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DEPENDENCE OF THE INTENSITY AND SOUTHERN BOUNDARY OF HYDROGEN EMISSION ON AE-INDEX

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Abstract

On the eve of the International Polar Year (2007-2008), the observatories Murmansk and Loparskaya, based on patrol spectrograph data, performed a statistical study of the relation of Hα emission to the AE-index of magnetic activity. The aurora observations for the seasons of both high solar activity (IGY, September-April 1958-1959, 1959-1960, 1960-1961) and low solar activity (IQSY, September-April 1963-1964, 1964-1965, 1965-1966) were used. It is shown that there is a nearly linear dependence between the mean intensity of Hα emission (within the interval from 0.2 kR to 1 kR) and AE-index for relatively low values of AE-index (up to 1000 nT). The latitude of maximum Hα emission linearly decreases (shifts southward) from 64^0 Φ to 60^0 Φ with AE-index increasing. No changes were registered in the dependencies of Hα emission intensity and its southward boundary location on the AE-index for different levels of solar activity.

Introduction

Hydrogen emissions Hα λ656.3 nm and Hβ λ486.1 nm in aurora spectra were found in Norway [Vegard, 1939]. The Doppler profiles of these emissions [see, for example, Meinel, 1951] indicate their extraterrestrial origin and, presumably, solar origin of hydrogen atoms intruding the Earth's atmosphere. In the Soviet Union, the first profound studies of hydrogen emissions started only from the time of IGY. Then Galperin [1959], using a SP-48 spectrograph with high dispersion and high optical efficiency, found that Hα emission was mostly present in the latitudinal forms of red, type A auroras. On the other hand, Yevlashin [1961], while studying aurora spectra with a C-180-S patrol spectrograph, designed by prof. Lebedinsky of the Moscow University [1961], found that Hα emission was prevailing in the spectra of quiet non-rayed green forms. These forms refer to the height of ~ 110 km and are observed in the evening time.

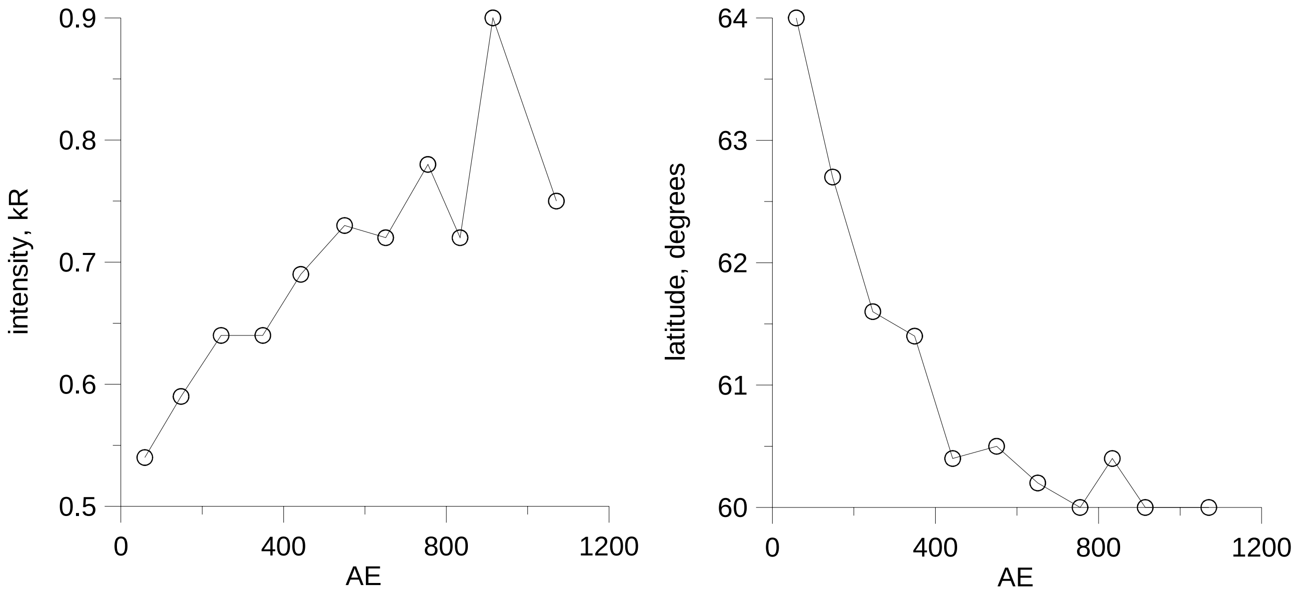
The morphology of hydrogen emissions and, in particular, its relation to the magnetic activity was studied by a number of scientists both in Russia and abroad. In particular, a lot of researchers were trying to find Hα variation in space and in time versus K_p index of geomagnetic activity [Montalbetti and Vallance Jones, 1957; Malville, 1959; Rees et al, 1961; Montbriand and Vallance Jones, 1962]. It was found that the intensity of hydrogen emission grows and the location of its occurrence shifts equatorward with K_p increasing. The same peculiarities in Hα emission behavior versus the local K-index were revealed by Yevlashin [1963]. In the paper of Pudovkin and Yevlashin [1962] a relation was found between the current systems in the ionosphere, responsible for the bay-type magnetic disturbances, and wide homogeneous arcs which exhibit hydrogen emission. Sharp et al. [1967] found that the proton flux is getting more intense with the K_p-index increasing, as indicated by spacecraft data. Eather and Sandford [1996] by observations at high latitudes obtained that the probability of observation of hydrogen emission increases as the local K-index increases and that this increase is not related to the phenomenon of polar cap absorption. In the paper [Evlashin et al., 1972] it was estimated separately the influence of the ring current (DR) and of the polar electrojet (DP) on the hydrogen emission oval. The observations of Murmansk station for the season of 1959-1960 were used. To measure the intensity of the ring current the Dst values were used, whereas the intensity of the Polar electrojet was characterized by the Q-index. One of the latest studies of the characteristics of hydrogen auroras versus magnetic activity was performed byf Canadian scientists [Greutzberg et al., 1988]. Based on the data of the chain of meridional photometers in the IMS period, they obtained the average distribution of hydrogen and electron aurora versus geomagnetic latitude and time for several ranges of the AE geomagnetic index. The energy of the proton flux was calculated from the intensity of $H_β$.

