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ON SOME PECULIARITIES OF AURORAL EMISSIONS' INTENSITY IN THE NEAR UV AND IR REGIONS OF THE SPECTRUM

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Abstract. There has been carried out a statistical study of the summarized intensity of aurora emissions within the auroral zone in the near UV (λ 300-390 nm) and in the near IR region (λ 700-1200 nm) of the spectrum. There was obtained that the luminosity intensity in those spectral regions with the maximum value Kp=9 in the electron auroras of the 1984-1985 season makes up respectively in energy units 2.28 erg/cm^{2}s, 2.20 erg/cm^{2}s, which is 3.5 times more than the total intensity of emissions' luminosity in the visible part of the spectrum (λ 390-700 nm), that was equal to 1.32 erg/cm^{2}s. The intensity of lines of the ionized oxygen in the near UV region [OII] λ 372.7 nm is usually less than 300 Rayleighs, which had been observed only in the great aurora of 10-11.02.1958, whereas the intensity of oxygen lines in the near IR region [OII] λ 732.0-733.0 nm reaches the values of 400-500 Rayleighs and is observed according to foreign data with the red auroras of A type, sunlit, basically in the region of the Polar cusp. Provided, there is a corresponding equipment available, variations of those lines may be used for studying the dynamics of the Polar ionosphere.

1. Introduction

The Sun is the basic source of energy, spent on the origination and development of magnetospheric storms and substorms. As known, auroras seem to be a manifestation of the solar origin plasma interaction processes with neutral and ionized component of the Earth's atmosphere. The energy of the solar wind during geomagnetic storms is transformed differently in the magnetosphere. In particular, this paper considers the energy dissipation in the ionosphere just by means of dissipating particles, whereas it is only spent directly on the generation of aurora luminosity in the auroral zone.

So far, it remains unclear, how the released energy is distributed over the spectrum. In a recent paper [Yevlashin and Maltsev, 2004] within the framework of studying the energetics of magnetic storms there was found the total intensity of luminosity energies within the visible region of spectrum depending on Kp-index for auroras of various types.

The goal of this paper is to estimate the total intensity of aurora emission luminosity in the near UV (λ 300-390 nm) and in the near IR (λ 700-1200 nm) regions of the spectrum at different geomagnetic activity.

2. Measurement results and the analysis of data obtained

The registration of aurora spectra has been accomplished using SP-49 (UV-region) and SP-50 (IR region) spectrographs with linear dispersion being ≈ 10 nm/mm. Due to the fact exposition time sometimes reached several hours, during spectra photography, it seems impossible to be able to estimate emission intensities for different types of aurora, as some of them existed for a considerably shorter time. That is why, basically, during the study the data were believed to belong to auroras, stipulated by the electron precipitation. There were used the data obtained during 2 seasons of observation: 1957-1958 and 1984-1985. The processed data on the summarized intensities are given in Tables 1 and 2. If one considers these materials and compares them to the data, obtained in paper [Yevlashin and Maltsev, 2004], one may conclude, that the summarized luminosity intensity in the near UV and IR spectrum regions, which, with the maximum value of Kp=9, made in energy units, respectively, 2.28 erg/cm^2 sec and 2.20 erg/cm^2 sec, 3.5 times more than the summarized intensity within the visible region of spectrum, which had made 1.32 erg/cm^2.

As one can see from Table 1, the basic contribution into the summarized intensity in the UV region of spectrum is provided by the bands of the second positive system of molecular nitrogen (2PGN_2), of Vegard-Kaplan (VK) and, partly of the first negative system of nitrogen ionized molecule (1 NG N_2^+). The data of table 2 are an evidence of the fact, that within the near IR spectrum region the basic contribution into the summarized intensity is made by the bands of the first positive system of molecular nitrogen and the system of molecular ionized Meinel nitrogen (MGN_2^+). The contribution of the intensity of neutral and ionized atoms of oxygen and nitrogen in both UV and IR regions of the spectrum is relatively small. Nevertheless, those emissions are of significant interest.

The ionized oxygen lines: λ 372.6-372.8 nm (a doublet with the center [OII] λ 372.7 nm) in the near ultraviolet, as well as the lines [OII] λ 732.0 – 733.0 nm in the near IR region may give one certain information about the ion dynamics O^+ in the F-region of the Earth's ionosphere.

3. Discussion of the results

The obtained results by the luminosity intensities of auroral emissions qualitatively agree with the theoretical calculations, published in the paper [Rees, 1975], which says, that the energy of auroral emission within the visible region of spectrum makes ~ 5% of the total energy of the entire spectrum emission. (30%). Unfortunately, the measurments of emissions in the middle and farther (UV and IR) regions of the spectrum are most difficult to do, as they require a special equipment, installed onboard the sounding high-altitude rockets and satellites. The measurements of that type are carried out in a most fragmentary way, so it dos not seem possible to use their results in order to obtain statistic regularities for studying luminosity in those regions.

Within the visible region of the spectrum the energy of the emission is determined to a large extent by the intensity of the forbidden oxygen lines [OI] λ 557.7 nm and [OI] λ 630.0 – 636.4 nm, the intensity of which is most easily found using simple enough tools, as they are practically not blended by any emissions. Thus, the studies of atomic oxygen lines in other regions of the spectrum is of a significant scientific interest indeed. In the near ultraviolet the permitted lines of the atomic ionized oxygen: OII λ 312.3 nm; OII λ 312.9 nm; OII λ 314.0 nm; OII λ 322.8 nm are partly blended by the bands $2PGN_2$, so they are most difficult to be quantitatively measured and, thus, interpreted. In the near IR region the lines of atomic oxygen OI λ 798.5 nm and OI λ 799.8 nm are blended by the bands $1PGN_2$, which also prevents one from finding their absolute intensities.

