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ORIGINAL ARTICLE

Electrostatic electron acoustic solitons in electron-positron-ion plasma with superthermal electrons and positrons

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Abstract Properties of fully nonlinear electron-acoustic solitary waves in an unmagnetized and collisionless electron-positron-ion plasma containing cold dynamical electrons, superthermal electrons and positrons obeying Cairns' distribution have been analyzed in the stationary background of massive positive ions. A linear dispersion relation has been derived, from which it is found that even in the absence of superthermal electrons, the superthermal positron component can provide the restoring force to the cold inertial electrons to excite electron-acoustic waves. Moreover, superthermal electron and positron populations seem to enhance the electron acoustic wave phase speed. For nonlinear analysis, Korteweg-de Vries equation is obtained using the reductive perturbation technique. It is found that in the presence of positron both hump and dip type solitons appear to excite. The present work may be employed to explore and to understand the formation of electron acoustic soliton structures in the space and laboratory plasmas with nonthermal electrons and positrons.

Keywords Electron-positron-ion plasmas · Superthermal electrons and positrons · Electron acoustic solitons

1 Introduction

The study of electron acoustic waves (EAWs) has grown to climax in the past few years because of their presence in various plasma systems ranging from laboratory generated plasmas to numerous astrophysical space plasmas (Mozer et al. 1977; Mace et al. 1991; Bostron 1992; Dubouloz et al. 1993; Mace and Hellberg 2001; Ergun et al. 2004; Kourakis and Shukla 2004; Pickett et al. 2004, 2005; Lakhina et al. 2008; Anderegg et al. 2009). These waves are the result of two distinct electron components at different temperatures. Depending upon the temperature difference, the cold electrons become inertia providing species and hot electrons provide the necessary pressure to develop the restoring force for the EAW to exist likewise the ion acoustic waves (IAW) in electron-ion plasma where the inertia is provided by the massive ions and the inertialess electrons provide the restoring force. Moreover, in EAW, the influence of the ion dynamics is ignored because of their larger dynamical time scale as compared to that of electrons and hence, ions are considered to establish only a stationary background. In addition to electrons and ions, positrons also constitute an essential component because of their presence in different plasma systems including both terrestrial and astrophysical space plasmas to form electron-positron-ion (e-p-i) plasma where the presence of positrons can lead to a change in the restoring force that plays the role of backbone to control the oscillations underpinning the electrostatic waves (Ginzburg 1971; Sturrock 1971; Miller and Witta 1987; Berezhiani et al. 1994; Popel et al. 1995; Lang et al. 1998; Moslem et al. 2007; Jehan et al. 2009). In fact, positrons are created by the interaction of the cosmic ray nuclei with atoms in the interstellar medium (Moskalenko and Strong 1998; Adrani 2009). It is also reported recently that positrons are also produced in tokamaks because of the collisions of runaway electrons with plasma ions or with thermal electrons (Helander and Ward 2003), and have also been observed in the joint European Torus (Gill 1993) and JT-60U (Yoshino et al. 1999).

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