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VARIATIONS OF EQUATORWARD BOUNDARY OF AURORAL LUMINOSITY IN DIFFERENT TYPES OF QUASI-STATIONARY STREAMS OF SOLAR WIND

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Abstract. Analysis of occurrence probabilities of different types of solar wind streams is performed to study duration of their interaction with the Earth's magnetosphere at maximum of the solar cycle and during its decline (1970-1975). The occurrence probability of the streams is shown to vary strongly from year to year because of different occurrence rate of their solar sources in the course of the solar cycle. The behavior of equatorward boundaries of auroral luminosity for different types of solar wind quasi-stationary streams is investigated. The average values of the latitude of the auroral luminosity equatorward boundary in the midnight sector are the following: for the body of high-speed solar wind streams from coronal holes $\phi' \sim 61.4^0$; for quiet heliospheric current sheet and coronal streamers $\phi' \sim 65.2^0$; for non-compression plasma density enhancement $\phi' \sim 64.2^0$. A peculiarity in the behavior of the luminosity equatorward boundary is a gradual increase of its latitude from $\phi' \sim 60^0$ on the first day up to $\phi' \sim 62^0$ on the sixth and subsequent days of the Earth passing the body of high-speed streams from coronal hole.

1. The occurrence probability of different types of the solar wind streams during the solar cycle

The data on aurora coupling with different types of solar wind streams are indicative of different quantitative characteristics of auroras under the same values of Q-index due to difference in streams' inherent properties [1]. That is why for the purpose of prognosis a bank of situations is being updated, in which data on auroras for different types of solar wind streams interacting with the Earth magnetosphere are being collected. In order to make up the bank one needs to have an idea of which events occur in the solar wind and what their recurrence rate is. Fig.1 presents the occurrence probability at the Earth orbit of different types of the solar wind streams at maximum of the solar cycle and during its decline (1970-1975). The types of the streams include: the high-speed stream from a coronal hole, quasi-stationary streams from flares and disappeared filaments, non-compression density enhancement of plasma, heliospheric current sheet and quiet solar wind. One can see that the occurrence probability of those streams varies strongly from year to year because of different occurrence rate of their solar sources in the course of the solar cycle. At maximum of the solar cycle the quiet solar wind prevails, whereas at its decline the number of the high-speed streams from coronal holes grows considerably.

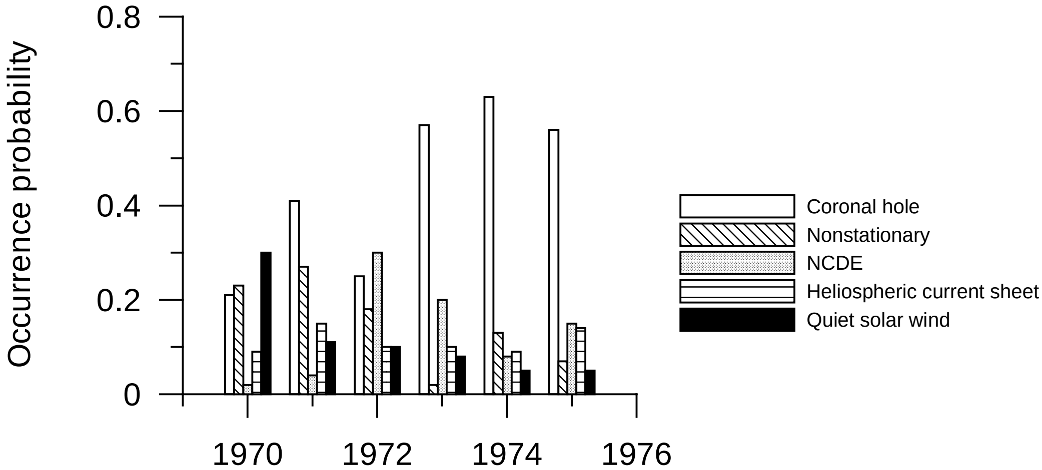

Fig.1 The occurrence probability of different types of the solar wind streams during the solar cycle

