RESEARCH OF THE EARTH'S IONOSPHERE («Space» Project)

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«Space» Experiment
SPACE-BORNE IONOSPHERE RADIO SOUNDING BY SIGNALS OF THE GROUND-BASED HF AND VHF BROADCASTING STATIONS

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The experiment proposes a new procedure of global near-Earth plasma monitoring with the method of radio sounding by signals of the ground-based HF and EHF broadcasting radio and television stations, received onboard the orbital space station (OSS). The possibility for tomographic ionosphere reconstruction with the proposed measurement procedure is analyzed, and the methods of determination of the local value of electron concentration in the OSS vicinity and the ionosphere penetration frequency are suggested.

During the almost 80 years of ionospheric research, the knowledge of physical processes in formation and dynamics of near-Earth plasma, development of the methods of ionosphere condition diagnostics and prediction, study of ionosphere influence on the performance of different radio systems, etc., have advanced considerably. However, sounding of the near space, i.e., the Earth's ionosphere and magnetosphere, still remains one of the most pressing problems in modern radio physics, for a number of reasons.

Firstly, the ionospheric channel is, probably, the most «overloaded» with signals of the ground-based and space-borne radio systems (long-haul radio, radar, navigation, telemetry and others). More and more detailed knowledge of the ionosphere parameters is needed to meet the ever-growing accuracy and operational reliability requirements for such systems, alongside with the problem of achieving their best performance.

Secondly, the upper atmosphere is the region where the basic interaction occurs between the radiation and corpuscular energy of the Sun and the gas envelope of the Earth. The energy fluxes of exospheric origin (solar flares and particle eruption) are hazardous for the control systems of space vehicles, frequently resulting in decoupling of space and ground radio communication channels, and are harmful for the human beings.

Thirdly, rapid progress of technology has led mankind to further expanding its environment, which now already covers the near space. Eventually, the man-made energy fluxes (powerful explosions, chemical deposits, space launches, electromagnetic pulses of powerful transmitters, industrial accidents, etc.) became comparable with those of natural origin (earthquakes, tsunami, typhoons, hurricanes, etc.), and in some cases even exceed the latter. The ionosphere, as a kind of delicate «pitchfork» responding to powerful energy release both of natural and artificial origin, can be used to reveal such processes when solving the problem of environmental monitoring and prediction of natural disasters.

Fourthly, the experiments proving the connection of the processes in the near space with the tropospheric and stratospheric meteorological processes, and phenomena occurring in the Sun and in the interplanetary medium, as well as on the surface and in depth of the Earth, open a prospect for creation of a self-consistent model — the concept of «space weather», being rapidly developed recently.

The project is aimed at development of a new procedure of global monitoring the near-Earth's plasma using the ISS-mounted HF and VHF receiver complex and applying the method of radio sounding with signals of the ground-based broadcasting and television stations. The tomographic methods are proposed for reconstruction of the ionosphere, which find ever-new applications in various areas of science and engineering. Despite rather detailed algorithms available for tomographic reconstruction of the ionosphere, they cannot be immediately incorporated into the suggested procedure. The point is that the conventional methods for measurement of linear integrals (total electron content (TEC) along the line of sight) imply arrangement of special transmitters onboard the space vehicle, while the transmitted signals are received on the Earth's surface.

Therefore, the experiment considers non-traditional methods for radio-tomographic reconstruction of the ionosphere by using the polarization patterns of the sounding signals. Apart from the tomographic reconstruction of the ionosphere, the intent is to use some other diagnostic capabilities of the said radio sounding procedure. It allows, for example, to fairly easily measure the local value of electron concentration in the space vehicle vicinity.

On-board equipment includes:

— HF and VHF antenna systems based on small-sized orthogonally polarized broadband dipoles;

— multi-range, coherent, program-driven receiver complex supplied with a panoramic scanner and multichannel sub-band recorders;

— fast analog digitizer;

— computing hardware coupled with the systems of data visualization, accumulation and transmission;

— applied software package ready for quick data processing, visualization and analysis onboard the ISS.

The above assumes close interaction with the ground-based diagnostic centers located in the space vehicle's sub-radar point. Application packages for data processing, storage and visualization will be developed on the basis of the built diagnostic algorithms. Computer simulation is suggested for testing and finalizing the method. Alongside with implementation of these items, analysis of a global net of transmitting centers will be done to select the radio sounding frequency, space and time ranges matching the ISS position in orbit. After manufacture of the prototype and flight models of a receiving-measuring complex, the ground observatory-based full-scale measurements will be performed.

The final result of the experiment is to manufacture an on-board unit with the appropriate software. Thus, due to a large number of HF and VHF stations, the suggested procedure of diagnostics will enable practically continuous global monitoring the near-Earth's plasma to be completed.

«Synthesis» Experiment

FEASIBILITY OF MAGNETOHYDRODYNAMIC INTERFEROMETRY IN THE MAGNETOSPHERE

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The transfer of energy and information between different parts of the «magnetosphere — ionosphere» system is largely determined by magnetohydrodynamic (MHD) waves, which are low frequency vibrations ($\omega < \Omega_i$) of the electric and magnetic fields, as well as by charged particle displacements and velocities in the interplanetary and terrestrial plasma. The conditions for MHD wave propagation through the geospace depend essentially on structural features of the magnetosphere and physical processes occurring in the magnetospheric/ionospheric plasma. This suggests a possibility of MHD diagnostics, i. e., determination of the propagation medium parameters from observed variations in