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SOME MEASUREMENTS OF IONOSPHERIC ELECTRON AND ION CONCENTRATIONS AND ELECTRON TEMPERATURE AT AURORAL AND SUBAURORAL REGIONS ON THE INTERCOSMOS 8 SATELLITE

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Two spherical ion traps, a Langmuir probe and a probe for measurement of the ionospheric electron temperature were installed on the Intercosmos 8 satellite launched on 1 December 1972 with apogee 676 km, perigee 215 km and orbital inclination 71°. Some results on the plasma concentration n_i, n_e and electron temperature T_e measurements at invariant altitudes of 50°–80° are given, including data obtained in the daytime southern topside ionosphere at 550–670 km altitude and in the northern bottomside ionosphere at 215–300 km altitude during the night and in the daytime. Data obtained by different satellites on n_i in the ionospheric trough are compared. It is pointed out that the scale of ionospheric disturbances along the satellite orbit decreases towards higher latitudes.

1. Introduction

The Intercosmos 8 satellite was launched on 1 December 1972 with apogee 676 km, perigee 215 km, orbital inclination 71°. The research programme included probe measurements of positive ionospheric ion and electron density (n_i, n_e) and the effective electron temperature (T_e) along the orbit. The probes on this satellite, which did not have any particular orientations, consisted of two spherical ion traps, a cylindrical Langmuir probe and a radio-frequency probe.

The results given in this work are based on data obtained from probe experiments on Intercosmos 8 at invariant latitudes between 50° and 80°.

Records obtained from the measurements have permitted the study of the spatial distribution of electron and ion density and electron temperature during daytime at 570–650 km altitudes and during the night at 215–270 km. Attention is concentrated here on the study of the main mid-latitude trough under conditions where atomic oxygen ions are dominant. Pecularities observed in the characteristics of the spherical ion traps permit a study of ionospheric irregularities.

2. Daytime Ionospheric Plasma Density and Electron Temperature

The greatest part of the experimental research in this region starting with Muldrew [1] relates to the study of the mid-latitude ionospheric trough and the polar peak of ionization limiting the trough on its polar side, the polar "cliff".

These studies were based on topside sounding data [1, 2] or on probe measurements carried by these satellites or others with similar orbits [3]. The topside ionospheric trough occurs always during the night; in the morning and daytime hours at an altitude lower than 1000 km the trough is rarely noticeable [4, 5]. Therefore there is a certain interest in the results obtained by Intercosmos 8 which passed through invariant latitudes $\Lambda > 50°$ in the daytime southern ionosphere at 570—650 km altitude. A clear trough can be seen in more than 50% of the total number of passes; some troughs were observed in the morning hours.

In Fig. 1 n_e and T_e data are shown; Fig. 1a relates to the local morning on a magnetically undisturbed day. In this diagram the maximum n_e and T_e in the region $\Lambda \sim 75°—79°$ correspond to the southern polar cusp or cleft. Fig. 1b corresponds to another afternoon pass through the trough under quiet magnetic conditions and Fig. 1c to a morning pass on a magnetically strongly disturbed day. The comparison between Fig. 1a and Fig. 1c shows that strong magnetic disturbances can provoke an extension of the trough zone and a considerable shift of the trough towards lower latitudes (in this case by $\sim 10°$). Also we suggest that the wide n_e maximum in the region $\Lambda \sim 72°$ on Fig. 1c corresponds to the polar cusp shifted to lower invariant latitudes compared with its normal situation near $\Lambda \sim 77°$ (see Fig. 1a), because of a strong geomagnetic storm. Ion trap data show that during all these measurements in the southern topside ionosphere the dominating ion was always O⁺.

