EXPERIMENTAL RESULTS OF THE VLF RADIATION FIELD INVESTIGATION OF A LOOP ANTENNA OUTSIDE THE STOREY CONE IN AN IONOSPHERIC PLASMA

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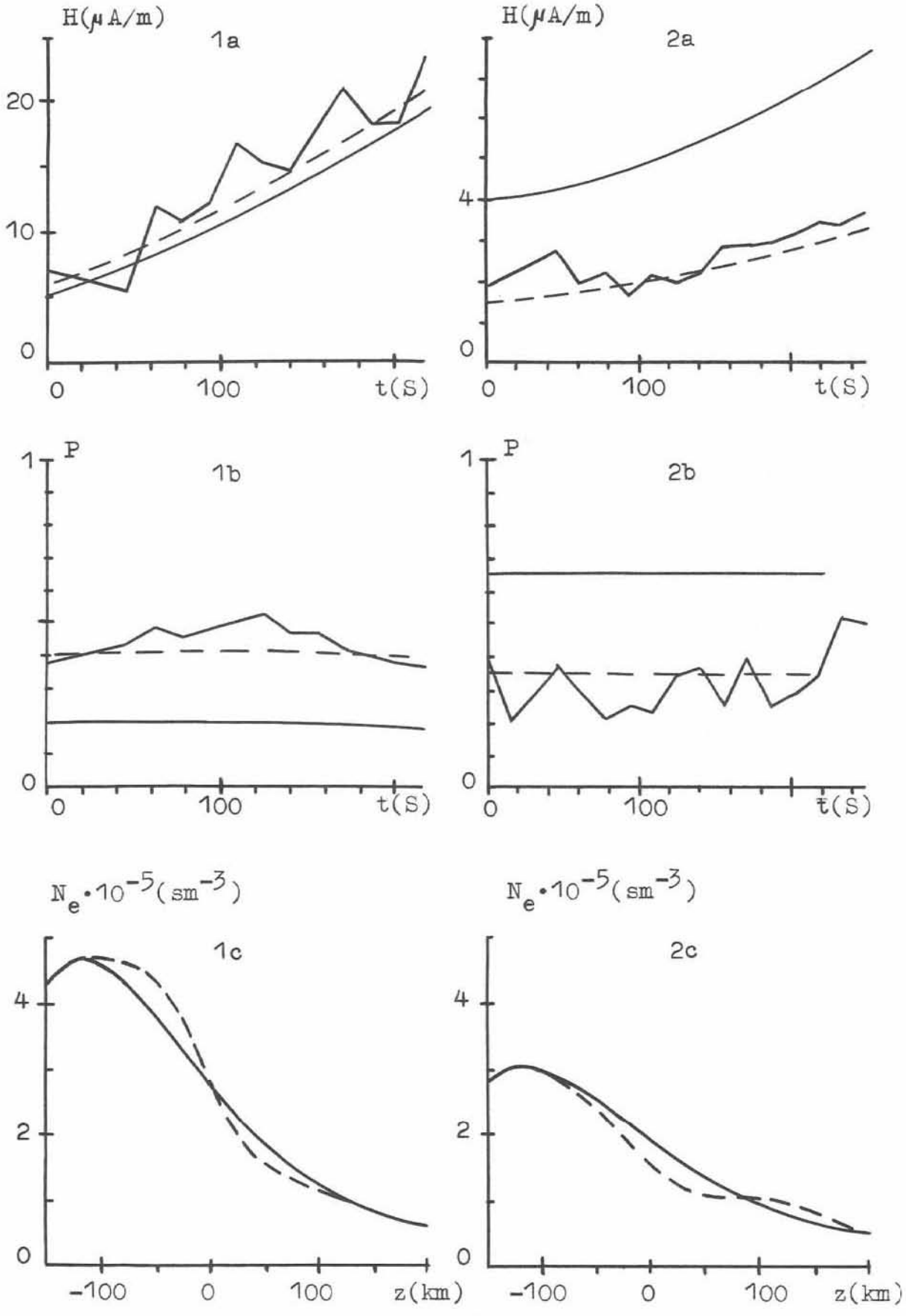
In March 1987 a space experiment on VLF emission of electromagnetic waves (a harmonic signal of 5 kHz frequency) in the Earth's ionosphere was made in the USSR. An emitting antenna in the shape of two loops, diameter 20 m each was mounted on a cargo spacecraft "Progress-28", the signal was received at an orbital station "Mir" by means of a receiving - analyzing complex "Parsek-A". The experiment of the sort, to our knowledge, was carried out for the first time. Its principle results are listed in the paper by Armand et al., 1988.

