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Properties of VLF waves in ionospheric plasma

The propagation of ULF waves in the ionospheric plasma usually is treated in terms of the Alfven and fast magneto sonic waves since the first publication of Greifinger and Greifinger (1968) on the properties of the ionospheric MHD waveguide in frame of magneto hydro dynamics (see f. e. Polyakov and Rapoport (1981), Lysak, at all, (2013), Eliasson, at all, (2012)).

We have examined the properties of low-frequency electromagnetic waves in the multicomponent ionospheric plasma in the 1-30 Hz band basing on the magneto ionic theory. The permittivity tensor was calculated at altitudes from 80 to 1000 km. Calculation of the refractive indices of two normal waves (ordinary and extraordinary) shows that they are highly dependent on the frequency and height.

The polarization of the two waves is elliptical in the whole range of investigated frequencies. Only at frequencies much lower than 1 Hz refractive index and the polarization of normal waves tend to the values obtained in the magneto hydrodynamic approximation. Therefore, it is possible only conventionally to name one of them the Shear Alfven (SA) wave, and the second fast magneto sonic (FMS) wave. The "Alfven" wave in the lower ionosphere becomes strongly damped and the refractive index of fast MS wave takes the form like for whistler mode and it is weakly damped in the lower ionosphere.

The dependence of the group velocity of the “Alfven wave" on the angle between the wave vector and the Earth magnetic field is also differs from the MHD approximation. An exact calculation shows that the vector of the group velocity of this wave is not directed along the magnetic field, but it is inside a cone within ± (20-25) degrees, depending on the frequency. The group velocity vector of the second wave corresponding to the fast MS is practically independent of the angle with the magnetic field, as in the case of MHD approximation.

The account of the true characteristics of normal waves in the ionosphere is important for obtaining the correct results on propagation of the ULF waves in the presence of sharp boundaries on which the linear transformation of the normal modes takes place. For example, one have to keep it in mind when solving the exit problem of ULF waves from ionospheric and magnetospheric sources to the Earth's surface through the complicate structure of the ionospheric Alfven resonator and when modeling it properties (see f. e. Ermakova at all, (2013)).

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