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HYDROGEN EMISSION H_α INTENSITY VARIATIONS MEASURED IN WINTER 2002-2003 IN APATITY

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Abstract

Measurements of energetic proton precipitation by means of hydrogen optical emission H_α registration during geomagnetic disturbances were performed by employing new spectral installation. The H_α emission used to be obscured with molecular nitrogen bands 1PG (7,4) and (6,3) emissions. A possibility of extraction of the H_α emission from the mixed H_α and $1PGN_2$ signal with the use of synthetic spectra is discussed. Spatial and temporal variations of the H_α intensity are compared with Lovozero all-sky camera data.

Introduction

In studying the nature of proton precipitation an important tool is examination of hydrogen emissions, in particular, of the H_α emission. Observations of the hydrogen optical emission H_α was performed by the cosmic rays laboratory through the winter of 2002-2003 at the PGI testing site in Apatity. Data were obtained using a spectral installation, which basic part is a SpectraPro 306 spectrograph and CCD camera completed with IPentaMax brightness intensifier. A detail description of the employed instrumentation and observational conditions has been given in paper /1/. Some data samples are provided in this work and a possibility of getting a clear emission H_α profile from the spectra obtained is discussed.

Data

An event occurred on December 6, 2002 was chosen to illustrate the experimental data obtained. On that day, Lovozero observatory registered magnetic field H-component variations that did not exceed 400 nT. The intensity of auroras was low. The atmosphere transparency was not high either. Figures1 a,b show the spectra of the aurora in the wavelength range 635.4 - 661.0 nm. The exposition time was 120 s. Each plot presents 50 spectra for the time period ~ 1 hr 40 min. One can clearly see the variations of the intensity of atomic oxygen red line 636.4 nm, H_α 656.3 nm line and the first positive system bands of molecular nitrogen $1PGN_2$, which basically contributes to the radiation intensity in the spectral range considered. Fig.2 sketches H_α intensity variation along with the behavior of the magnetic field H-component. We would like to note a variation of the H_α intensity during the magnetic bay around 23:30UT, when the H-component decreased down to 400 nT. This feature has been previously reported /2,3/.

Examples of auroral spectra with well-pronounced profiles of H_α emission are shown in Fig.3. These profiles can be seen in the wide range of wavelengths.

In many cases we managed to make the exposition for the auroral spectra around the H_α line shorter in order to increase the time resolution of the data. Fig.4 shows spectra, obtained with exposition of 30 sec on November 30, 2002.

