Second order statistical moments of scattered electromagnetic waves in the conductive magnetized ionospheric plasma

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The ionosphere is greatly influenced by ionizing radiation including both electromagnetic flux and energetic particles. The ionosphere is immersed in a magnetic field and the interactions of radio waves with the ionosphere are complex and exhibit the following properties: anisotropy, absorption, dispersion, birefringent. The ionospheric effects on radiowave systems depend upon the focus of the treatment. The development of inhomogeneous electron density structures is responsible for radiowave signal fluctuations. A comprehensive treatment of radiowaves propagation in the ionospheric plasma is based on the investigation of the statistical moments of both amplitude and phase fluctuations of scattered radiation. In this paper analytical calculations of the statistical characteristics in the conductive collision magnetized ionospheric plasma have been carried out for the first time using the complex geometrical optics approximation. Stochastic wave equation of the phase fluctuations includes both dielectric permittivity and conductivity tensors which are random functions of the spatial coordinates and time. Using the boundary conditions correlation function of the phase fluctuations has been obtained for arbitrary second order statistical moment of electron density fluctuations (large and small ionospheric plasmonic structures); observation points are spaced at small distance. The index of refraction contains both ordinary and extraordinary waves. Angular power spectrum (broadening, shift of its maximum) of scattered electromagnetic waves is investigated. It was shown that Hall's, Pedersen, and longitudinal conductivities have a substantial influence on the frequency fluctuation of an incident wave. Doppler spread associated with random ionospheric structure, and Doppler shifts associated with relative motion of the ray path with respect to the elongated plasmonic structures. Spatial-temporal broadening of the spatial spectrum depends on the anisotropy factor of elongated plasma irregularities, inclination angle with respect to the lines of forces of geomagnetic field, collision frequency between plasma particles, conductivity fluctuations, and the movement of ionospheric plasmonic irregularities. Shift of the spectral maximum changes the sign depending on the anisotropy factor of elongated plasma irregularities, inclination angle with respect to the lines of forces of geomagnetic field and conductivity fluctuations. Numerical calculations and spatial-temporal modeling are carried out for both large and small-scale ionospheric plasma irregularities using experimental data and experimentally observing power-law spectrum of electron density fluctuations. The obtained results are useful for solving the reverse problem restoring plasma parameters, in satellite communication and navigation systems that operate in the earth-space regime. The influence of the conductivity fluctuations on the second order statistical moments will open new horizons in understanding and forecasting new phenomena in
the upper ionosphere caused due to spatial-temporal parameters fluctuations.