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SOME EFFECTS IN THE REGION OF THE TROUGH FROM THE "INTERCOSMOS-10"

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ABSTRACT

On the satellite "Intercosmos-10",which was launched on 30.10.1973 into the orbit with apogee 1477 km, perigee 265 km and inclination of 74^{o}, among scientific instruments the apparatus was installed for the measuring of VLF-emissions, the concentration and temperature of electrons, fluctuations of the electric field strength.

In the region of the equatorial and polar boundaries of the middle-latitude trough some changes of VLF-emission spectra and the electron temperature occured and fluctuations of the electric field strength in the range of 0.03-70 Hz were observed. Some samples are presented and these effects are discussed.

1. Introduction

Measurements of VLF-emissions, electron concentration and temperature as well as of electric field intensity fluctuations have been performed during 5 months on board the satellite "Intercosmos-10", which was launched on 30.10.1973 into the orbit with apogee 1477 km, perigee 265 km, inclination 74°. Devices for VLF registration have worked out in CSSR, those for electron concentration and temperature measurements in the GDR and the USSR and those for electric field fluctuation measurements in the USSR.

This satellite had no compulsory orientation and was rotating around the centre of mass with main period equal to 10 to 20 min. Besides the ordinary telemetry system a broad band system TS-1 was set up by means of which the broadband VLF registration channel data as well as the Langmuir probe and electric field fluctuations meter data were transmitted. These data were received via TS-1 at CSSR observatories (Panska Ves 50.5° N; 14.6°E), the GDR (Neustrelitz 53.3°N; 13.1°E), the USSR (Moscow 55.5°N, 37.3°E, Apatity 67.5°N, 33°E).

The present report gives the results of VLF emission measurements received through the TS-1 system in CSSR, and in the USSR, Langmuir probe results received through the TS-1 in the USSR and electric field fluctuations received through the TS-1 in the GDR and the USSR and also through the ordinary telemetry system in the USSR. A statistical analysis of these data has not been accomplished the present report deals with the results of complex processing of the data received on some revolutions chosen among those being at the period from 12.12.1973 to 12.03.1974. The orbit of "Intercosmos-10" and the scientific equipment installed on it permitted to investigate more completely the physical processes in the main midlatitude trough region and their relation with magnetospheric phenomena which provokes a great interest at present /1-3/. Such investigations by the above mentioned scientific equipment have not yet been realized, as we know.

Below a brief description is given for the used equipment and the techniques of measurements as well as the basic results obtained in the region of the main trough that is defined from sharp change of electron concentration at invariant latitudes $50^\circ < \Lambda < 70^\circ$ and at altitudes of 600 to 1300 km.

2. Brief Description for Equipment and Measurement Techniques

2.1. <u>VlF and ELF emission measurements</u>. In order to receive electric component of the electromagnetic field in the frequency range of 20 Hz to 20 kHz an electric dipole aerial was used with length of 2.35 m oriented perpendicularly to longitudinal axis of the satellite. The spherical grid probes of this aerial were connected with pre-amplifiers fixed on a bar in a cylindric body just near the probes. The input resistivity of preamplifiers was 18 MgoM and sensitivity of the total equipment system was 10^{-7} v/$\sqrt{Hz}$. The signals received by a broadband amplifier were transmitted to the Earth by the telemetry system TS-1. The equipment was realized in such a way to be able to registrate VLF spectral components at frequencies of 720 Hz and 4.0 kHz. To determine VLF waves of the electric field absolute value the periodical measurements of probe impedance and calibration of amplifiers using a noise signal were performed. The further processing of data was made on sonograph which allowed to determine VLF-noise dynamical spectra.

2.2. Equipment for the electron concentration and temperature measurements. The cylindric probe collector was made in the form of a steel bar with diameter of 1 mm and with length of 116 mm. To diminish the edge effects a guard section was fixed near the bar fastening; the guard section was supplied with the same voltage as a probe collector : from - 3 to +6v. The cylindric guard section had a diameter of 4 mm and a length of 116 mm. The probe was fixed at the end of separate conductive metal bar so that the distance between the probe guard section and the satellite surface was 116 cm. One full work cycle was 8 sec and consisted on 4 subcycles of 2 sec each. During the first second of each subcycle the electronic unit sawt tooth generator worked at 8 Hz and during the second one at 2 Hz. The probe current measurements were carried out throughout three subcycles and during the fourth one the automatic calibration of the amplifier. During each subcycle the amplifier operated in a separate subrange of sensitivity whose ratio was 0.1; 1; 10. In this case the biggest range was $-1.2x10^{-6}$ to $1.2x10^{-7}$A, and the amplifier calibration was carried out in the middle subrange.

