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ORIGINAL ARTICLE

Ion acoustic drift solitons and shocks with κ-distributed electrons

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Abstract The impact of superthermal particles on nonlinear drift solitary and shock like structures are presented in an inhomogeneous electron-ion plasma with κ-distributed electrons. It is shown that the amplitude of the drift solitons and shocks is modified significantly in the presence of superthermal particles. The condition for the existence of drift solitons is found modified in the presence of higher energy particles. Furthermore, Kadomtsev–Petviashvili (KP) equation is also derived for the present plasma model.

Keywords Drift solitons · Inhomogeneous plasma

1 Introduction

Low frequency ion acoustic and drift waves are fundamental linear modes of magnetized electron-ion plasmas. However, the nonlinearities present in the system can give rise to nonlinear structures like solitons, vortices and shocks etc. Drift type structures only exist in magnetized plasmas having density/temperature inhomogeniety, while acoustic type nonlinear structures can be present both in magnetized and unmagnetized plasmas. The dispersive and dissipative nature of plasma medium play a very significant role in the development of solitary and shock waves. It is fairly well known that in a nonlinear dispersive medium, shock waves are formed owing to the interplay between nonlinearity (causing wave steepening) and dissipation (e.g. caused by viscosity, collisions, wave particle interaction, etc.). The plasma systems with prevailing dispersive and negligible dissipative properties sustain the propagation of solitary waves due to a balance between nonlinearities and dispersion. A lot of research work has been carried out on the nonlinear evolution of the acoustic modes. Washimi and Taniuti (1966) derived the well known Korteweg-de Vries (KdV) equation and investigated the small amplitude ion acoustic waves in an unmagnetized plasma consisting of cold ions and hot isothermal electrons. Due to the importance of KdV equation, numerous generalizations of this equation have been discussed in the plasma physics literature (Hasegawa and Mima 1976; Laedke and Spatschek 1982; Shukla and Yu 1978) and references therein.

Nonlinear shock-like drift wave equation for an inhomogeneous plasma was derived by Tasso (1967). The magnetized plasmas having density and temperature gradients support the nonlinear coherent structures like drift solitons (or solitary waves) (Oraevskii et al. 1969; Petviashvili 1977) or two-dimensional vortices (Laedke and Spatschek 1986) etc. The role of density gradient, $\kappa_n = |\frac{1}{n_0} dn_0/dx|\hat{x}$ and temperature inhomogeniety, $\kappa_T = |\frac{1}{T_0} dT_0/dx|\hat{x}$ on the dynamics of drift type solitons are discussed by many authors (Meiss and Horton 1982; Petviashvili 1977; Rahman and Shukla 1980). It is widely accepted that the density inhomogeniety determines the phase speed of linear drift wave and temperature gradient gives rise to the nonlinear term in the long wave length drift differential equation (Horton and Ichikawa 1996), which can give rise soliton-like solution. Contrary to these findings, it was discussed in Lakhin et al. (1987, 1988)

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