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ORIGINAL ARTICLE

Arbitrary amplitude electron acoustic waves in a magnetized nonextensive plasma

M. Shahmansouri · H. Alinejad

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Abstract Arbitrary amplitude electron acoustic (EA) solitary waves in a magnetized nonextensive plasma comprising of cool fluid electrons, hot nonextensive electrons, and immobile ions are investigated. The linear dispersion properties of EA waves are discussed. We find that the electron nonextensivity reduces the phase velocities of both modes in the linear regime: similarly the nonextensive electron population leads to decrease of the EA wave frequency. The Sagdeev pseudopotential analysis shows that an energy-like equation describes the nonlinear evolution of EA solitary waves in the present model. The effects of the obliqueness, electron nonextensivity, hot electron temperature, and electron population are incorporated in the study of the existence domain of solitary waves and the soliton characteristics. It is shown that the boundary values of the permitted Mach number decreases with the nonextensive electron population, as well as with the electron nonextensivity index, q. It is also found that an increase in the electron nonextensivity index results in an increase of the soliton amplitude. A comparison with the Vikong Satellite observations in the dayside auroral zone is also taken into account.

Keywords Electron-acoustic waves · Nonextensive electrons · Solitary waves · Magnetized plasma

M. Shahmansouri (✉)
Department of Physics, Faculty of Science, Arak University, Arak 38156-88349, Iran
e-mail: mshmansouri@gmail.com

H. Alinejad
Department of Physics, Faculty of Basic Science, Babol University of Technology, Babol 47148-71167, Iran

1 Introduction

Electron-acoustic (EA) waves as high frequency electrostatic waves (in comparison with the ion plasma frequency) occur in multi-species plasma, e.g., cool and hot electrons (Watanabe and Taniuti 1977; Tokar and Gary 1984; Gary and Tokar 1985). Oscillation of cold inertial electrons against an inertialess hot electrons background provides the essential restoring force. The FAST satellite observations verify the occurrence of EA waves associated with auroral density cavities (Pottelette et al. 1999) and in the mid-altitude auroral zone (Ergun et al. 1998). During the last decades, the linear and nonlinear properties of EA waves have been extensively investigated (Watanabe and Taniuti 1977; Shukla and Yu 1978; Yu and Shukla 1983; Dubouloz et al. 1991; Berthomier et al. 2000; Singh and Lakhina 2001; Mace and Hellberg 2001; Tagare et al. 2004; Cattaert et al. 2005; Lakhina et al. 2008, 2009; Pottelette and Berthomier 2009; Pakzad and Tribeche 2010). Landau damping restricts the existence region of EA waves, especially when the phase velocity approaches the thermal velocity of either electron components. Thus, the EA wave can be propagated in the plasma within a restricted range of parameter values. Some authors showed that for distinctive parameter values of $T_h/T_c \geq 10$ and $0.2 \leq n_c/n_e \leq 0.8$, (where $n_e = n_c + n_h$), oscillations of EA waves are stable, otherwise it will be heavily damped (Tokar and Gary 1984; Gary and Tokar 1985; Mace and Hellberg 1990; Berthomier et al. 1999). Thus, in a case study of nonlinear EA structures, plasma configuration must be chosen in such a way that guaranties the minimization of Landau damping. The two/three temperature electron plasmas have been considered in the earlier models of EA solitons. These models could explain the existence of positive potentials which has been observed in space plasmas (Singh et al. 2001; Tagare