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ORIGINAL ARTICLE

Cylindrical and spherical electron acoustic solitary waves in the presence of superthermal hot electrons

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Abstract Propagation of cylindrical and spherical electron-acoustic solitary waves in unmagnetized plasmas consisting of cold electron fluid, hot electrons obeying a superthermal distribution and stationary ions are investigated. The standard reductive perturbation method is employed to derive the cylindrical/spherical Korteweg-de-Vries equation which governs the dynamics of electron-acoustic solitons. The effects of nonplanar geometry and superthermal hot electrons on the behavior of cylindrical and spherical electron acoustic soliton and its structure are also studied using numerical simulations.

Keywords Electron acoustic · Cylindrical and spherical solitary waves · KdV equation · Superthermal electrons

1 Introduction

Electron acoustic waves (EAWs) are one of the basic wave processes in plasmas and they have been studied for several decades. EAWs can be created in a two-temperature (cold and hot) electron plasma. Multispecies models were originally used for laser-plasma interaction but there are several similar situations. The evidence of two populations of electrons in laboratory and space plasmas has already been reported. The observations (Parks et al. 1984; Onsager et al. 1993) in the plasma sheet boundary layer have shown that there exist two types of electrons, namely background plasma electrons and cold electron beams having energies of the order of few eV to few hundreds of eV. Intense broadband electrostatic noise is commonly observed in such these plasma sheet boundary layer of the Earth's magnetosphere (Gurnett et al. 1976). Matsumoto et al. (1991) have shown that broadband electrostatic noise emissions in the plasma sheet boundary layers are not continuous noise but consist of electrostatic impulsive solitary waves. Polar cap boundary layer (Tsurutani et al. 1998), the magnetosheath (Pickett et al. 2003), the bow shock (Bale et al. 1998), and strong currents associated with the auroral acceleration region (Ergun et al. 1998) are other examples of plasmas consisting of two and three similar particle population. The EAWs are typically high frequency waves in comparison with the ion plasma frequency. Therefore ions remain stationary and form a neutralized background. The phase speed of the EAW lies between the cold and hot electron thermal velocities, so that the Landau damping effects are ignored for the consistency of fluid theory in two electron population plasmas. Motivated by these observations, we examine the generation of small amplitude solitons in a plasma with two components namely, cold electron beam and background plasma electrons. Watanabe et al. (1977) used a linear electrostatic Vlasov dispersion equation to show that electron acoustic waves can be destabilized in such plasma. Later on, Yu and Shukla (1983) and Gary et al. (1985) obtained a dispersion relation for EAWs in a two (electron-ion) and three (two-temperature electrons and ions) component plasmas, respectively. The electron-acoustic solitary wave (EASW) (as same as other localized waves in nonlinear me-

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