2. Behavior of auroral luminosity boundaries for different types of quasi-stationary solar wind streams

The quasi-stationary streams are known to mostly keep their main characteristics invariable during the Earth crossing them on its passage along the orbit. The technique of identification of a certain type of the streams at the

Earth orbit is described in [2]. Dynamics of the auroral equatorward boundary under different parameters of the solar sources is investigated in [3]. At present, numerous statistic studies of auroral boundary position both against the level of geomagnetic activity and parameters of the interplanetary medium have been conducted by using optical observations as well as data on particle precipitation. However, all the previous studies ignored the type of the solar wind stream, which are characterised by different geoefficiency. We have made an attempt to classify some typical features in the auroral dynamics related entirely to a specific type of quasi-stationary streams of the solar wind. The data on the position of the equatorial boundary of auroras for 1972-1975 were taken from DMSP observations [4].

High-speed streams from coronal holes

The typical parameters for the body of high-speed streams are the following: v_p=(450÷650) km/s; $n_p \approx 6$ cm^{-3}; |B|= (4÷9) nT; $T_p \approx (10^5 \div 1.5\ 10^5)$ K. The duration of the Earth crossing the stream body varies from 1 to 10 days. To determine the position of the equatorward boundary of auroras we used 59 events of high-speed streams, with duration from 3 to 10 days. For each event we determined the lowest latitude of the equatorward boundary on the first, second and subsequent days and used the superimposed epoch technique to compute the average latitude of the aurora equatorward boundary position in the period of the Earth's being within the body of high-speed streams. The day of the Earth crossing the leading edge of the high-speed streams was taken as the initial (zero) day, although the leading edge of the high-speed streams can rather be related to the nonstationary streams of the solar wind. Fig.2 shows average values of auroral equatorward boundary lowest latitude on the first to ninth days of the Earth passing through the high-speed stream body. The vertical lines indicate the RMS errors. One can see that the lowest average values of the auroral equatorward boundary latitude are observed on the 1-st day of the Earth being in the stream body ($\phi' \sim 60^0$) with a subsequent increase up to $\phi' \sim 62^0$ by the 6-th day. This finding may be related to the gradual decrease of the interplanetary medium main parameters during the Earth passing the stream body, which is also suggested by a change in daily average AL-index from -280 nT on the 1-st day of the stream body passage to -160 ÷ -180 nT by the 6-th and 7-th days. The value of the equatorward boundary latitude averaged over the whole body of high-speed streams is $\sim 61.4^0$ with that of AL-index being ~ -190 nT.

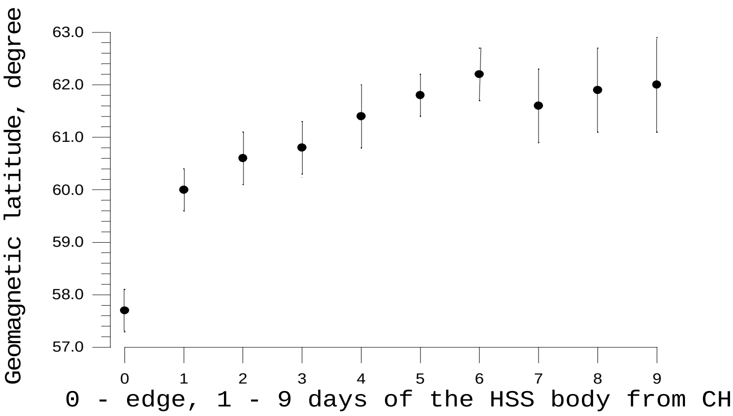

Fig.2. Position of the auroral equatorward boundary during the Earth passing the body of high-speed streams originated from coronal holes.

Heliospheric current sheet and coronal streamer

At the Earth orbit both quiet heliospheric current sheets and coronal streamers are characterized by rather similar parameters. For a quiet streamer: v_p = 360 km/s; n_p = (10÷15) cm^{-3}; |B| = (7÷10) nT; $T_p = 5 \cdot 10^4$ K; whereas for a quiet heliospheric current sheet: v_p = 350 km/s; n_p =(20÷30) cm^{-3}; |B|= (4÷8) nT; $T = 5 \cdot 10^4$ K.

