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ORIGINAL ARTICLE

Ion acoustic solitons in negative ion plasmas with superthermal electrons

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Abstract Korteweg-de Vries (KdV) equation for electrostatic wave in an unmagnetized negative ion plasma with superthermal electrons is derived using reductive perturbation technique. A generalized Lorentzian distribution (kappa distribution) is assumed for the electrons. The influence of spectral index (kappa) on the soliton is discussed in the presence of the negative ions. It is found that different plasma parameters such as (negative ion temperature, positive ion temperature, negative ion concentration, mass ratio of positive to negative ion) in the presence of superthermal electrons modify the ion acoustic solitary wave structure significantly.

Keywords Negative ion plasma · Kappa distribution · Solitons

1 Introduction

The plasma consisting of negative ions, positive ions and electrons is called negative ion plasma (Song et al. 1991). Negative ion plasma has been observed in space and astrophysical environments (Gill et al. 2004). This type of plasma has its importance in various fields of plasma science and technology (Massey 1976; Swider 1988; Portnyagin et al. 1991; Gottscho and Gaebe 1986; Bacal and Hamilton 1979; Jacquinot et al. 1977; Nakamura et al. 2001; Weingarten et al. 2001; Ichiki et al. 2002). In the past few years, many researchers have studied the nonlinear structures such as solitons and shocks in negative ion plasmas by considering Maxwellian as well as non Maxwellian electrons distributions. Gill et al. (2004) studied the ion acoustic soliton and double layers in plasma consisting of positive and negative ions with non thermal electrons. They explored the fact that the nonthermal electrons strongly effects the formation of nonlinear structures in negative ion plasma. Mahmood and Rehman (2010) studied the formation of electrostatic solitary shock structures in the pair ion plasma (which is a type of negative ion plasma) by considering equal masses of ions. Their investigation revealed that the polarity of solitary structure depends on the temperature ratio of positive and negative ions in such a plasma system.

Many observations of the space plasmas indicate the presence of the superthermal electrons in a variety of astrophysical environments (Formisano et al. 1973; Mendis and Rosenberg 1994; Scudder et al. 1981; Marsch et al. 1982; Leubner 2004; Lazar et al. 2008; Amemiya et al. 1999). The flux of these superthermal electrons follow power law distribution in the observations of collision less plasmas across the solar system (Hapgood et al. 2011). These superthermal electrons are described by the so-called Kappa (κ) or generalized Lorentzian velocity distributions functions as shown for the first time by Vasyliunas (1968). The kappa distribution explains various astrophysical and space plasmas, such as solar wind (Shrauner and Feldman 1977), magnetosphere (Christon et al. 1989; Maksimovic et al. 1997), interstellar medium (Leubner and Voros 2005), and auroral zone plasma (Olsson and Janhunen 1998). It

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