



The global weather forming ULF electromagnetic wave structures in the ionosphere

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In the present article the results of theoretical investigation of the dynamics of generation and propagation of planetary (with wavelength 10^3 km and more) ultra-low frequency (ULF) electromagnetic wave structures in the dissipative ionosphere are given. The physical mechanism of generation of the planetary electromagnetic waves is proposed. It is established, that the global factor, acting permanently in the ionosphere – inhomogeneity (latitude variation) of the geomagnetic field and angular velocity of the earth's rotation – generates the fast and slow planetary ULF electromagnetic waves. The waves propagate along the parallels to the east as well as to the west. In E-region the fast waves have phase velocities $(2 \div 20)$ $\text{km} \cdot \text{s}^{-1}$ and frequencies $(10^{-1} \div 10^{-4})$ s^{-1} ; the slow waves propagate with local winds velocities and have frequencies $(10^{-4} \div 10^{-6})$ s^{-1} . In F-region the fast ULF electromagnetic waves propagate with phase velocities tens-hundreds $\text{km} \cdot \text{s}^{-1}$ and their frequencies are in the range of $(10 \div 10^{-3})$ s^{-1} . The slow mode is produced by the dynamo electric field, it represents a generalization of the ordinary Rossby type waves in the rotating ionosphere and is caused by the Hall effect in the E-layer. The fast disturbances are the new modes, which are associated with oscillations of the ionospheric electrons frozen in the geomagnetic field and are connected with the large-scale internal vortical electric field generation in the ionosphere. The large-scale waves are weakly damped. The features and the parameters of the theoretically investigated electromagnetic wave structures agree with those of large-scale ULF midlatitude long-period oscillations (MLO)

and magnetoionospheric wave perturbations (MIWP), observed experimentally in the ionosphere. It is established, that because of relevance of Coriolis and electromagnetic forces, generation of slow planetary electromagnetic waves at the fixed latitude in the ionosphere can give rise to the reverse of local wind structures and to the direction change of general ionospheric circulation. It is considered one more class of the waves, called as the slow magnetohydrodynamic (MHD) waves, on which inhomogeneity of the Coriolis and Ampere forces do not influence. These waves appear as an admixture of the slow Alfvén and whistler type perturbations. The waves generate the geomagnetic field from several tens to several hundreds nT and more. Nonlinear interaction of the considered waves with the local ionospheric zonal shear winds is studied. It is established, that planetary ULF electromagnetic waves, at their interaction with the local shear winds, can self-localize in the form of nonlinear solitary vortices, moving along the latitude circles westward as well as eastward with velocity, different from phase velocity of corresponding linear waves. The vortices are weakly damped and long-lived. They cause the geomagnetic pulsations stronger than the linear waves by one order. The vortex structures transfer the trapped particles of medium and also energy and heat. That is why such nonlinear vortex structures can be the structural elements of strong macro-turbulence of the ionosphere.