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STUDY OF THE EQUATORIAL IONOSPHERE BY THE INTERCOSMOS 8 SATELLITE

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The equatorial anomaly in late afternoon and night hours at altitudes of 300—500 km has been studied using observations made aboard the Intercosmos 8 satellite. The results obtained in the longitudinal interval from 150° W to 0° show that the anomaly is closely connected with the real geomagnetic field. In the Brazilian magnetic anomaly region the north maximum is expressed better and it shifts almost to the equator. In the night hours from 1830 to 2100 LT a quick anomaly decay has been observed in the same longitudinal interval. A well expressed large-scale irregular structure has been observed in the Brazilian magnetic anomaly region. The electron temperature measured in these conditions is close to the neutral one up to geomagnetic latitudes of $\pm 40°$.

1. Introduction

The study of the distribution of ionospheric electrons and ions with respect to the magnetic equator is of considerable importance for classification of the roles played by solar, geomagnetic and dynamic processes in determining ionospheric behaviour. For 30 years the well known equatorial (Appleton) anomaly in the latitudinal distribution of the density of charged particles has been studied [1—9]. The presence of the anomaly at altitudes of 900—1200 km during the night and the separation of crests of proton and oxygen ion concentrations have been discussed [7—8], and in [10—12] irregularities in the equatorial zone have been studied by probe methods. But still we do not have sufficiently reliable experimental data about the conditions of formation and disappearance of the anomaly, particularly at the F region maximum as well as manifestations of the anomaly at other altitudes. The inavailability of observations of the planetary distribution of electron and ion temperatures and their temporal changes are a principal difficulty for all contemporary ionospheric models. The electron and the ion concentration measurements and the electron temperature measurements performed by the Intercosmos 8 satellite whose orbit crossed the equatorial regions at different times of the day therefore represent interesting observations.

2. Results from Ion Density Measurements

Ion traps described in [13, 16], a Langmuir probe [14, 16], a planar radiofrequency electron temperature probe [15] and improved electronics [16] have been used on board the Intercosmos 8 satellite. This satellite performed measurements of the equatorial latitudes at geographic longitudes from 150° W to 60° E; the passes over the magnetic equator appeared in the afternoon and night hours. These results have been obtained during the period December 1972/January 1973. The measurements are separated into two groups, with regard to the local time of the equatorial crossing mainly; the first one relates to the afternoon period, before 1830 LT, and the second to the night period (after 1830 LT).

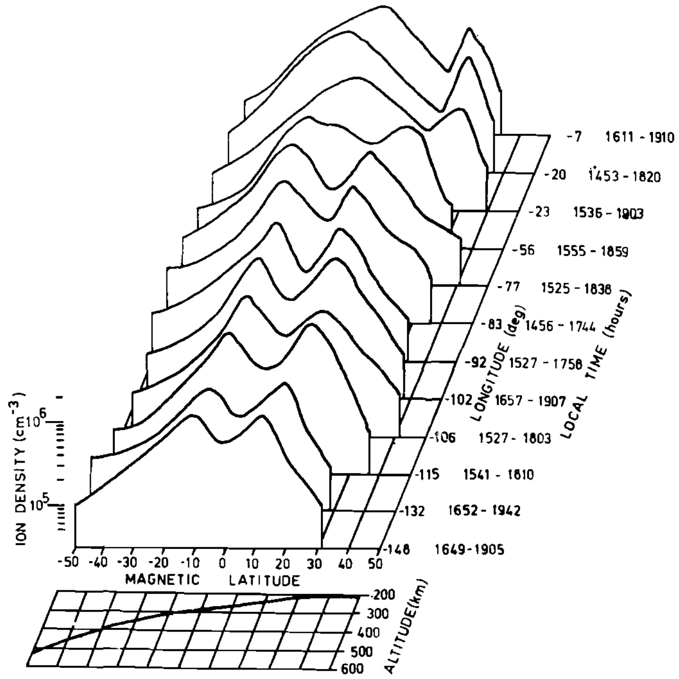

Fig. 1. Latitudinal (and altitudinal) distribution of ion density for several Intercosmos 8 passes across the magnetic equator at different local times. Longitudes marked on right indicate equatorial crossing points.

The ion concentrations for those passes crossing the equator between 1700 and 1830 LT at altitudes from 308 km to 360 km at quiet magnetic conditions ($Kp < 3$) are represented in Fig. 1. The distributions show the typical afternoon equatorial anomaly [6—8]. The two characteristic minima, at between 15° and 20° magnetic latitude north and south of the equator and a clearly expressed minimum in the region of the geomagnetic equator are seen in this figure. Here a definite longitudinal effect can be observed too. At longitudes between 150° W and 70° W, the maxima are located symmetrically at ±15° with respect to the geomagnetic equator. Between 70° W and the Greenwich meridian the southern maximum tends to shift from −15° to −5°, towards the equator, and the northern one becomes considerably smaller. This is because the satellite passes through the F region peak, and is below it in the North.

