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ORIGINAL ARTICLE

Electrostatic envelope excitations under transverse perturbations in a plasma with nonextensive hot electrons

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Abstract Nonlinear dynamics of electron acoustic waves (EAWs) in a plasma consisting of stationary ions, cool inertial electrons and hot electrons having a nonextensive distribution is studied. Under transverse perturbations, the nonlinear wave can be described by the general form of the Davey-Stewartson (DS) equations. The reductive perturbation technique is employed to derive Davey-Stewartson equations. From the solutions of these equations, amplitude modulation properties and stability regions of EAWs are studied in two-dimensional plasma. Further, the influence of nonextensivity of hot electrons (via q) on the characteristics of EAWs has been analysed.

Keywords Electron acoustic · Solitary waves · Nonextensive distribution · Davey-Stewartson equation · Dromions

1 Introduction

Electron acoustic waves (EAWs) occur in plasma which consists two kinds of electron population; 'cold' electrons and 'hot' electrons with temperatures T_c and T_h respectively. The frequency of these waves is very high as compared to ion plasma frequency. For such a high frequency scale, positive ions form a uniform background and also provide charge neutrality. The inertia is provided by cold electrons and restoring force by hot electrons pressure. EAWs in plasma can propagate only within some restricted range of parametric values because Landau damping dominates when phase velocity approaches the thermal velocity of either electron component. A more rigorous analysis shows that EAWs will be heavily damped unless $T_c \ll T_h$ (Tokar and Gary 1984; Dubouloz et al. 1991b). Electron acoustic waves are weakly damped for a temperature ratio $T_c/T_h \leq 0.1$ and provided cold electrons represent an intermediate fraction of total electron density: $0.2 \leq n_c/(n_h + n_c) \leq 0.8$ (Tokar and Gary 1984; Mace and Hellberg 1990; Berthomier et al. 1999). Electron acoustic waves survive Landau damping over a wide range of parametric values (Mace et al. 1999).

Electron acoustic waves exist in laboratory experiments (Henry and Trguier 1972; Ikezawa and Nakamura 1981) and space plasmas, e.g., in the Earth's bow shock and in the auroral magnetosphere (Feldman et al. 1983; Thomsen et al. 1983; Tokar and Gary 1984; Bale et al. 1998). These waves are associated with broadband electrostatic noise (BEN) which is a common high-frequency background activity, regularly observed by satellite missions in the plasma sheet boundary layer. Over the last many years, the propagation of electron acoustic waves received a great deal of attention for research because of existence of two electron temperature plasma in laboratory and space environments. Gary and Tokar (1985) studied conditions for the existence of the EA waves, which are of potential importance in interpreting BEN observed in cusp of terrestrial magnetospace in auroral region and in geomagnetic tail (Tokar and Gary 1984; Schriver and Ashour-Abdalla 1989; Dubouloz et al. 1991b; Pottelette et al. 1999; Berthomier et al. 2000). The EA mode has also been used to explain wave emissions in different regions of the Earth's magnetosphere. EA solitary waves in a four-component plasmas have been studied to explain the Viking satellite observations in the dayside auroral zone (Singh et al. 2001). A model based on electron-acoustic

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