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THE EFFECT OF MAGNETOSPHERIC PROCESSES ON THE IONOSPHERE DURING THE MAGNETIC STORM OF 1 DECEMBER 1977 BASED ON COSMOS-900 DATA

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ABSTRACT

The effect of the magnetospheric disturbances on the high-latitude ionospheric plasma during the magnetic storm of 1.XII,77 is investigated using the data of measurements onboard Cosmos-900 satellite (the circular orbit at a height of 500 km, its inclination is 83°, the orbit period is 94.4 min). The measurements made it possible to correlate the regions of energetic electron precipitation with aurorae and the intensity of protons forming the storm ring current and to study the dynamics of the main ionospheric trough and polar peaks of the density and the temperature of the ionospheric plasma.

Electrons and protons with energies of ≳ tens of keV were measured by differential semiconductor spectrometers. The aurorae were recorded in the line 3914 Å by an onboard spectrophotometer, whose field of view is a cone of full angle 9° looking to nadir. The thermal plasma density measurements were carried out by a three-electrode ion trap, with the potential of the outer grid floating, and the electron temperature was measured by a radiofrequency electron temperature probe. Electron temperature and airglow data are only obtained for the dark parts of the orbits crossing the North hemisphere early morning sector (3 to 6^h MLT).

Fig.1 shows the parameters described above under moderate (a) and strong (b) magnetic disturbance conditions. From the top, Fig. 1 presents:
(1) the airglow intensity (in kiloRayleighs) in the 3914 Å line;
(2) the counting rate of the 30 to 50 keV channel (with a geometrical factor of $\sim 4 \times 10^{-3}$ cm^2ster) for electrons precipitating along the field lines;
(3) the counting rate of the 50 to 80 keV channel ($\sim 8 \times 10^{-3} cm^2$ster) for protons from the ring current, locally mirroring at the Cosmos-900 height;
(4) the ionospheric plasma density;
(5) the electron temperature.

The Cosmos-900 pass given in Fig. 1a corresponds to the initial phase of the storm (the geomagnetic data are shown in the lower part of Fig. 2).

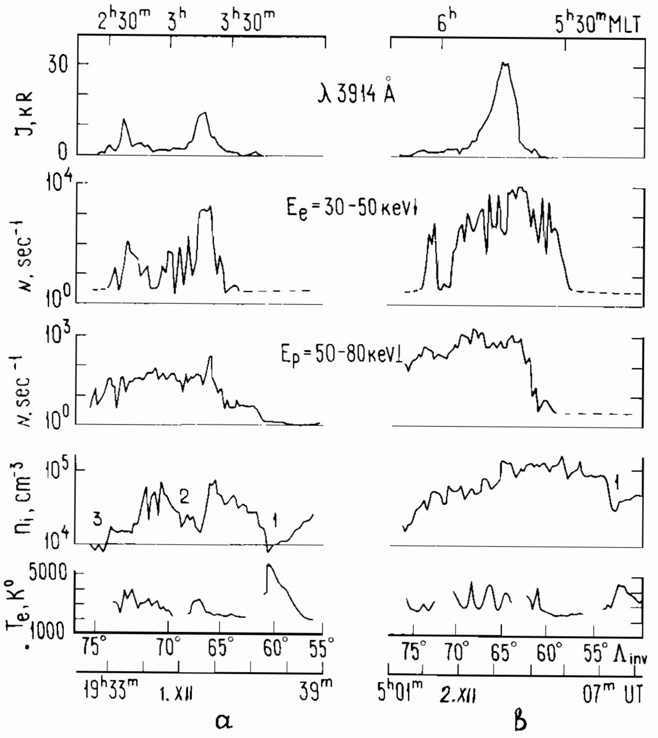

Fig. 1. Examples of the latitudinal profiles of the ionospheric and magnetospheric parameters observed during moderate (a) and strong (b) magnetic disturbances. Geographic longitudes are: 179°-183°(a), 39°-42°(b).

Two 3914 Å emission maxima at invariant latitudes of 67° and 73° are apparent; two electron precipitation regions match them. The most intensive electron precipitations and airglow are observed near the inner edge of the ring current protons. The profile of the ionospheric plasma density is typical of the winter ionosphere during moderately disturbed periods it shows the main electron density trough (1), the density of which increases more steeply on the polar side of the trough, then the auroral peak and the auroral trough (2), the polar peak and the polar trough (3). In the region of minimum electron density an electron temperature maximum associated with heat flow from above [1] is observed. The electron temperature increase in polar latitudes begins in the intense precipitation regions.

