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VARIATIONS OF EQUATORWARD BOUNDARY OF AURORAL LUMINOSITY CONNECTED WITH NON-STATIONARY STREAMS OF THE SOLAR WIND

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Abstract. The behavior of equatorward boundaries of auroral luminosity for different types of nonstationary solar wind streams is investigated. The average values of equatorward boundary locations of auroral luminosity in the midnight sector make: for solar flare-generated streams $\Phi' \sim 51^0$; for disturbed heliospheric current sheets $\Phi' \sim 61^0$; for leading edge of a high-speed solar wind streams from coronal holes $\Phi' \sim 58^0$. The average equatorward boundary locations of auroral luminosity for nonstationary solar wind streams are a few degrees lower than those for quasi-stationary streams indicating a higher geoefficiency of nonstationary streams.

Introduction

The behavior of equatorward boundaries of auroral luminosity for different types of solar wind quasi-stationary streams was investigated in [1]. Non-stationary streams in the interplanetary space are caused by non-stationary phenomena in the Sun. One can group with them sporadic flares, instantly disappearing filaments in the active regions of the Sun and outside them [2]. We place in non-stationary streams as well, the leading edge of high speed stream from a coronal hole (the edge of HSS from CH) and the disturbed heliospheric current sheet (disturbed HCS). Those streams possess a high enough geoefficiency and are related to the development of geomagnetic storms and appearance of bright auroras. The identification method and basic parameters of non-stationary streams of the solar wind are presented in [3]. The position of auroras equatorward boundaries were determined with the data of a large network of visual observations during the IGY (1957-1958) [4] and from DMSP observations for 1973-1975 [5].

Flare streams

Flare streams in the orbit of the Earth have two large structural regions: the shock wave and the magnetic cloud. Flare streams of the solar wind are characterized by the following parameters: in the shock wave v_p= (450÷700) km/s, n_p= (10÷30) cm^{-3}, T_p= (1÷3) 10^5 K, $|B|$ = (10÷20) nT; in a magnetic cloud V_p= (450÷600) km/s, n_p=10 cm^{-3}, $T_p<10^5$ K, $|B|$= (10÷15) nT.

There were picked 23 flares in the Sun. Often flares occurred in series each lasting for several days. The latitude of auroras equatorward boundary was determined by visoplots [4]. The data with aurora registration at the zenith of observation point were used only. In total there were obtained 79 measurements of auroras equatorward boundary positions.

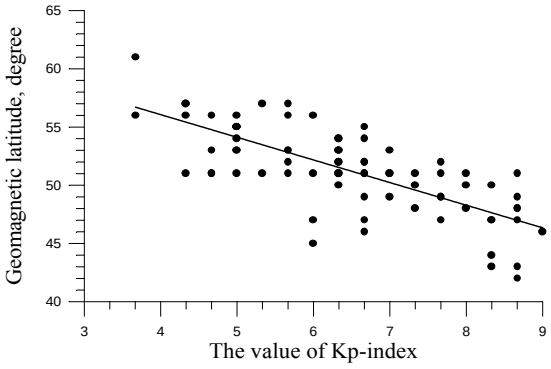

Fig.1 Positions of the equatorward boundaries of auroras during flare streams of the solar wind

Fig.1 provides positions of auroras equatorward boundary for flare streams of the solar wind at the corresponding magnitudes of K_p-index. Basically, all measurements of aurora boundary positions fall on magnetic disturbances with the value $K_p>4$. This agrees well enough with the results of study [6], where one can see, that with interplanetary disturbances of the shock front/coronal mass ejection type the distribution of geomagnetic K_p index the occurrence probability is shifted from $K_p=3$ towards greater values of K_p. With K_p index change from 4 to 9 the equatorward boundary of auroras is placed within the range of 57^0 to 42^0. In all measurments, with the mean value

K_p=6+ the equatorward boundary of auroras lies at $\Phi'=51^0$. The solid line stands for the regression line, obtained by the least squares method. The regression equation has the following form:
Φ' (degrees) = 63.84^0 - 1.944 K_p.

The disturbed heliospheric current sheet

The disturbed HCS is characterized by the enhancement of density and velocity of the solar wind, compared to the quiet HCS. According to [3] there often occur type A red auroras with the emission ratio value being 630.0/577.7 ≥ 1, as the Earth crosses disturbed HCS.

