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SHORT-TERM VARIATIONS OF THE INTENSITY OF Hα HYDROGEN EMISSION OF AURORAS DURING THE ONSET OF AURORAL SUBSTORM

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Abstract. There are studied spectral data of auroras, obtained by C-180-S camera with a photomultiplier tube (exposure time – 2 min, wavelength resolution - 2 nm) at the observatory of Loparskaya during the IMS period. 8 events have been analyzed. It was found that no systematic short-term decrease or increase of Hα line intensity occurred during the onset of auroral substorm or at the time of breakup either. Statistical analysis allowed to identify only long-period variations of 557.7 nm and 656.3 nm emissions intensities during the growth phase of substorm.

1. Introduction

Hydrogen lines H_α λ656.3 nm and H_β λ486.1 nm in spectra of auroras belong to protons of solar origin, which, along with auroral electrons, penetrate into the atmosphere of the high latitudes of the Earth and result in the luminosity of auroras [Chamberlain, 1961]. By studying the variations of the intensity of these emissions, one can determine the energy, introduced into the atmosphere or ionization caused by them and to assess the contribution of protons into the development of auroral substorm as well.

The issue of long-period variations of hydrogen emissions (tens of minutes) in spectra of auroras during the development of auroral substorm at present is more or less clear: at the growth phase the intensity of hydrogen line H_α is large enough, while at the phase of expansive its intensity drops abruptly and in the period of the recovery phase the H_α emission intensity increases again [Yevlashin and Yevlashina, 1980].

As far as the fast variations of hydrogen emissions intensity (minutes) are concerned, especially in the initial period of substorm development, this issue is still open to discussion. So, in paper [Belon et al., 1974] it is noted that the intensity of the line H_β increases dramatically at the moment of breakup concurrently with the enhancement of the arc brightness in the emission [OI] λ557.7 nm. The authors of the paper [Pellinen and Heikkila, 1978] found, that along with a short decrease of electron aurora intensity (emission N_2^+ λ427.8 nm) a weakening of the intensity of proton aurora (emission H_β) takes place prior to breakup. At the same time in paper [Fedorova et al., 1988] it was found that a breakup, as a rule, preceded by the brightening of emission H_α , which most probably starts within a 7-min time interval and less prior to the onset of breakup, without any signs of local activation of the substorm at that time. Besides, in some events an intensification of H_α is observed during a breakup. In a recently published paper [Borovkov et al., 2005], it is shown, using a new spectrograph with high temporal and wavelength resolution and high sensitivity, unfortunately just in one event, that at the growth phase of substorm some decrease of H_α line intensity takes place with a brightening just before the breakup. As far as breakup is concerned, at that moment an abrupt decrease of H_α intensity takes place with a subsequent significant increase of its intensity after the breakup.

Due to such contradictory data, we have made an effort, using previously obtained materials (8 observation nights), within the framework of "International Magnetospheric Study", to trace the regularities of the behaviour of hydrogen emission H_α during the initial period of substorm.

2. Results of the study

There were analyzed both standard materials of the C-180-S camera [Lebedinsky, 1961], obtained with exposure of 20 min and wavelength resolution of 5 nm and the data of the camera C-180-S B1, in which a photomultiplier tube was used as a intensifier intensity of emission, which allowed us to reduce the exposure time to 2 min, while increasing the wavelength resolution, which made 2 nm. This camera covered a large interval of latitudes (from 60^0 to 70^0 Φ) within the wave range from 550.0 to 750.0 nm, while the spectrum included all basic auroras emissions. The record threshold for emission H_α made at that ~ 100 Rayleigh.

Based on magnetograms of Loparskaya observatory for 1980-1983 there were selected the days, when in the near-midnight hours one could observe a single negative bay in the H-component with the intensity in the maximum over $|200|$ nT~, which could be identified with the availability of an isolated substorm.

For photometry there were selected spectral data, obtained only at night with satisfactory transparence, without any stray lighting (the Moon), with a good quality of spectra registration, RF-3 fluorographic film was used. In all there were selected 20 nights for photometry. Spectra were adjusted using 21 step attenuators. The obtained data were processed with MF-4 microphotometer, and EPP-09 automatic recorder to record the data. The time period for photometry of spectra made for each night ~1 hour: 40 min at the positive value of H-component of the magnetic field and 20 min at the subsequent negative value of H-component. For detailed analysis there were selected only 8 events, which were characterized by an abrupt enough transition of H-component from the positive values to the negative ones: 20-21.09.81; 28-29.10.81; 24-25.12.81; 18-19.01.82; 14-15.12.82; 3-4.02.83; 10-11.03.83; 15-16.03.83. As an example fig.1 presents the time dependence of intensities of emissions, [OI] 557.7 and H_α 656.3 nm for the substorm of 24-25.12.81 between 21^h and 23^h of UT. On the left there is presented the time dependence of emission intensities, obtained by the main camera (without photomultiplier tube) with exposure time of 20 min, while on the right there is provided the time dependence of intensities with a 1 min resolution, obtained by 2 cameras, equipped with photomultiplier tubes. Below the H-component of the magnetic field of the Earth at Loparskaya observatory is shown. In the assumption of the mean altitude of the luminosity for emissions 557.7 and H_α, equal to 110 km, there are determined the intensities values for different geomagnetic latitudes. Fig. 1 provides the intensities values in their projection on the Earth's surface for 62^0, 63^0, 64^0, 65^0 66^0 and 67^0 of the geomagnetic latitudes. If one compares the results of fig.1 and the data, obtained for other events, one can find most various short-time variations of intensities of emissions at the initial period of substorm development.