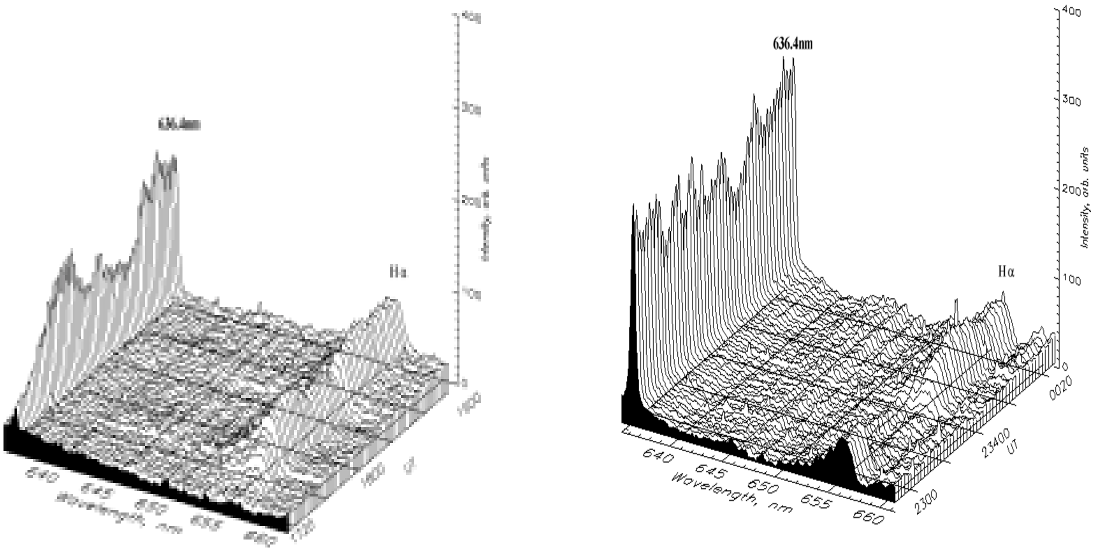

Fig. 1a,b Auroral spectra on December 6, 2002, Apatity

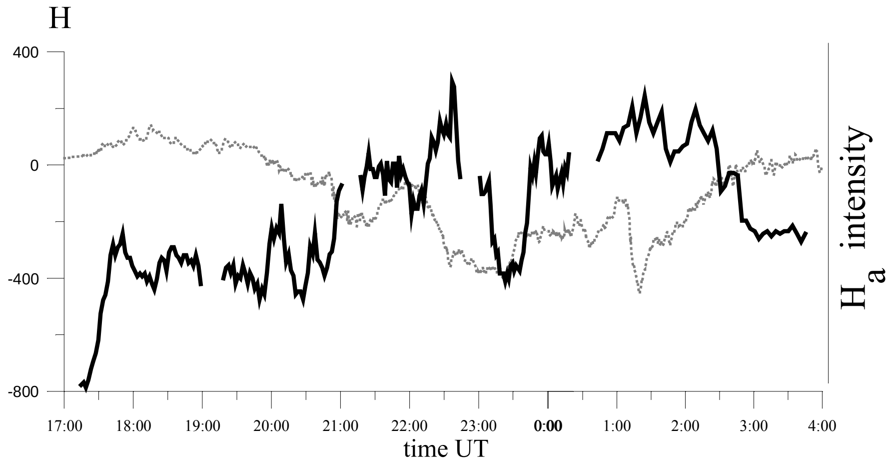

Fig.2 Temporal variation of H_{α} emission and magnetogram from Lovozero on December 6-7,2002

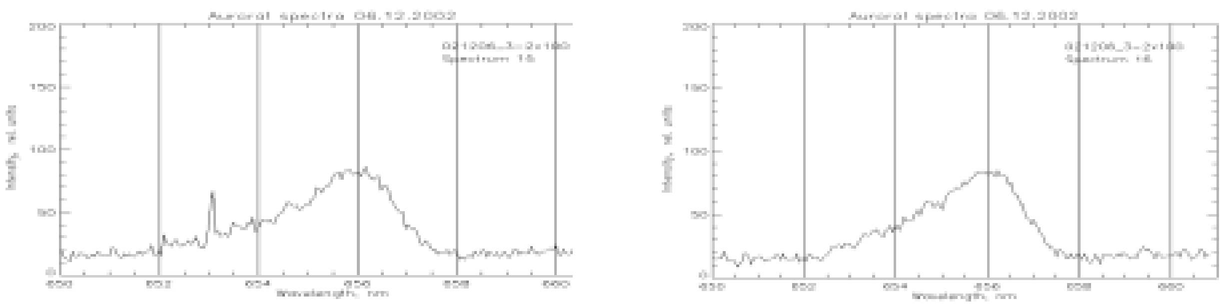

Fig.3 Auroral spectra with Hα profile on December 6,2002

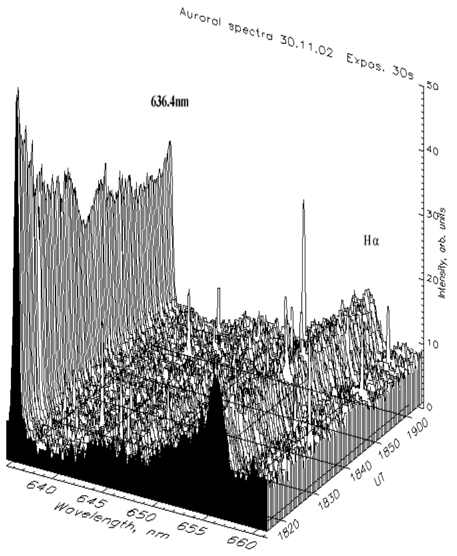

Fig.4 Auroral spectra with exposition 30s on November 30, 2002

Synthetic spectra

The ultimate goal of our study is to get a clear profile of H_α emission from the experimentally observed auroral spectrum. A separate stage of the work is calculation of theoretical spectra of bands and lines that lie within the wavelength range of interest. Within the range of 630-680 nm, the contribution to auroral luminosity is due to N_2^+ 1PG, N_2 IRA, O_2^+ 1N, O_2 At as well as nitrogen and oxygen atomic lines. The first positive system of the molecular nitrogen N_2 1PG is the main contributor to auroral luminosity in this wavelength range. The synthetic spectrum of this system of bands that we have simulated is presented in Fig.5.