Fig.2 presents the distribution of the positions of equatorward boundaries of auroral luminosity by DMSP observations data for 1972-1975, at the Earth crossing disturbed HCS with the corresponding mean daily values of AL-index. 30 events have been considered. In most cases the equatorward boundary of auroras lies within 66^0-55^0 with the daily mean value of AL-index changing from -50 to -350 nT. On the average, for all considered events the equatorward boundary of auroras lies at $\Phi' \sim 61^0$ with the mean value AL=-154 nT. The dash line stands for the regression line, obtained by the least squares method. The regression equation has the form:

Φ'(degree) = $64{,}5^0$ + 0.0235 AL, where AL is in -nT.

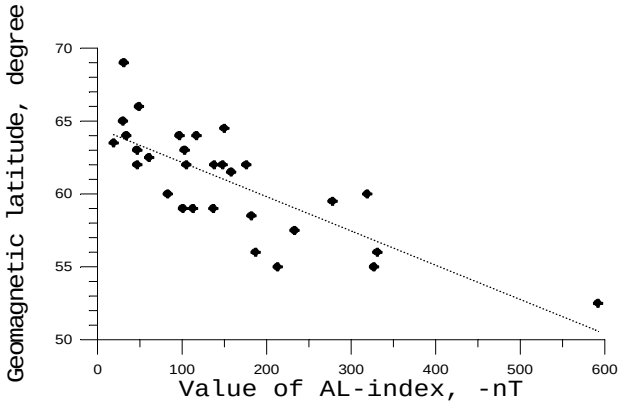

Fig.2 Positions of the equatorward boundaries of auroras in the streams of disturbed HCS

The edge of the high speed stream of a coronal hole

The leading edge of HSS from CH is characterized by the following changes of the solar wind parameters: the velocity is enhanced from the level of quiet solar wind to the one, typical of HSS body (on the average between ~350 and ~550 km/s); the concentration increases sharply from the quiet solar wind (~5 cm^{-3}) to ~20 cm^{-3} and then drops sharply to the previous value level; the distribution |B| has a bell-like shape with the maximum of about (12 ÷ 15) nT. The Earth crossing of the HSS edge lasts for about 12-15 hours [3].

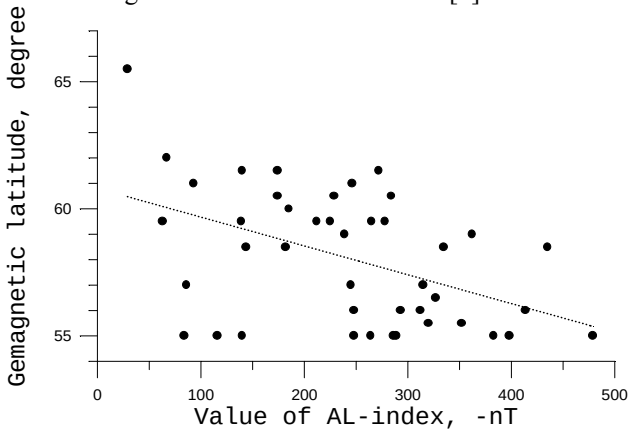

Fig.3. Positions of the equatorward boundaries of auroras during the passage of the edge of HSS from CH

Fig.3 shows the distribution of the position of minimum latitude of the luminosity equatorward boundaries depending on the daily mean values of AL-index, during the Earth passing the edge of HSS from CH.The latitude of the equatorward boundary of auroras was determined by the DMSP observations for 1972-1975. There were used 43 events. In most events the equatorward boundary of auroras is placed within 55^0 - 62^0 latitudes with the daily mean

values of AL-index varying from - 100 to - 500 nT. By all events the mean value of latitude of auroras equatorward boundary makes 58.1^0 with the mean value of AL= -241 nT. The regression equation has the form:

$\Phi' = 60.8^0 + 0.0113$ AL, where AL is in -nT.

Summary

1. For flare streams with the K_p-index varying from 4 to 9, the auroras equatorward boundary is placed within 57^0 to 42^0 of geomagnetic latitude. With the average value of K_p = 6+ the average position of auroras equatorward boundary makes about 51^0.
2. As the Earth crosses solar wind streams of the "disturbed heliospheric current sheet" type, the equatorward boundary of auroras is placed within 66^0 to 55^0 of geomagnetic latitude with the daily mean values of AL-index varying from -50 nT to -350 nT. With the mean value of AL=-154 nT the equatorward boundary of auroras is placed at the latitude of about 61^0.
3. As the Earth passes the leading edge of the HSS from CH, the equatorward boundary of auroras lies within 62^0 and 55^0 with the daily mean value of AL-index varying from -100 nT to -500 nT. With the mean value of AL= -240 nT the mean geomagnetic latitude of the auroras equatorward boundary makes about 58^0.

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