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ORIGINAL ARTICLE

Propagation of two-solitons in an electron acoustic waves in a plasma with electrons featuring Tsallis distribution

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Abstract A first theoretical work is presented to study the propagation of two-solitons in an electron acoustic waves (EAWs) within the theoretical framework of the Tsallis statistical mechanics. For this purpose, cylindrical and spherical Korteweg-de Vries (KdV) equations are derived for electron acoustic solitary waves (EASWs) in an unmagnetized three species plasma system comprised of cold electrons, immobile ions and hot electrons featuring Tsallis statistics by employing the standard reductive perturbation method. The effects of electron nonextensivity and the fractional number density of the hot electrons relative to that of the cold ones number density (α) on the profiles of two-soliton structures are investigated numerically. Results would be helpful for understanding the localized structures that may occur in space plasmas.

Keywords Electron acoustic waves · Two-solitons

1 Introduction

The electron-acoustic wave (EAW) can exist in plasmas which contains two populations of electrons, i.e., hot and cold electrons. It is basically an electrostatic wave in which the inertia is provided by the cold electrons and the restoring force comes from the pressure of the hot electrons. The ions play the role of a neutralizing background, i.e., the ion dynamics does not influence the EAWs. 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. The existence of electron acoustic wave has been first discovered by Watanabe and Taniuti (1977). The propagation of EAWs in a plasma system has been studied by several investigators in an unmagnetized two electron plasma (Mace et al. 1991; Dubouloz et al. 1991; Pottelette et al. 1999; Berthomier et al. 2000; Mamun and Shukla 2002; Singh and Lakhina 2004; El-Shewy 2011; Chen and Liu 2012; Pakzad 2012) as well as in magnetized plasma (Mace and Hellberg 2001; Mamun et al. 2002; Berthomier et al. 2003; Shukla et al. 2004; Anowar and Mamun 2008; Shalaby et al. 2011). Dubouloz et al. (1993) studied electron-acoustic solitons in an unmagnetized and magnetized two-electron component and motionless ion plasma. They could explain the negative polarity electrostatic solitary potential structures observed by the Viking satellite in the dayside auroral zone. Positive polarity soliton structures have been studied in the auroral plasma by the FAST and POLAR spacecraft (Berthomier et al. 2003). Singh et al. (2001) studied electron-acoustic solitons in four-component plasmas and applied their results to Viking satellite observations in the dayside auroral zone. Lakhina et al. (2008a, 2008b) studied ion and electron-acoustic solitary waves in three and four-component plasmas and applied their results to the plasma sheet boundary layer and the magnetosheath plasma. Verheest et al. (2005) showed that the inclusion of the hot electron inertia can lead to positive potential electron acoustic solitons.

Over the last two decades, a great deal of attention has been paid to non-Maxwellian particle distributions. The Maxwellian distribution is applicable to systems in thermodynamic equilibrium. However, astrophysical systems and space plasmas are observed to have particle distributions that depart from the Maxwellian distribution due to nonequilibrium stationary state. This state may arise due to a number

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