The pass given in Fig. 1b occurred during a magnetic storm main phase, with intense geomagnetic bay disturbances. The 3914 Å emission peak is displaced down to a latitude of about 64.5°. The precipitating electron flux increased strongly (by up to an order of magnitude), and the precipitation region extended to lower latitudes. Trapped proton fluxes at 50 to 80 keV also increased greatly and the inner edge of their profile also shifted to lower latitudes. As in the previous case, the airglow (and the most intense precipitations) appear near this inner edge of the proton profile. The behaviour of the ionospheric irregularities significantly changes: the main density trough becomes less pronounced and shifts to lower latitudes, the auroral trough disappears, the irregularities become less marked and their zoen of occurrence is exntended.

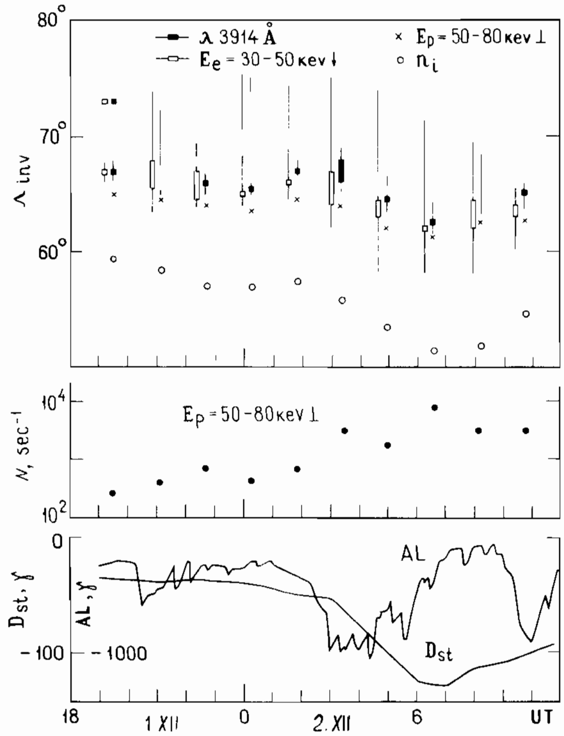

Fig.2. Time variation of ionospheric and magnetospheric parameters observed during the storm of 1 and 2 December 1977.

Fig. 2 shows time variations of magnetospheric and ionospheric parameters in the Northern hemisphere during the geomagnetic storm; from the top are shown:

1) the position of maximum 3914 Å (black rectangles); the half-width is designated by vertical bars;
2) the region of precipitating electrons (open rectangles); the size of the precipitation region is designated by vertical bars whose boundaries were determined by the counting rate decrease to 10 sec^{-1};
3) the inner edge of trapped protons between 50 and 80 keV (crosses) determined by the time that the counting rate decreased by the order of magnitude relative to its maximum value;

4) the position of the main ionospheric trough (open circles);
5) the counting rate at the proton intensity maximum (black circles);
6) D_{st}- variation;
7) AL - index.
All these variations follow one another well.

The regions of maximum electron precipitation and maximum 3914 Å radiation are on the high latitude side of the inner edge of the region of trapped protons. The halfwidth of the 3914 Å maximum is less than 3.5°, excluding the passes at 21^h and at 08^hUT, when large regions of low intensity glow (< 10 kR) are observed. Under conditions of moderate magnetic disturbance the low-latitude boundary of energetic electron precipitation practically coincides with the inner edge of the trapped energetic proton profile, whereas during the main storm phase it is about 3° closer to the equator.

The main trough displacement to lower latitudes can be interpreted as demonstrating the magnetospheric electric field increase during storm development. The penetration of energetic protons and electrons deeper into the magnetosphere seems to be explained by the increased magnetospheric convection. As mentioned above, electrons moving in the increased electric field penetrate more deeply into the morning sector than do protons. This effect agrees well with the picture of the combined drifts in the convection and corotation electric fields and in the inhomogeneous magnetic field. If the convection is from the night side, positive particles will penetrate into the magnetosphere more deeply in the dusk sector and negative ones in the morning sector [2] .

As seen in Figs 1 and 2 the intense radiation at 3914 Å appears near the ring current inner edge. According to theoretical ideas [3] , bright aurorae are associated with currents flowing along field lines from the Earth (electrons flowing towards the Earth). These currents appear strongly at the ring current boundaries and, in the case of the low-latitude boundary, are directed away from the Earth on its morning side.

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