2.3. <u>Electric field fluctuation measurement equipment</u>.

The electric field fluctuation measurements were realized by registering potential difference between three pairs of spherical probes with diameter 50 mm set apart at a distance of 1.5m and making a system of three dipoles perpendicular to each other. Each pair of probes was connected with the amplifier input having input resistance not less than 10^8 om. The frequency range of the electric field measured was chosen so as to exclude the influence of field E = / V x B/ associated with the satellite motion with velocity V in the Earth's magnetic field; it is on the order of 400 mv/m and changes slowly as the satellite rotates and therefore makes no obstacles to the electric field measurements in the chosen frequency range: 0.03 to 70 Hz. Information on the instantaneous values of signals in the frequency range of 4 to 10 Hz was transmitted in real time from the satellite ordinary telemetry system and was recorded by a memory device in the frequency range of 0.03 to 1.5 Hz for components X, Y. The mean intensity values at 3 to 70 Hz and 15 to 70 Hz were registered for all the three field components with sampling rate 1/8 Hz. Information for one component (X) in the whole frequency range from 0.03 to 70 Hz was transmitted in analog form through TS-1 system.

3. Experimental results

3.1. <u>VLF - emissions and electron concentration trough</u>.

The earlier performed investigations /4/ and analysis of the data received from "Intercosmos-10" show that in the ionosphere through region the sharp variations of the character and the properties of VLF-emissions observed are most often. In this case the emissions of hiss type with the frequency range from 2.5 to 5.0 kHz are most frequently observed; they exist sometimes throughout the trough region under consideration. The central frequency of hiss band may change within the limits from 3 to 18 kHz. Sometimes the observed signals have a continuous spectrum structure in other cases, on the contrary, a clearly pronounced discrete structure takes place. The character of change of these spectra depends on a concrete geophysical situation. Fig. 1 gives as an example the typical variations of VLF - emission registered on 3.01.1974 during the revolution 918 (K_p = 2). During this revolution at $L \simeq 7$ an electron concentration polar trough was observed; at the high latitude side of the trough ($L = 6.6$) polar hisses were observed with low cutoff frequency about 9.0 kHz. Several subbands of the emission appear in the frequency range from 2 to 4 kHz at the latitude $\sim 64^{\circ}$. As the satellite leaving the trough n_e increasing and simultaneously VLF noise frequency grows.

3.2. Electric field fluctuations. Measurements of the electric fields in the frequency range: 0.03 to 1.5 Hz have shown that the intensive fields with the amplitude above 30 mv/m are usually observed at 60 to 80° invariant latitudes. Field fluctuations in this case may be considered as a spatial variation of the field with scales characteristic for the ionospheric irregularities of 5 to 800 km interpreted by moving satellite as a time variation. Fig. 2 gives the statistics for November - December 1973 for the north hemisphere of the noncorrelated fluctuations of two electric field components (X,Y), the amplitude being above 30 to 40 mv/m. A solid curve in this Figure corresponds to the main trough diurnal variation for $K_p = 2$ according to Muldrew [5] . It is evident that the field fluctuation occurence correlates with the position of the main trough in the evening & night sector; and the fluctuation region is situated by several degrees to the north in the morning-night sector. The region of maximum amplitudes of fluctuations E above 50 to 60 mv/m being singled out, we see that its shape is the same as this one of auroral oval: the fields are localized at the night side between 63 to 76^o of invariant latitudes and at the day side between 73 to 81^o Λ . In the sector 8^h to 11^{h}LT the more intensive and extended in latitude (72 to 83^o) fluctuations were observed than in sector 13^h to 16^{h}LT. In the sector 20^h to 24^{h}LT the more intensive and extended in latitude signals are observed; and the zone is shifted towards the equator (62 to 76^o) as compared with the sector 01^h to 05^{h}LT (65 to 79^o). Besides the oval-like region of the electric fields corresponding to the zone of discrete precipitation occurrence there exist on the day side (65^o) a thin ($\sim 2^o$) region of the fields (up to 50 mv/m).