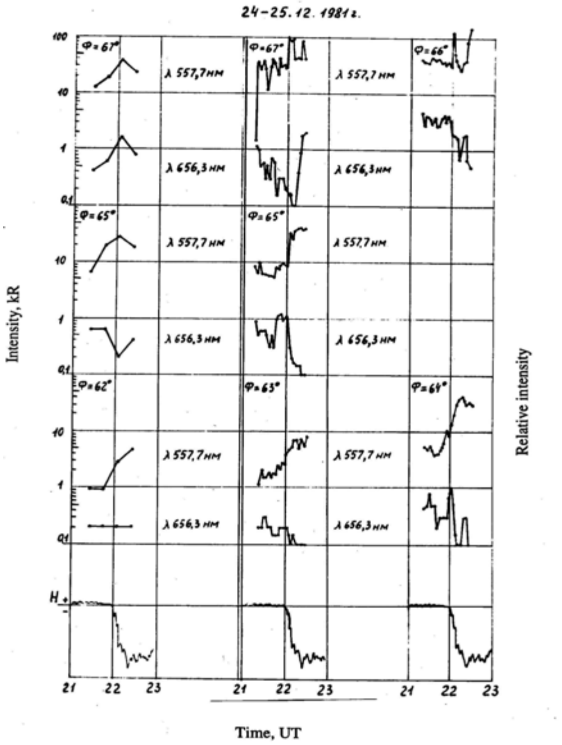

Fig.1. Dependence of the intensities of emissions 557.7 and 656.3 nm on time at different geomagnetic latitudes.

In order to find some regularities in the behaviour of the studied emissions, there were averaged the intensities values of emissions at different geomagnetic latitudes and distinctly recorded time moments relative to the transition point of the H-component from the positive values to the negative ones, which was identified with the moment of breakup. Then, using the sliding average technique with a step of 5 min, there were built smoothed average values of intensities at different geomagnetic latitudes for 8 considered events. The results are presented in fig.2. The analysis of these data shows, that there is observed an enhancement of 557.7 nm emission intensity at all geomagnetic latitudes at the moment of abrupt change of the H-component. This is an evidence of the fact, that the method of breakup determination in this way corresponds to the truth, since, according to all earlier known studies, at the moment of breakup there occurs an enhancement of the total brightness of auroras, including in emission 557.7 nm [Akasofu, 1968]. As far as hydrogen emission H_α is concerned, judging by data in fig.2, only the fact of gradual increase of its intensity prior to the onset of breakup with a subsequent decrease after the breakup can be considered certain enough.

3. Conclusion

As a result of this study, it is shown, that no any systematic short-time rise or drop of the hydrogen emission H_α, intensity at the initial period of auroral substorm as well as at the moment of breakup was recorded. The statistic analysis has identified only long-period variations of the intensities of emissions [OI] 557.7 and H_α 656.3 nm during the growth phase of the substorm and the moment of breakup.

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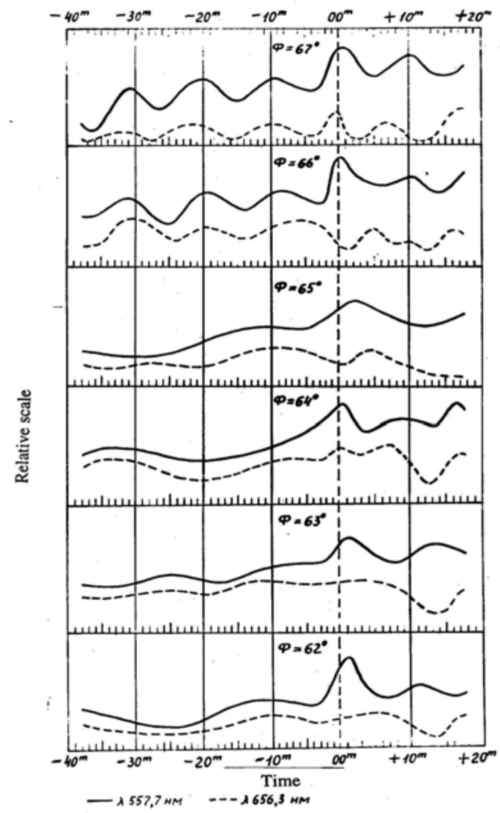

Fig.2. Averaged smoothed values of the intensities of emission 557.7 and 656.3 nm at different geomagnetic latitudes depending on time during a substorm.

References

Akasofu S.I., Polar and magnetosphere substorms// D.Reidel Publ., Holland, 315 p., 1968.

Belon A.E., Romick G.J, Stringer W.J. Proton precipitation during the auroral breakup// Planet Space Sci., v.22, N.4, p.735-742, 1974.

Borovkov L.P., Kozelov B.V., Yevlashin L.S., Chernouss S.A. Variation of auroral hydrogen emission near substorm onset// Ann.Geophys., v.24, N.5, p.1623-1635, 2005.

Chamberlain J.W., Physics of the aurora and airglow// Academic Press, New York, 777 p., 1961.

Fedorova N.I., Tsirs V.E. and Lazutin L.L. Impulsive enhancements of the aurora luminosity before the substorm active phase //Geomagn.Aeron., v.28, N.1, 87-91, 1988.

Lebedinsky A.I. Synchronous auroral registration by all-sky camera C-180 and patrol spectrograph C-180-S// In: “Ann..Internat. Geophys.Year”, v.11, p.133-143, 1961.

Pellinen R.J., Heikkila W.J. Observations of auroral fading before breakup// J.Geophys.Res.,v. 83, N.4, p. 4207-4217, 1978.

Yevlashin L.S. and Yevlashina L.M., Field aligned electric field as main source of particle acceleration during auroral substorm// In: “The structure of particle acceleration during auroral substorm (Results of IMS)”, Apatity, Kola Science Centre RAS, 45-53, 1980.