Modelling of distribution of nonlinear ion-sound waves in a collisionless plasma

Nonlinear kinetic equation for distribution ions function $f(t, x, u)$ in dimensionless variables

$$\frac{\partial f}{\partial t} + u\frac{\partial f}{\partial x} - \frac{1}{\rho}\frac{\partial \rho}{\partial x}\frac{\partial f}{\partial u} = 0, \quad \rho = \int f du \tag{1}$$

describes the one-dimensional motion of a quasineutral collisionless plasma [1]. Model (1) falls into the class of systems with operator coefficients, for the study of which a generalization of the method of characteristics was proposed by V. M. Teshukov [2]. In [3] conditions for the generalized hyperbolicity of equation (1), exact solutions in the class of traveling waves and a hydrodynamic analogy are established with the flow of an ideal fluid in a channel with elastic walls. The main focus of this work is on obtaining hydrodynamic reductions and approximations of the kinetic model (1), reducible to hyperbolic systems of one-dimensional differential equations. A model of cold plasma (an analog of the equations shallow ox), gas-dynamic approximation, reduction of waterbag and "Multilayer" approximation are considered. Based on the listed equations numerical simulation of the propagation of waves arising as a result of the breakup of the initial discontinuity was performed. It is shown that the model of cold plasma and gas-dynamic approximation describe evolution of density quite well. For more accurate modeling, including the effect kinetic tipping, leading to instability of the flow, it is necessary to use the equations of "multilayer" approximation (1).

Another part of the work is related to the consideration of the dispersion model of ion-sound waves, which in the absence of dispersion is reduced to the equations of a cold plasma. For this model a linearized solution is written and a numerical solution algorithm is proposed based on splitting.

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[3] Khe A.K. and Chesnokov A.A. Propagation of nonlinear perturbations in a quasineutral collisionless plasma // Prikl. 2011.Vol. 52, No 5. P. 3–16.

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