The investigation of dependence of the electric field fluctuation registration zone on a degree of geomagnetic disturbance has shown that, firstly, the fluctuation intensity does not depend essentially on K_p; secondly, when K_p are high the zones shift by several degrees towards the equator, the width remaining practically constant. The shift of the fluctuation zone E towards the equator is shown also in Fig. 2 where the regions E for $K_p < 2$;$2 < K_p < 4$ and $K_p > 4$ are designated by different symbols. The electric field fluctuation data for the satellite flights on days when $K_p < 1$ and $K_p > 4$ are given in Table 1.

3.3. Examples of simultaneous VLF-emissions, E fluctuations, n_e and T_e data. Measurements of VLF from the satellite at 600 to 1300 km characterize the sources of these emissions and the medium between the source and the satellite. On the other hand the measured n_e, T_e values are related to the region near the satellite; the measured fluctuations E characterize the changes taking place at 5 to 800 km from the satellite. Fig. 3 gives the results of the simultaneous measurements of VLF-emissions, n_e and T_e, fluctuations E during the quiet magnetoactive period when $K_p = 2$ at 600 km for LT 21^h. One may see that the satellite was crossing the north boundary of the main trough at 64^o which is confirmed by a sharp change n_e from 2.10^4 to $3.10^3 cm^{-3}$.

