DETERMINING PARAMETERS OF IONOSPHERIC IRREGULARITIES FROM STATISTICAL CHARACTERISTICS OF RADIO WAVES ON AN OBLIQUE SOUNDING PATH

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The electron density irregularities in the ionosphere considerably affect high frequency (HF) radio wave propagation. However, great variety of the ionospheric irregularity shapes and parameters makes it difficult to calculate the variations of radio wave characteristics caused by the presence of these non-uniform structures along the radio path. The electron density irregularities in the ionosphere are usually stretched along the Earth's magnetic field lines. Such irregularities are characterized by power-law or gaussian-power-law intensity spectra. At present, there is still a lack of reliable information about the ionospheric irregularity shape factor (i.e. the ratio between their scales in the directions parallel and normal to magnetic field lines), although isolated spacecraft measurements have shown that the irregularities may have coaxial and "pancake" shape. This is why developing new methods for ionospheric irregularity diagnostics is an important task.

In this work a new technique for determining the parameters of the field-aligned irregularities is developed and implemented. The suggested method makes use of statistical characteristics of the HF radio waves on oblique sounding path at the instants close to a radio rise and radio decline. For successful restoration of the irregularity parameters, it is sufficient to make measurements only at one operating frequency that makes the proposed technique easy to implement.

The newly developed technique is an evolution of the method of ionospheric irregularity diagnostics described in [1]. The algorithm is based on solving the electrodynamic problem of reconstructing the parameters of irregularities from statistical moments of radio waves. The statistical moments used in reconstruction are the variances of the azimuthal and zenith angles of arrival, as well as the phase variance and the mean intensity of the received signal. The correlation ellipsoid oriented along the magnetic field lines and characterized by intensity $(dN/N)^2$, and the irregularity scales lx, ly, and lz (with x-axis directed along the magnetic field lines) is introduced to describe the irregularities. Using geometrical optics and the perturbation method, some asymptotic formulas for the statistical characteristics of radio waves in the presence of the field-aligned irregularities on the oblique path are obtained. The interference integral method is used for calculating the mean intensity of radio waves and allows avoiding the singularity of the geometro-optical wave field in the vicinity of a caustic that is formed during a radio rise and radio decline. Combining the obtained asymptotic expressions for the statistical moments of radio waves into the system of equations enables us to formulate the inverse problem for determining the parameters of the correlation ellipsoid of the ionospheric irregularities. Thus, by measuring the fluctuation characteristics of the received signal at only one operating frequency it is possible to determine the parameters of ionospheric irregularities present along the radio path.

The developed method for random ionospheric irregularity diagnostic has been tested using the University of Massachusetts Lowell Digisonde [2]. In this experiment HF radio signals from several broadcasting radio stations were continuously monitored in order to calculate their statistical moments. The preliminary results obtained testify about the reliability of the proposed method.

REFERENCES

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