; then the profile of H_α is blended with an emission of 1PG N_2 . The half-width of the H_α profile that is free from blending on the magnetic horizon is equal to 13 A. The results of observations at Roshchino coincide with those obtained at the Loparskaya and Zvenigorod stations (Refs. 3 - 5).

On nights free of aurorae, six spectrograms in the red region were recorded with emissions of hydroxyl, taken while sighting at an angle of 20° above the horizon. Four spectrograms were recorded at the magnetic zenith (approximately 20° to the south of the zenith). The rotational temperature, determined for the bands (8.2) and (9.3), in a northward direction, is 275° ±12° K and in the zenith it is 265° ±12° K. The temperature was determined from the allowed branch of P by means of the graph $[\ln \frac{I}{i(J')} ;\ J'(J'+1)]$.

The intensity of the lines was measured in the maximum. The accuracy of each of the derived values of T, determined from the dispersion of points on the indicated graph, is 6 to 7 percent; it is therefore impossible to speak with assurance about the temperature differences that correspond to the different directions. There is no doubt, however, that the temperature measured at Roshchino (latitude φ = 60°) is higher than at Byurakan (φ = 42°, T = 230° K) and at Zvenigorod (φ = 56°, T = 240° K) and lower than at Loparskaya (φ = 69°, T = 290° K in the zenith and 330° K at an angle of 15° above the northern horizon) (Refs. 2 - 5).

Several spectra of aurorae were recorded in the nearer ultraviolet region of the spectrum (SP-49 spectrograph). Figure 1 reproduces a spectrum produced by flaming forms of aurorae; similar spectra have been obtained from ray-like forms.

Fig. 1. Spectrum of a low-latitude aurora in the ultra-violet region, recorded on the SP-49 spectrograph. The relative intensities of emissions and their assumed identifications are cited in Table 1.

Table 1 gives the measured wavelengths of observed emissions (precision +2 A), laboratory λ taken from the tables in Refs. 6 - 8, presumed identification (for atomic lines, the corresponding transition is shown), and the intensity expressed as a ratio to the intensity of the line [NI] λ 3466 A. When determining the magnitude of the value for T, use was made of a characteristic curve in the visible field (a nine-stage attenuator illuminated by a white luminophor, imprinted on film with an exposure of 1.5 hours). For molecular bands, the full value of intensity enclosed within the boundaries of the band was determined, and for atomic lines the intensity in the maximum was determined.

The spectral sensitivity was evaluated from the curve published in Ref. 9 for a plate of the D_H type[1]. Table 2 gives a Frank-Condon parabola for 2PG N_2, and Table 3 gives one for 1NG N_2^+. In both tables the values for intensity were taken from Table 1.

Table 1

$\lambda_{measured}$ Å	λ_{lab} Å	Identification		I
3997	3998,4	N_2 2*PG*	(1,4)	2,2
3943	3943,0	N_2 2*PG*	(2,5)	0,35
3914	3914,4	N_2^+ 1*NG*	(0,0)	24
3882	3884,0	N_2^+ 1*NG*	(1,1)	3,8
3872		OII, NII?		1,9
3857	3857,9	N_2^+ 1*NG*	(2,2)	0,57
3832	3835,4	N_2^+ 1*NG*	(3,3)	0,32
3804	3804,9	N_2 2*PG*	(0,2)	4,5
3773		?		0,23
3756	3755,0	N_2 2*PG*	(1,3)	2,9
3707	3710,5	N_2 2*PG*	(2,4)	1,6
3684	3684,0	N_2 *VK*	(1,11)	0,06
3582	3582,1	N_2^+ 1*NG*	(1,0)	2,2
3576	3576,9	N_2 2*PG*	(0,1)	8,9
3535	3536,7	N_2 2*PG*	(1,2)	4,3
3466	3466,0	NI $2p^3\,{}^4S - 2p^3\,{}^2P$		1,0
3500	3500,5	N_2 2*PG*	(2,3)	1,4
3425	3424,6	N_2 *VK*	(1,10)	1,5
3371	3371,3	N_2 2*PG*	(0,0)	11
3341	3339,0	N_2 2*PG*	(1,1)	0,95
3285	3285,3	N_2 2*PG*	(3,3)	0,94
3270	3268,0	N_2 2*PG*	(4,4)	1,2
3160	3159,3	N_2 2*PG*	(1,0)	2,5
3134	3136,0	N_2 2*PG*	(2,1)	0,92

[1] The absorption of the atmosphere and the ozone layer and that passing through the spectrograph was not taken into consideration. This leads to an apparent decrease in intensity at the short-wave end of the spectrum.

Table 2

v' \ v''	0	1	2	3	4	5
0	11	8,9	4,5			
1	2,5	0,95	4,3	2,9	2,2	
2		0,92		1,4	1,6	0,35
3				0,94		
4					1,2	

Table 3

v' \ v''	0	1	2	3	4
0	2,4				
1	2,2	3,8			
2			5,7		
3				0,32	

ABSTRACT[2]

Some results of the spectroscopical studies at Roshchino are reported. Auroral hydrogen H_α profile coincides with that obtained at the other two stations. Hydroxyl rotational temperature is equal to $265° \pm 12°$ K in the zenith and $275° \pm 12°$ K in the northern direction 20° above the horizon. Some results of treatment of auroral ultraviolet spectra are presented.

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