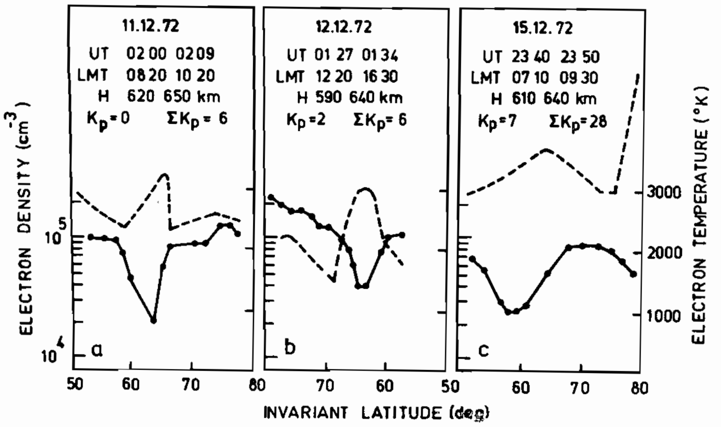

Fig. 1. Distribution of electron density and temperature in a quiet magnetic period (1a and 1b) and in a magnetically disturbed period (1c).

3. Night-time Ionospheric Density of Plasma and Electron Temperature at 215—270 km Altitude under $\Lambda > 50$ °C

Thanks to the peculiarities of the Intercosmos 8 satellite orbit in the initial period of its flight the latitudinal trough below the maximum of the F2 region was observed during the night (LMT 2000—0300) and in the morning (LMT 0100 to 0800). In Fig. 2a examples of the ionospheric plasma density distribution from the spherical ion trap data (n_i) and the T_e values are shown, and on Fig. 2b and 2c n_e and T_e values from Langmuir probe data.

In Fig. 2a the distributions of n_i and T_e for the morning pass, where the minimum n_i at $\Lambda \sim 62°$ and at ~ 215 km corresponds to the terminator, are given. In Fig. 2b a night-time trough is shown—the minimum corresponds to $\Lambda \sim 60°$, ~ 270 km altitude. An example of another night-time trough (LMT 2100) with a similar behaviour of T_e having a maximum at $\Lambda \sim 62°$ is given in Fig. 2c. The value of T_e as a rule attains its maximum value at the minimum plasma density (in contrast to data concerning greater altitudes [5]).

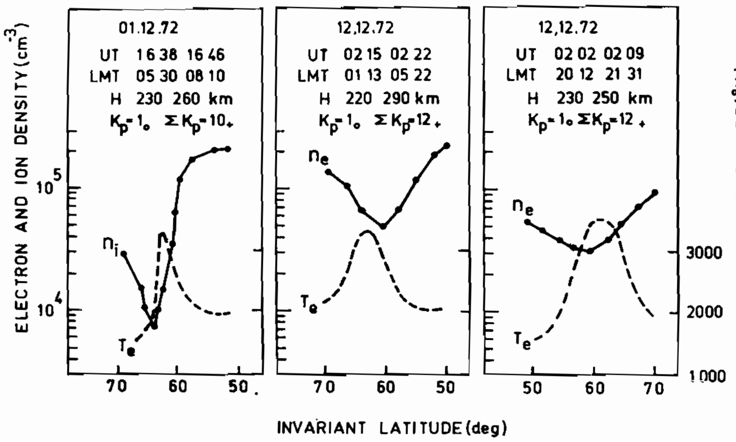

Fig. 2. Distribution of ion density (2a), electron density (2b) and electron temperature (2c) in quiet magnetic conditions at altitudes below 300 km.

The dominating ion in all longitudinal and latitudinal regions discussed here is O^+, excluding several cases when near satellite perigee (~ 215 km) in the latitudinal trough molecular ions with concentrations comparable with those of O^+ were observed.