Table 1

	Time of the day	Hemisphere	Λ	LT (h)
Kp < 1	day	south	76 to 81	8 to 9
		north	74 to 79	13
	Night	south	63 to 73	22 to 23
		north	65 to 75	20 to 21
Kp > 4	day	south	72 to 79	8 to 9
		north	72 to 78	12
	night	south	53 to 73	22 to 23
		north	59 to 72	20

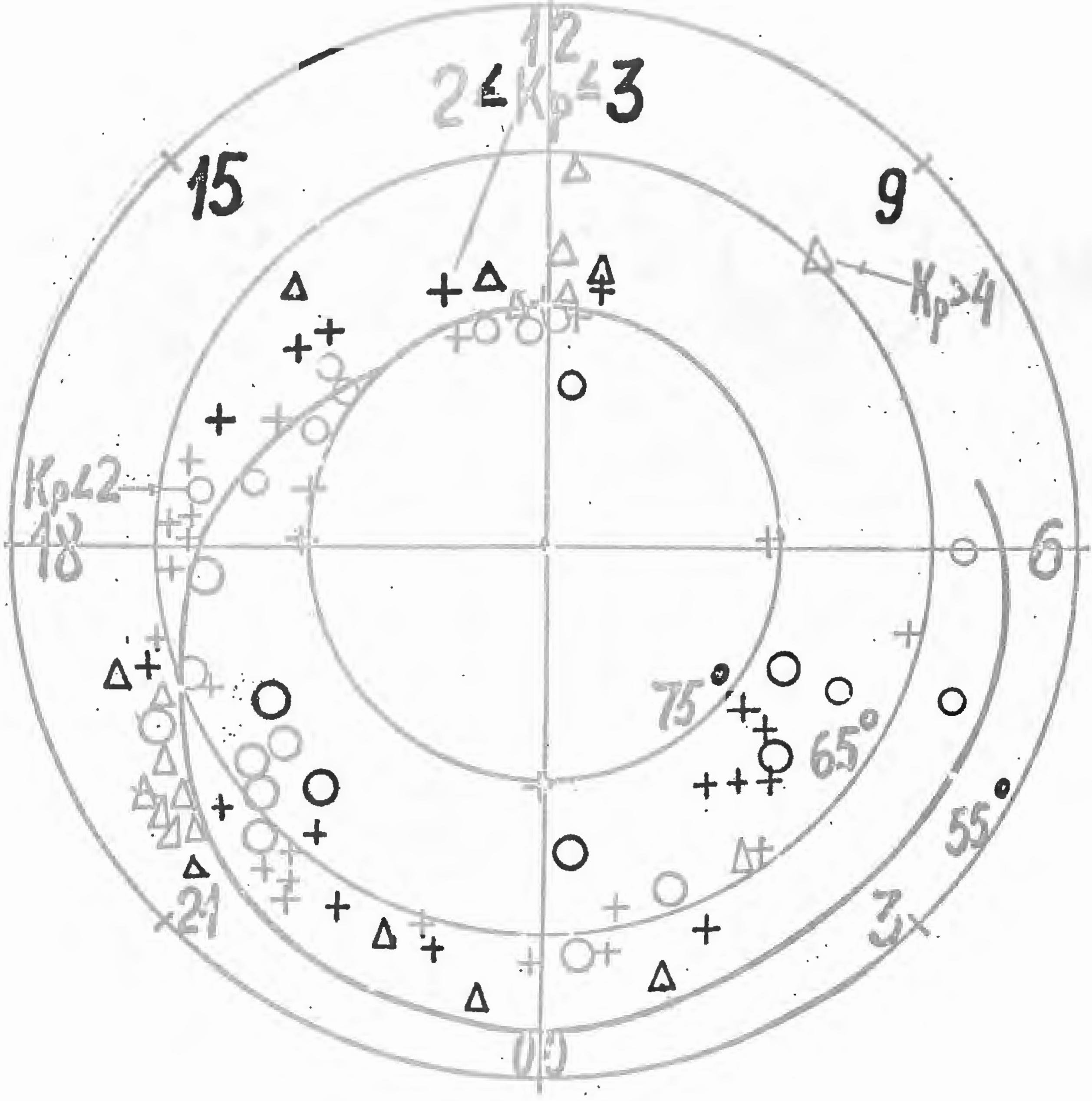
Concentration distribution northward from the main trough shows the auroral peak at $\Lambda \sim 65^o$ and a part of polar peak at $\Lambda \sim 68^o$. Such a latitude dependence is typical for the evening time in the north hemisphere in winter. Latitude changes of T_e are reverse to those of n_e. The Figure shows also that the VLF emission spectrum correlates with the n_e change. In the polar peak region the spectrum has lower cut-off frequency equal to 7 kHz. The VLF noise spectrum cut-off frequency is somewhat lower in the auroral peak of n_e region. In the trough region n_e spectrum decreases sharply and the lower cut-off frequency drops down to 2.7 to 2.5 kHz. Sharp spectrum irregularities at the main trough n_e boundary should be especially noticed. A consideration should be given to the fact that intensive fluctuations are observed northward from the main n_e trough at the northern boundary of the trough E changes its sign.