The permitted lines of atomic oxygen OI λ 844.6 nm and OI λ 777.4 nm are relatively free of the blending influence of molecular bands. The statistically found (see Table 2) ratio of their intensities is equal to 1.3, which is somewhat different from what had been observed in the bright forms of auroras, and constitutes the value equal to 2 [Vallance Jones, 1974]. As to the lines of ionized oxygen [OII] λ 732.0 – 733.0 nm, the values of their intensities are not provided in Table 2, as the measurements of their absolute values are most difficult to do. According to the literature data the line [OII] λ 372.7 nm with the intensity < 300 rayleighs was observed in the spectrum only once, during a great aurora of February 10-11, 1958 [Wallace, 1959]. The lines [OII] λ 732.0-733.0 nm in the near IR-region according to data [Sivjee and Shen, 1997] and [Deehr et al., 1980] had only been observed in red type A auroras, sunlit, and mostly in the region of the polar cusp with the intensity of 400-500 rayleighs.

4. Conclusions

1. The summarized intensity of auroral luminosity in the near UV and IR regions of the spectrum with Kp=9 is 3.5 times larger, than the summarized intensity of the luminosity in the visible region of the spectrum.
2. It does not seem possible to obtain a reliable registration of the intensities of emissions of the ionized oxygen in the near UV-region [OII] λ 372.7 nm and in the near IR-regions [OII] λ 732.0 – 733.0 nm in usual auroras, observed in the auroral zone using standard equipment.

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Table 1

The maximum value intensity of emissions electron aurora in the near UV-region with Кр=9

λ, nm	Atom or molecule	Transition	Intensity, kR
311.7	N_2	2PG(3-2)	7
312.3	0II	3^4D^0-4^4P	3
312.9	0II	3^4D^0-4^4P	3
313.6	N_2	2PG(2-1)	18
314.0	0II	$3^4D^{0-}4^4P$	18
315.9	N_2	2PG(1-0)	40
319.8	N_2	VK(1-9)	8
328.5	N_2	2PG(3-3)	3
328.8	0II	3^4P^0-4^4P	3
329.9	N_2^+	1NG(3-1)	10
330.9	N_2	2PG(2-2)	10
317.1	N_2	2PG(0-0)	55
342.5	N_2	VK(1-10)	4
346.6	[NI]	2^43^0-2^2P^0	11
350.0	N_2	2PG(2-3)	5
353.0	N_2^+	1NG(4-3)	20
353.7	N_2	2PG(1-3)	18
354.9	N_2^+	1NG(3-2)	20
356.4	N_2^+	1NG(2-1)	28
357.7	N_2	2PG(0-1)	25
358.2	N_2^+	1NG(1-0)	38
372.7	[0II]	2^4S^0-2^2D^0	<0.3
375.5	N_2	2PG(1-3)	8
380.5	N_2	2PG(0-2)	15
388.4	N_2^+	1NG(1-1)	28

Total: 398 kR=2,28 erg/cm^{2}s

Table 2

The maximum value intensity of emissions electron aurora
In the near IR-region with Кр=9,6,3

λ, nm	Atom or molecule	Transition	Intensity, kR		
			Kp=9	Kp=6	Kp=3
706.9	N_2^+	MG(4-1)	6	1	-
727.4	N_2	1PG(6-4)	5	1	-
727.6	N_2^+	MG(5-2)	10	3	-
738.7	N_2	1PG(5-3)	27	4	1
750.5	N_2	1PG(4-2)	52	10	2
762.7	N_2	1PG(3-1)	61	10	3
775.4	N_2	1PG(2-0)	59	9	2
777.4	0I	3^5S^0-3^5P	6	1	0.5
785.4	N_2^+	MG(2-0)	62	11	3
798.7-9.5	0I	3^3P-3^3D^0	5	0.4	0.1
808.5	N_2^+	MG(3-1)	43	10	2
818.5-8.8	NI	3^4P-3^4P^0	1	0.1	-
821.6-2.3	NI	3^4P-3^4P^0	1	0.3	0.1
824.2	NI	3^4P-3^4P^0	0.5	0.1	-
833.0	N_2^+	MG(4-2)	14	3	1
844.6	0I	3^3S^0-3^3P	8	3	1
854.2	N_2	1PG(3-2)	13	3	-
859.0	N_2^+	MG(5-3)	6	2	-
864.5	0_2	Атм(0-1)	51	9	3
868.0-8.3	NI	3^4P-3^4D^0	1	0.5	-
872.3	N_2	1PG(2-1)	66	9	3
891.2	N_2	1PG(1-0)	75	13	3
918.4	N_2^+	MG(1-0)	98	17	4
947.1	N_2^+	MG(2-1)	41	-	-
977.6	N_2^+	MG(2-1)	-	-	-
1039.5-40.4	[NI]	2^2D^0-2^2P^0	6	3	1
1046.9	N_2	1PG(0-0)	77	12	4
1108.8	N_2^+	MG(0-0)	88	15	5
		Total:	880 kR= 2.20 erg/cm^{2}s	138 kR= 0.35 erg/cm^{2}s	37 kR= 0.09 erg/cm^{2}s