RESULTS OBTAINED ONBOARD THE INTERCOSMOS-19 SATELLITE USING THE P4 DEVICE

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A b s t r a c t: Albeit the P4 device was in operation to the 236th orbit only, the results obtained by means of the cylindrical probe and the spherical ion trap compared with other measurement data provided to determine:

1. *The fidelity of the charged particles concentration probe measurement [1];*
2. *The possibility of low-frequency wave excitation in the main ionospheric trough (MIT) and the auroral region [2,3,4];*
3. *The low-frequency wave propagation along the magnetic field below the MIT level [5];*
4. *To verify experimentally the interrelation between magnetospheric and ionospheric processes [6].*

A survey of the papers referred to and the main results obtained using the P4 device is made.

1. Fidelity of the charged particles concentration probe measurement.

Some instruments for measurement of the charged particles concentration were placed onboard the IK-19 satellite: the IS-338 ionospheric station [7], two spherical ion traps, a cylindrical Langmuir probe (the P4 device) [8], and the KM-3 device measuring electron concentration every 4 sec along with its primary function – to measure the electron plasma temperature by a high-frequency method [9]. The measurement methods used in all these instruments were analyzed and the experimental data obtained from them was compared every several orbits, so as to check the fidelity of the charged particles concentration probe measurement [1]. It should be noted that concentration measurement accuracy depends on the ion-probe plasma frequency.

The results of the measurement of the electron concentration n_e by the Langmuir probe are shown in Fig.1 (curve 2); curve 1 represents the ion-probe data n_i (IS-338); curve 3 – the device KM-3 n_e data with data correction compared to the ion-probe; curve 4 – n_i data from the spherical ion trap with a “floating” potential.

Universal Moscow Time (UT); Magnetic Latitude (MLAT); Local Time (LT); and Satellite Altitude (ALT) are given along the x-axis.

It becomes evident from [1] that the data from the spherical ion trap with a “floating” potential has the highest resolution time. Concentration variations according to ion-probe and ion trap data are cophasal and have a similar pattern although the concentration values exceed the possible measurement error being most likely relevant to the partial trap “occultation” (due to the solar batteries) by the plasma flow, arising as a result of the satellite’s flight. Therefore, the Langmuir probe data is used for comparison only and the ion trap with a “floating” potential data is used to follow the fine structure of plasma concentration variations.

The ionospheric station data allows to measure n_e at a distance of 5-8 km in the presence of distinct trails on the ionogram. Taking this into account, when the Langmuir probe measurement error is about 10%, it can be maintained that the results obtained in the satellite’s neighbourhood by the Langmuir probe and the ion-probe coincide.

The spatial variations of heat plasma density and the fluctuations of the magnetic component of the field of low-frequency plasma radiation with a frequency of 15 kHz in the MIT neighbourhood depending on D_{st} are given in Fig.2. D_{st} is the variation during the plasma storm of March 9–11, 1979 (22:04 LT). The following symbols are used in the figure: 1 – MIT boundary near the equator, 2 – concentration minimum, and 3 – MIT boundary near the pole.

2. Possibility of low-frequency wave excitation in the MIT and auroral region.

Experimental data is analyzed statistically in [2]. The correlation coefficients of the measured mutually perpendicular electromagnetic field components (the magnetic and electric components B_x

and E_y, respectively) are measured. The correlation coefficient is quite low at ELF-frequencies, tending to unity at frequency of 15 kHz.

The low correlation coefficient at lower frequencies may be attributed to the fact that wave field structure at low frequencies is more complex compared to the field structure at higher frequencies. The ion plasma components are of great importance to wave propagation: there are waves of different kinds with different amplitudes and different wave vector orientations.

The low correlation coefficient at ELF-frequencies shows that the waves are, generally, electrostatic. It is known that electrostatic waves cannot propagate at great distances away in the ionospheric plasma. Therefore, it can be asserted that excitation of such waves occurs in a highly non-homogeneous medium [3,4].

3. Verification of the quasi-longitudinal propagation of low-frequency waves at mean latitudes in the high ionosphere.

As the direction diagram is large enough, the signal level practically does not change within a wide enough corporal aerial angle. In this connection, at first approximation, the B_x and E_y satellite components obviously coincide with the total wave amplitude. In this case, the relation between the magnetic and electric component amplitudes of the noise field at quasi-longitudinal wave propagation is:

(1) $B_x/E_y = 3.336\, n_o$

where B_x is magnetic field induction, E_y – electric field strength in nT/√Hz and μV/m√Hz respectively, and n_o – wave refraction index at quasi-longitudinal propagation.

(2) $n_o = \omega_{oe}^2 / \; \omega(\omega_{be}\cos\theta - \omega)$

where ω and ω_{oe} are the circular and plasma frequencies

$\omega_{oe} = 4\pi\, n_o / \omega$

ω_{be} – electron gyro-frequency,

θ - the angle between the wave normal direction and the geomagnetic field vector B_o.

The results from the calculations using formulae (1) and (2), cos θ, the amplitude to amplitudes B_x and E_y ratio, and the measured values of n_e are shown in Fig 3.

It is evident that the values of n_e practically coincide with the calculated ones. This gives a reason to maintain the theory of quasi-longitudinal propagation of low-frequency waves at mean latitudes in the high ionosphere.

Conclusion

Albeit the P4 device was in operation to the 236th orbit only (later the device resumed operation), the electron concentration data obtained by it generally coincides with the ionospheric station IS-338 data. The ion concentration data can be used when $n_e = n_i$; the spherical ion trap with a “floating” potential data has the highest resolution time and therefore, it is used to follow the fine structure of plasma concentration variations.

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