Fig. 4 represents the electron concentration distribution during the moderately disturbed magnetic period when $K_p = 3$ at 1300 km for LT $\sim 21^h$ near the main n_e trough. Minimum value $n_e = 2.5 \cdot 10^2$ cm^{-3} was observed at $\Lambda = 63.5^o$. Northward from the minimum n_e the changes of concentration have the same character as in Fig. 3 (auroral and polar peaks are observed). As different from Fig. 3 Fig. 4 gives the data on n_e from the equatorial side of the trough. Fig. 4 also gives the data on VLF-emission spectrum and on E fluctuation when the satellite flies over the equatorial side of the main trough. As it may be seen from the Figure the concentration grows non-monotonoulsy to $n_e = 10^4$ cm^{-3} at the equatorial side of the minimum n_e. It is also evident that the VLF noise lower cut-off frequency has a great similarity with the n_e change. Lower cut-off frequency has minimum in the trough region and increases non-monotonously from 5 kHz to 15 kHz. From the equatorial side of the n_e minimum the fluctuations E have the values of ~ 3 mv/m.

4. Discussion and conclusion

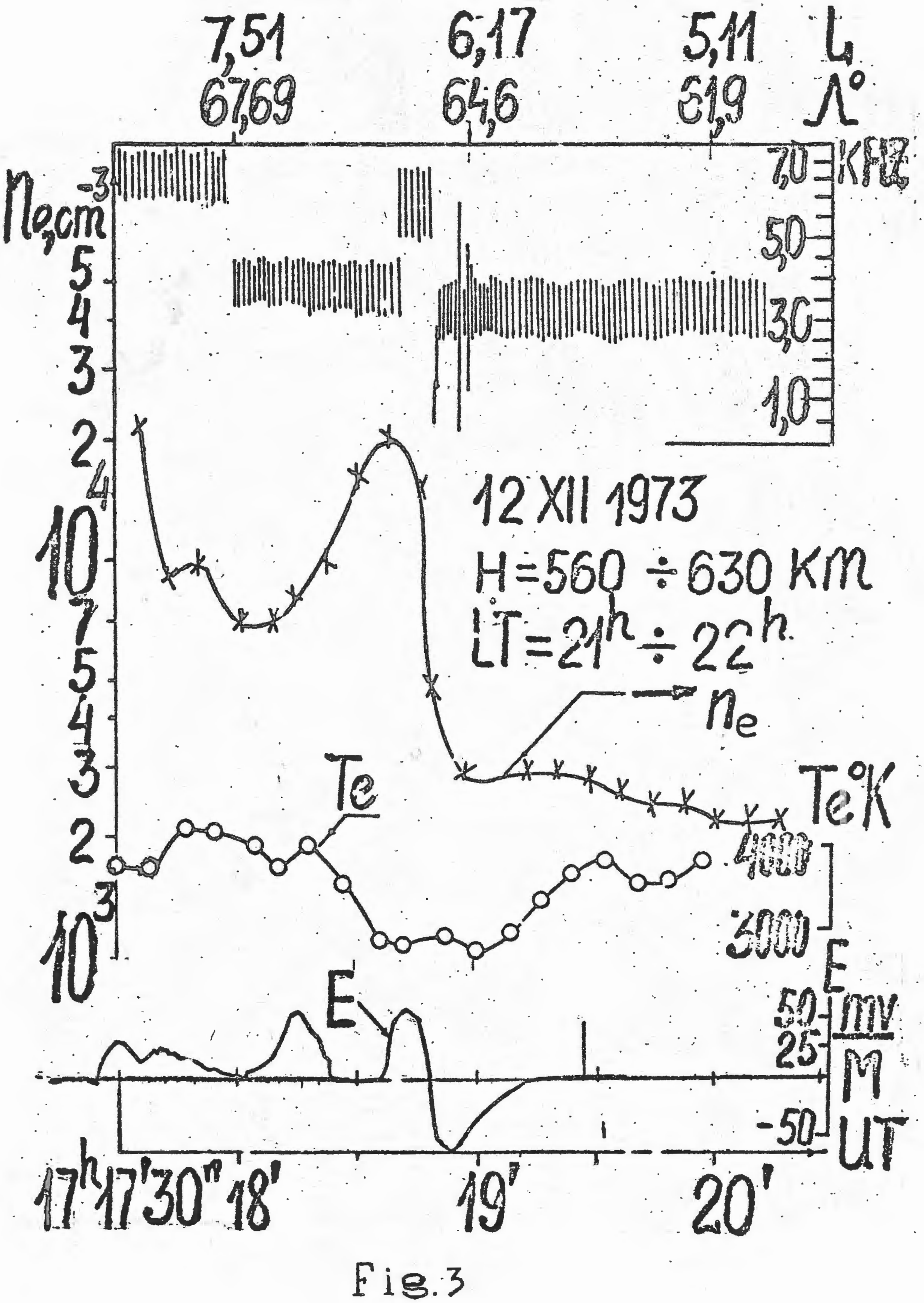
The experimental results presented in this report are an example of a complex investigation of plasma electric properties A good correlation of n_e variations with the lower cut-off frequency of VLF noise spectrum (see Figs. 1, 3, 4) allows to assume that electrostatic waves play an important part in registered emissions. Besides, a good correlation between n_e and VLF psectrum may be interpreted as an evidence that a low hybrid resonance noise exists in the VLF emission spectrum also. According to our estimation the LHR frequency correspond the observed n_e values. As a rule noise spectrum in the n_e trough contains more low frequency subbands. At the trough polar boundary VLF-emission spectrum fluctuations appear. The appearance of irregularities in ELF-emission spectrum near the trough polar boundary apparently coincides with "Alouette's" data according to which irregularities were observed in VLF-noise spectrum near the invariant latitude $\Lambda \sim 60^{\circ}$ [6]. A comparison of invariant latitudes Λ of the minimum n_e in Figs. 3 and 4 permits to suggest a small shift towards the equatorial side of the trough when K_p increases that corresponds to the data available (see, for example, [7]).

The distribution of E fluctuations given in the present report does not contradict to the satellite "Injune-5" [8] and "OGO-6" [9] data on the dc E component measurements and those of fluctuating fields in the range 3 to 30 Hz from the satellite OVI-10 [10] and in the range 10 to 500 Hz from the satellite OVI - 17 [11] .



