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ORIGINAL ARTICLE

Solitons and double-layers of electron-acoustic waves in magnetized plasma; an application to auroral zone plasma

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Abstract A theoretical investigation is carried out for understanding the properties of electron-acoustic potential structures (i.e., solitary waves and double-layers) in a magnetized plasma whose constituents are a cold magnetized electron fluid, hot electrons obeying a nonthermal distribution, and stationary ions. For this purpose, the hydrodynamic equations for the cold magnetized electron fluid, nonthermal electron density distribution, and the Poisson equation are used to derive the corresponding nonlinear evolution equation; modified Zakharov–Kuznetsov (MZK) equation, in the small amplitude regime. The MZK equation is analyzed to examine the existence regions of the solitary pulses and double-layers. It is found that rarefactive electron-acoustic solitary waves and double-layers strongly depend on the density and temperature ratios of the hot-to-cold electron species as well as the nonthermal electron parameter.

Keywords Electron-acoustic solitary waves · Double-layers · Reductive perturbation theory · Modified Zakharov-Kuznetsov equation

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1 Introduction

Potential studies on the propagation of electron-acoustic (EA) waves shown a great deal of interest due to their importance in interpreting the electrostatic component of the broad-band electrostatic noise observed in the cusp region of the terrestrial magnetosphere (Tokar and Gary 1984; Singh and Lakhina 2001), in the geomagnetic tail (Schriver and Ashour-Abdalla 1989), in the dayside auroral acceleration region (Dubouloz et al. 1991; Pottelette et al. 1999) etc. The propagation of EA waves in a plasma system has been studied by several investigators in an unmagnetized two electron plasma (Dubouloz et al. 1991; Chatterjee and Roychoudhury 1995; Berthomier et al. 2000; Mamun and Shukla 2002), as well as in magnetized plasma (Mace and Hellberg 2001; Mamun et al. 2002; Berthomier et al. 2003; Shukla et al. 2004). Electron-acoustic waves (Lashmore-Davies and Martin 1973; Mohan and Buti 1980; Dubouloz et al. 1993) can propagate in a magnetized plasma where the ion temperature is larger than the electron temperature and the waves propagate in a direction perpendicular to the magnetic field. In the case of unmagnetized plasma, EA waves have been observed in the laboratory when the plasma consisted of two species of electrons with different temperatures, referred to as "hot" and "cold" electrons. Electron-acoustic waves are high frequency (in comparison with the ion plasma frequency) electrostatic modes (Stix 1992) in