Algorithm of the calculation of the synthetic spectrum of any band system is reduced to determining the transition intensity of each band for each rotational line /4/:

$$E^{n}_{j'j''} = A_{j'j''} N_{v'} (2j'+1) \frac{(1+\delta_s)}{2} \frac{hcB_{v'}}{kT} \exp\left(-\frac{hc}{kT} F(n)\right)$$

where v - is the vibrational quantum number, j - is the rotational quantum number, $\delta_s = 1$ for the symmetric rotational term and $\delta_s = 0$ for the asymmetric ones. $A_{j'j''}$ are the probabilities of spontaneous transitions, $N_{v'}$ is the population of the vibrational level, corresponding to the transition, $B_{v'}$ is the rotational constant, h is the Planck constant, k is the Bolzmann constant, c is the speed of light, T is the rotational temperature, $F_j(n)$ is the rotational energy of the term.

Relative intensities of 1PG system bands depend on the rotational temperature. As one can see from Fig.5, the synthetic spectrum broadens as the temperature increases. Fig.6 provides a comparison of experimentally obtained and calculated synthetic aurora spectra. One can see that the spectra agree well with each other. However, in order to obtain a clear emission profile H_α, one has to know contributions from other molecular systems and lines that lie within the wavelength range considered.

Conclusion

The spectral installation developed at the laboratory of cosmic rays of the PGI enables to obtain aurora spectra within the range of 635.0-660.0 nm with the time resolution up to 30 sec. Shown is a temporal variation of the intensity of hydrogen line during a substorm. One can note a decrease of H_α intensity during the maximum deviation of the magnetic H-component. Discussed is a possibility of extraction of a clear emission profile H_α from the experimental spectra by using the theoretically obtained spectrum

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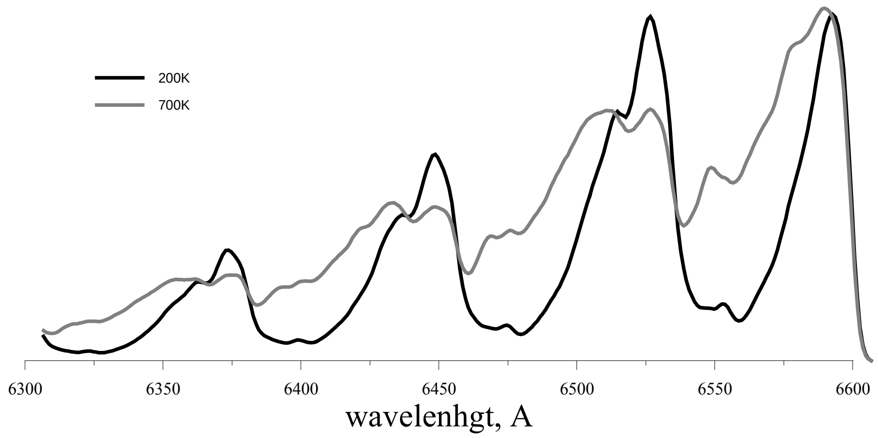

Fig.5.Synthetic spectra of the first positive bands system 1PG N_2

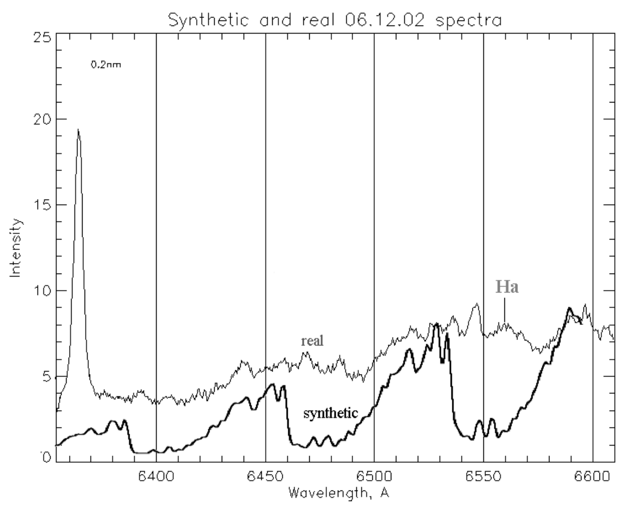

Fig. 6. Synthetic spectrum 1PG N_2 and real spectra 635-660 nm on December 6,2002