The purpose of the present paper is to study the influence of magnetic field variations on the Hα emission by using a large data set on the hydrogen emission in the years of both high and low solar activity (IGY – 1958-1960 and IQSY - 1963-1966) and AE-index, which was introduced only in 1966 and calculated for the periods of IGY and IQSY only in the 1990s. Such an analysis means to increase the reliability of previously obtained conclusions.

Equipment and observations

In the present paper we use the spectral observations of auroras at the observatories of Loparskaya and Murmansk for the seasons of both high solar activity (IGY, September-April 1958-1959, 1959-1960, 1960-1961) and low solar activity (IQSY, September-April 1963-1964, 1964-1965, 1965-1966). The mean annual value of the solar radioemission flux $F_{10.7}$ was 200 (in units 10^{-22} Wm^{-2} Hz^{-1}) for the period of IGY and 83 for the period of IQSY. To register the spectra of auroras a C-180-S patrol spectrograph was used, which had been designed by prof. Lebedinsky from the Moscow State University [1961]. The spectrograph slit was permanently oriented along the geomagnetic meridian, with its width corresponding to 5 nm in the focal plane of camera lenses. The photographic film was subject to hypersensibilizing before shooting – a short flash from a bright light source. In this case, the sensibility was such that for 10 minutes of exposition there were registered aurora emissions with the mean intensity of 200 R each. The observations for 842 nights were processed, with Hα emission being registered at 347 nights. Hα intensity was estimated by its maximum value for a given night. There was adopted the following Hα intensity scale: point 1 - I Hα = 0.3 kR; point 2 - I Hα = 0.6 kR; point 3 - I Hα = 1 kR; point 4 - I Hα ≥ 2 kR; The position of the southward boundary was characterized as follows. When the southward edge of the hydrogen line reached the zenith angle of 30^0 relative to the northern horizon, this corresponded to 68^0 Φ and was designated with a digit 1. If the southern edge was in the zenith, this corresponded to 64^0 Φ and was designated with a digit 2. If the southern edge of the hydrogen line reached the zenith angle of 30^0 or less relative to the southern horizon, this corresponded to 60^0 Φ (digit 3).

The characteristics of Hα lines, registered in this way, were compared with the hourly values of the AE-index gained from Kyoto via Internet and then the whole data set was processed on computer. The results obtained are shown in the Figure below.



Dependence of hydrogen emission intensity (left) and geomagnetic latitude (right) on the AE-index for observational periods of 1958-1961 and 1963-1966.

Conclusions

The results of the present study are basically consistent with the conclusions of the previous papers. We emphasize, however, that the occurrence of the hydrogen emission of significant intensity ($I_{H\alpha} > 0.1\ I_{557.7}$) testifies the presence of hydrogen (proton) auroras under comparatively low values of the AE-index (from 0 to 1000 nT). At the same time, the electron auroras usually emerge under much higher AE-indices (up to several thousand nT on the average). The displacement of the southward boundary towards lower latitudes is also in agreement with the earlier studies, where the planetary K_p –index was used as a measure of magnetic activity. It is worth mentioning that the solar activity practically does not affect the relation of H_α hydrogen emission intensity and its southward boundary location to the AE-index.

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