# INVESTIGATION OF THE ANGULAR SPECTRA OF A VECTOR FIELD REFLECTED FROM THE F2 IONOSPHERE LAYER

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The results of experimental studies of two-dimensional angular spectra of orthogonal projections of the vector of a partially scattered field, reflected from the $F_2$ ionosphere layer upon vertical sounding are presented. It is found that the center of the angular spectrum deviates from the undisturbed direction, the scattering of the wave along and across the terrestial magnetic field is anisometric, and also the degree of the scattering of orthogonal projections of the field differs.

Studies of the time properties of partially scattered fields resulted in several mathematical models [1-4]. The spatial properties of partially scattered fields have been less extensively explored. The purpose of the present study was to investigate experimentally the spatial and angular characteristics of a vectorial partially scattered field, arising upon diffraction by inhomogeneities of the ionosphere.

The experiments were performed with three polarization antennas, placed in the vertexes of a right triangle with legs of about 50 m, and a set of coherent transceiving apparatus, which made possible simultaneous measurement of the quadrature components of the orthogonal projections of the vector of a field reflected, upon vertical sounding, by the F2 layer of the ionosphere.

It was found by investigating the autocorrelation functions of the quadrature components and of the amplitude of the field that, when a wave is reflected by the ionosphere, there is no relationship between these features of the partially scattered field and the coordinates in the wavefront plane. This fact points to homogeneity of the vectorial field reflected from the ionosphere and of its parameters (amplitude, phase). The study of the angular spectrum of $G(s_1, s_2)$ (where $s_1$ and $s_2$ are, respectively, angles in the latitudinal and meridional planes) is based on its relationship with the spatial correlation function of the field $\hat{R}_E(\mathbf{r})$ [5] (where $\mathbf{r}$ is the radius vector of the point of observation). The experimental results show that $\hat{R}_E(\mathbf{r})$ is a complex function, and this can be attributed to the shift of the center of the angular energy spectrum of the partially scattered field relative to the undisturbed direction of wave propagation, and can also be used for determining its approach angle. Analysis of the spatial correlation functions of envelope $R_A(\mathbf{r})$ and function $\hat{R}_E(\mathbf{r})$ show that the model of partially scattered fields with completely shifted spectrum [4] can be used in the study of not only time, but also space properties of the field. The spatial coefficients of correlation of the orthogonal projections of the field, measured on the three polarization antennas made it possible to calculate two-dimensional angular

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energy spectra of these projections. The calculations involved approximating the spectrum by a two-dimensional Gaussian distribution. The cross sections of angular spectra in the space of variables $s_1$ and $s_2$ were approximated by ellipses with semiaxes $s_{**1}$ (major) and $s_{**2}$ (minor). The experiments show that the orientation of the major axes of the angular energy spectra clusters along the latitude. The means values of ratio $h = s_{**1}/s_{**2}$ for the $E_x$- and $E_y$- projections of the field are respectively $\langle h_x \rangle = 1{,}63$, $\langle h_y \rangle = 1{,}8$ (the y axis coincides with the direction of the magnetic meridian). The fact that $\langle h \rangle$ is different from unity means that the degree of scattering of the wave in the ionosphere in the plane of the meridian is lesser than in the latitudinal plane, with the anisometry of scattering manifesting itself more perceptibly for the $E_y$- projection of the field. The width of the two-dimensional angular energy spectrum was described by the quantity $s_* = \pi s_{**1} \cdot s_{**2}$, approximately equal to the solid angle, bearing on the cross section of the angular spectrum, passing on half level of function $G(s_1, s_2)$. Figure 1 depicts a histogram of ratio $s_{*y}/s_{*x} = q$. The most probable value is $q \approx 1.2$, and this means that the width of the two-dimensional angular spectrum for the projection of the vector of the field coinciding with the plane of the magnetic meridian is greater than for the projection of the vector perpendicular to it. The width of the angular spectrum is the spatial measure of scattering of the field, and it can be compared with the energy measure of scattering $\beta^2 = |E_0|^2 / \langle E_{sc}^2 \rangle$, where $E_0$ and $E_{sc}$ are, respectively, the determined and the scattered components of the field. Using features specific to polarization of a partially scattered field reflected from the atmosphere [6], we can show that we should have $(s_{*y}/s_{*x}) \simeq (\beta_x^2/\beta_y^2)$. Figure 2 shows a histogram of $\psi = (\beta_x^2/\beta_y^2)/(s_{*y}/s_{*x})$. For the average values of $\beta^2$ and $s_*$ we have $\psi = 1.01$, and this means that the spatial and energy parameters of scattering do not contradict one another. The agreement between these parameters is a logical result of the established uniformity of the partially scattered field.

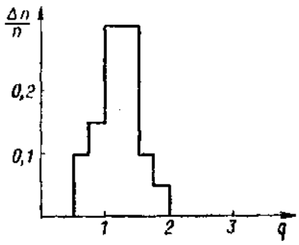


Fig. 1

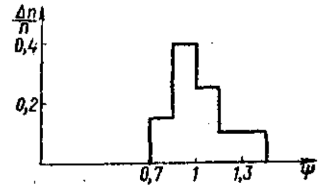


Fig. 2

**Results.** 1. The maximum of the two-dimensional angular energy spectrum of each projection of the vector of a partially scattered field is shifted relative to the undisturbed direction of propagation.

2. The cross sections of two-dimensional angular energy spectra have two different characteristic dimensions along the orthogonal axes.

3. The difference between the two characteristic dimensions of the spectrum indicates that reflection of a radio frequency wave from the ionosphere involves anisometry of the scattering of each orthogonal projection of the field's vector.

4. The component aligned along the plane of the magnetic meridian is the stronger scattered of the two projections of the field of the vector.

The above results do not contradict the basic conclusions of the theory of diffraction of a vectorial field on elongated and concave-shaped bodies [7], concepts concerning the shape of ionosphere inhomogeneities [8, 9], and features of scattering on them [10].

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