The space vehicles moved in ionosphere along the orbit close to the circular one, with inclination of $51{,}6^{\circ}$ and height 350-370 km above the surface of the Earth, diverging with velocity $\simeq$ 1 km/h. The reception and the registration of a magnetic component of the signal at the antenna profile currents up to 70A were made at various distances from the transmitter both inside the Storey cone and outside its boundary. Comprehensive analysis of the experimental data obtained is listed in the paper by Reznikov et al., in printing &.

Of considerable interest are measurements of the amplitude and polarization of a wave outside the Story cone. As shown by the authors (Reznikov et al., the present "Proceeding") a signal of the sort carries information about the plasma parameter distribution between the emitter and the point of reflection which is located in the domain of the electron density N_e drop at a distance $z_r \cong 6000\rho^2/L$ along a geomagnetic field **B**. Here ρ is the distance between the receiver and a force line of the field coming through the emitter, L is the characteristic dimension of the electron density variation along **B**. Under the experiment a typical L value calculated by a standard ionosphere model was about 150 km. The evaluation cited for the coordinate of the reflection point is valid, if only $z_r \leq L$, i.e. for $\rho \leq$ 2km. While measuring outside the Storey cone ρ varies from 1 km to 5 km. The polarization of the magnetic component of the emission largely depends upon electron density gradient along the geomagnetic field. If this gradient varies to a small extent between the emitter and the reflection point, the polarization is to grow monotonously with increasing ρ. For $\rho \leq$ 2 km the ratio of the polarization ellipse axes can be estimated as 25 ρ/L (Reznikov et al., in printing *a*). The observations, however, do not confirm such monotonous dependence. This can be explained, if one assumes the existence of a fine structure of the electron density variation along the geomagnetic field.

As an example, let us examine two observation sessions carried out in a mid-latitude ionosphere through one loop of the space vehicles. For the first session the distance ρ was about 1.0 km, for the second one - 3.3 km. The figure shows the amplitudes H (1a, 2a) and the ratio of the polarization ellipse axes P (1b, 2b) of the magnetic component of the signal depending on time *t*. What corresponds to the magnitudes observed are polygonal curves. The solid smooth lines are theoretical curves calculated


H(μA/m)
1a
20
10
0
0
100
t(S)
H(μA/m)
2a
4
0
0
100
t(S)
P
1b
1
0
0
100
t(S)
P
2b
1
0
0
100
t(S)
$N_e \cdot 10^{-5} (sm^{-3})$
1c
4
2
0
-100
0
100
z(km)
$N_e \cdot 10^{-5} (sm^{-3})$
2c
4
2
0
-100
0
100
z(km)

in the assumption that the ionosphere parameters are described by an IRI model. The electron density variation along **B** for this model is shown by a solid curve in Fig. 1c, 2c. Dashed curves of the field and polarization have been calculated in the assumption that there is a certain fine structure in the electron concentration distribution. Respective N_e dependences on the distance along **B** are demonstrated by a dashed line in Fig. 1c, 2c. The reverse problem of the search of a fine structure, having a minimum distortion of the standard electron density distribution, was solved, at the first stage, in a quasifar zone approximation for the first session, and in a far-field zone approximation for the second session (Reznikov et.al., the present "Proceedings"). Final curves have been obtained in the approximation of the second near-field zone.

We came to conclusion that the characteristics of the loop antenna emission observed outside the Storey cone can be treated in the framework of the linear theory for a cold plasma in the presence of a fine structure of the ionospheric plasma parameter variation along the geomagnetic field. The gradients formed by the fine structure are to be compared with the standard ionosphere parameter gradients.

Reference

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