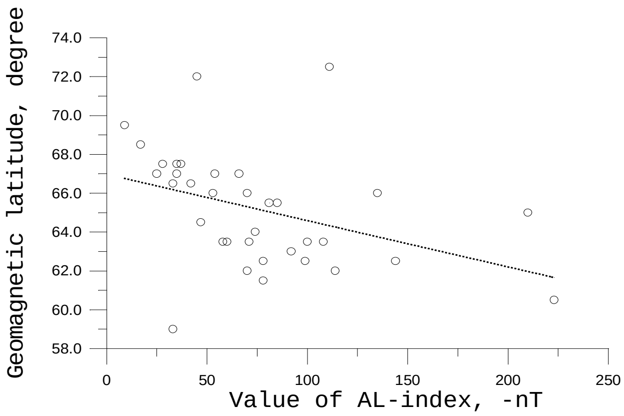

Fig.3. The position of equatorward boundary of auroras during quiet heliospheric current sheet and streamer

That is why we perform a common study of the auroral characteristics for these two types of the streams. To determine the auroral equatorward boundary position we chose 35 events of the Earth crossing a heliospheric current sheet or a coronal streamer. In Fig.3 the circles stand for the lowest values of the equatorward boundary latitudes for each event at the corresponding daily average value of AL -index. On the whole, for all the events considered, the equatorward boundary of auroras lies at $\phi' \sim 65{,}2^0$ with the average value of AL-index being -75 nT. The dashed line is obtained by the least square technique, the regression equation having the form:

ϕ' (degree) $=67^0 + 0.024$ AL, where the AL is expressed in - nT.

Interstream plasma

Attributed to solar wind quasi-stationary streams is the stream of low-speed cold plasma, which originates in the solar wind between a streamer and a high-speed stream from a coronal hole. At the Earth orbit this type of the stream is identified as non-compression density enhancement (NCDE) of type III and characterized by the small magnitude $|B| \approx 3$ nT; low temperature $T \approx 2 \cdot 10^4$ K; low velocity $v \approx 350$ km/s and somewhat increased density $n_p \approx (10 \div 12)$ cm^{-3}. To study the variation of the aurora equatorward boundary position during the Earth passing through those streams, 63 events were considered. Fig.4 presents minimum values of the latitude of aurora equatorward boundary at the corresponding values of AL-index. In most cases, the equatorward boundary of auroras lies in the range 60^0 - 68^0. The average value for all the events makes $\phi' \sim 64.2^0$ with the average AL≈-77 nT. The equation for the regression line has the form:

ϕ' (degree)$=67.2^0 + 0.039$ AL, where AL is expressed in -nT.

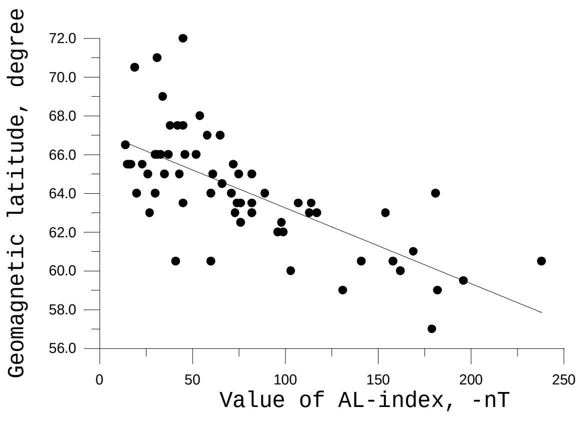

Fig.4. The position of equatorward boundary of auroras in the streams of NCDE

Summary

1. The average latitudes of the equatorward boundary of the auroral luminosity in the midnight sector are the following: for the body of a high-speed solar wind streams from coronal holes $\phi' \sim 61.4^0$; for quiet heliospheric current sheet and coronal streamers $\phi' \sim 65.2^0$; for non-compression plasma density enhancement $\phi' \sim 64.2^0$.

2 A peculiarity in the behavior of the luminosity equatorward boundary is a gradual increase of its latitude from ϕ‘ ~60^0 on the first day up to ϕ‘ ~62^0 on the sixth and subsequent days during the Earth passing the body of high-speed streams from coronal hole.

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