In Fig. 2 characteristic data for the night group are shown; the altitude of the equatorial crossing is between 455 km and 360 km as the satellite descends

going from the south to the north. The general trend is for the equatorial minimum to disappear; the concentration decreases in the crests (for the northern one by almost an order of magnitude, and for the southern one by two or three times), while the concentration in the minimum almost maintains its value. For two transits between 55° E and 60° E a clear, double crested distribution of the ion

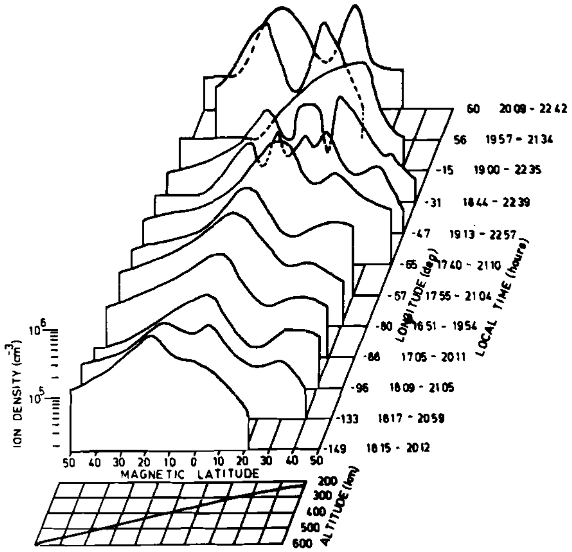

Fig. 2. Latitudinal (and altitudinal) distribution of ion density for several Intercosmos 8 passes across the magnetic equator at different local times. Longitudes marked on right indicate equatorial crossing points.

concentration has been recorded. This indicates that the effects between 70° W and 0° are of a local character influenced by the magnetic field peculiarities there. The deviations of the positions of the minima from the geomagnetic equator demonstrates the deviation of the dipole magnetic field from the real one; in the region of the Brazilian magnetic anomaly (about 60° W) the deviation attains 10° latitude. By comparison of Figs. 1 and 2 it can be concluded that the equatorial anomaly in the region under examination decays by 1900. In the region of the Brazilian magnetic anomaly large-scale irregularities manifest themselves until after 2100 approximately.

3. Electron Temperature Results in the Equatorial Region

In Fig. 3a the local morning results obtained by the radio-frequency electron temperature probe over the height (H) range shown between ±40° geomagnetic latitudes under quiet magnetic conditions ($Kp < 2_+$, $\Sigma\, Kp = 10_+$) are represented. The temperature of the neutral particles T_n close to the equator [17] are also shown; T_n variations in this period do not exceed 20 °K. In Fig. 3b data relate to the night hours 2000—2200 LT. Considering that the photoelectron flux and the electron concentration at solar zenith angles $\chi < 85°$ attain their stationary daytime levels [18], the results shown in Fig. 3a are characteristic of the daytime, and those in Fig. 3b of the night-time, since $\chi > 110°$. From 0800—1100 LT (Fig. 3a) there exists a deep electron temperature trough near the geomagnetic equator, with T_e values close to T_n. The minimum T_e values at or near the equator coincide with T_n values for most of the cases, but in some passes $T_{e\,min}$ exceeds T_n by 300°—400°K.

At nightfall (Fig. 3b), T_e decreases markedly from 2000—3000°K at —40° magnetic latitude to 1200° ± 100°K at —25°, and then decreases monotonically

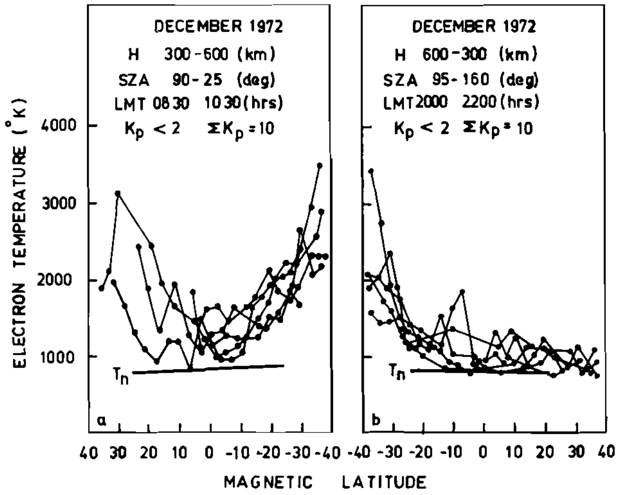

Fig. 3. a) variation of electron temperature with magnetic latitude during the local morning; b) variation of electron temperature with magnetic latitude during the local evening.

to 900° ± 100°K at +40°. The initial decrease of T_e occurs within 30 minutes. Sunset at the satellite for these passes occurred between —20° and —30°. In contrast to mid-latitudes, in the equatorial region heat input from the plasmasphere is absent. Thus after sunset there are no significant sources for near-equatorial electron gas heating. The gradual decrease of T_e beyond —25° magnetic latitude when the satellite moves to the northern hemisphere is connected probably with the altitudinal decrease. Moreover, since T_e is close to T_n, the T_n decrease of about 100°K at the transition from 2000 LT and —30° in the summer hemisphere to 2200 LT and +30° in the winter hemisphere [17] plays a certain role.

The behaviour of T_e and electron density n_e in the sunrise transition from night to day, 0500—0900, is shown in Fig. 4. The figure represents results from three satellite passes — one performed during a continuous quiet magnetic period and two under strongly disturbed conditions. The main peculiarity of these curves is the high T_e value; T_e exceeds 2000°K in quiet conditions over the geomagnetic equator at ≈ 500 km altitude, and attains 3800°K in the magnetically disturbed period. Moreover, both in quiet and disturbed periods, T_e is inversely proportional to n_e; this is clearly expressed even in the smallest details. Northern mid-latitudes were crossed by the satellite at the end of the night before sunrise

($\chi > 100°$). At that time T_e should be close to $T_n < 1000°K$ (Fig. 3b) because the heat flux from the magnetosphere at the end of the night before sunrise cannot cause a considerable difference between T_e and T_n [19]. Therefore values of $T_e > 2000°K$ at mid-latitudes in the northern hemisphere are determined by the only significant heating source, namely the photoelectron flux from the magnetically conjugate region of the ionosphere, which was illuminated at that time ($\chi < 87°$).

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