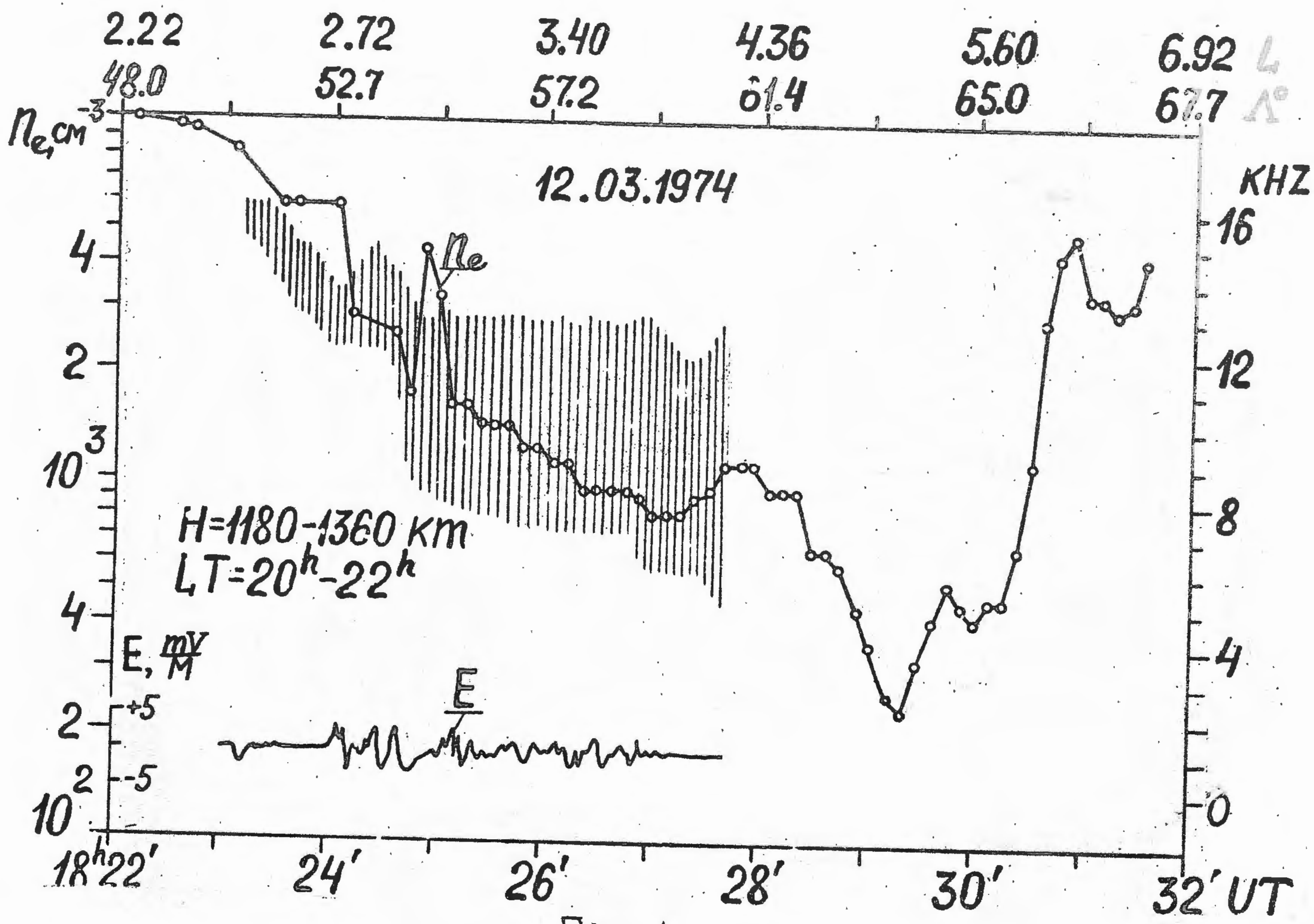
LT-Λ°

Fig. 2



7,51
6,17
5,11
L
67,69
64,6
61,9
Λ°
n_e, cm^{-3}
7,0
KHz
5,0
3,0
1,0
12 XII 1973
H=560 ÷ 630 Km
LT=21^h ÷ 22^h
n_e
Te
Te°K
4000
3000
E
E
mv/M
50
25
-50
UT
17^h
17'30''
18'
19'
20'

Fig.3



2.22
2.72
3.40
4.36
5.60
6.92
L
48.0
52.7
57.2
61.4
65.0
67.7
Λ°
n_e, cm^{-3}
12.03.1974
KHZ
16
12
8
4
0
n_e
4
2
10^3
4
2
10^2
H=1180-1360 Km
LT=20^h-22^h
E, mV/M
+5
-5
E
18^{h}22'
24'
26'
28'
30'
32' UT

Fig. 4