4. Ionospheric Irregularities

The spherical ion traps on Intercosmos 8 functioned using the retarding potential method similar to that described in [6]. In Fig. 3a is given a part of one ion trap current-voltage characteristic obtained from Intercosmos 8, which totally corresponds to the theoretically expected variation. Nevertheless, in many cases the characteristics obtained differ from the "ideal" form (an example is given in Fig. 3b) and cannot be related to measuring errors. They can be explained either by ionospheric irregularities or by plasma waves (or both); they contain valuable information on ionospheric structure. Authors in [7—9] used the collector current oscillation to the flat retarding analyser on the OGO 6 satellite to study the irregularities. In [10] the dimensions of ionospheric irregularities were determined using spherical ion traps on ISIS 1. Ozerov [11] determined the regions of most frequent existence of ionospheric irregularities by the spherical ion trap data from the Cosmos 378 satellite.

In these measurement we can distinguish irregularities corresponding to a duration 0.1 sec which corresponds to a dimension $\sim$ 1 km. With the duration of the measurement of one characteristic $\sim$ 6 sec we can find irregularities of dimensions up to 10—20 km and more. However, as the invariant latitude Λ increases there can be noticed a tendency for the decrease of the irregularity dimensions. This can be explained by the fact that the irregularities are aligned along the geomagnetic field lines and are crossed by the satellite at increasing angles to its orbit. It can also be related to the fine structure of the precipitating fluxes of charged particles ionizing the atmosphere at high latitudes. The ionospheric irregularities recorded in this way may be connected with ion velocity oscillations (for instance magneto-acoustic waves, Alfvén waves, etc.).

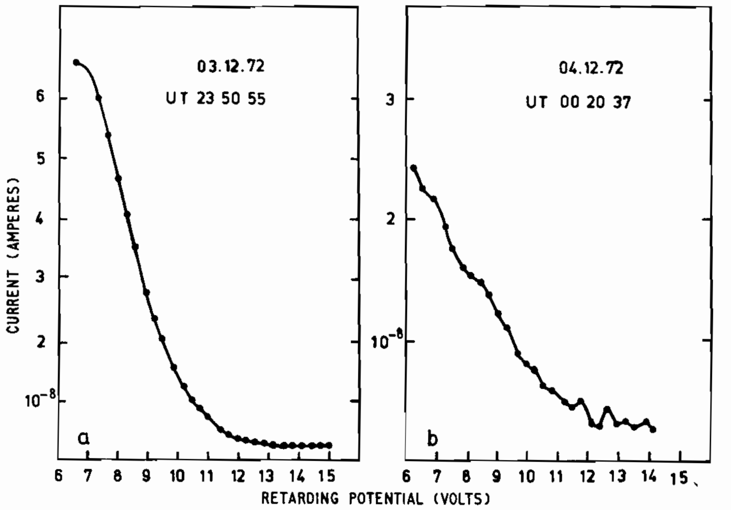

Fig. 3. An example of a smooth (3a) and irregular (3b) current-voltage characteristic of spherical ion traps.

5. Discussion and Conclusion

The experimental data obtained by plasma probes and traps from Intercosmos 8 satellites attest that at 550—650 km altitude the broad trough of ionization is observed not only at night but also during the morning and daytime hours; together with the polewards plasma density increase it is always observed in the night-time ionosphere below the F2 region maximum, at $\sim$ 215—300 km altitude.

The electron temperature T_e at $\Lambda > 50°$ in this altitudinal interval as a rule changes in such a way that T_e is a maximum where n_e (or n_i) is a minimum; in most cases the night-time T_e maximum does not exceed 3000 °K. The comparison of these T_e maxima with those determined in [12] with the help of the Langmuir probe on ESRO 1 satellite at $\sim$ 400 km altitude at night show that these data do not contradict each other. From the Langmuir probe data from Explorer 22 at $\sim$ 1000 km altitude T_e in the daytime trough under quiet magnetic conditions does not exceed 3400 °K.

The collector current oscillations of the spherical ion traps in the retarding potential regime show that the scale of the ionospheric irregularities along the satellite orbit decreases with the increase of invariant latitude. In many cases the observed irregularities can be explained by different types of waves causing ion velocity variations.

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