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Propagation of dusty sound waves in the dusty plasma waveguides formed by particles with variable masses

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Dusty plasmas in space, the Earth's ionosphere, and in volcano eruptions now are under investigations. An important property of dusty plasmas is the support of various waves and oscillations, both linear and nonlinear ones. As usually, the dusty plasmas are inhomogeneous, for instance, in the volcano fumaroles, and can produce the waveguides for plasma waves. In the report, the waveguides created by the distribution of dusty particles with various masses m = m(x) are investigated. Here x is the transverse coordinate whereas the dusty sound waves propagate along the z-direction.

A general method to analyze the dusty acoustic waveguides is presented. This method is based on hydrodynamics for the dust with the variable mass of particles. The solution of the problem of propagation of linear modes has been obtained by the shooting method. In the case of the contact of the dusty plasma with a semi-infinite dielectric, there exists the dusty acoustic mode that possesses the negative group velocity (the backward wave) in the specified interval of wave numbers. This phenomenon takes place, when the mass of dust particles is maximum in the center of the waveguide. The necessary conditions for existence of such a mode have been determined. The presence of the backward wave can lead to absolute instabilities in such a system. This mode can be used also for soliton excitation, because also there exists the value of the wave number where the group velocity is equal to zero and the wave dispersion is high. When the mass of dust particles is minimum in the center of the waveguide, the peculiarities of the dependence of the transverse electric field on the transverse coordinate x, like non-monotonic transverse profile, can occur. The estimations have demonstrated that the pointed above phenomena can occur in fumaroles under volcano eruptions.