Astrophys Space Sci (2013) 346:155–163
DOI 10.1007/s10509-013-1431-4

ORIGINAL ARTICLE

Ion acoustic solitons in a nonextensive plasma with multi-temperature electrons

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Received: 1 January 2013 / Accepted: 24 March 2013 / Published online: 6 April 2013

Abstract The properties of propagation of small amplitude ion acoustic solitary waves (*IASWs*) are studied in a plasma containing cold fluid ions and multi-temperature electrons (cool and hot electrons) with nonextensive distribution. Korteweg-de Vries (*KdV*) equation with finite amplitude is derived using a reductive perturbation method. From the solitary solutions of *KdV* equation, the combined effects of nonextensivity and density ratio are studied on characteristics of ion acoustic (*IA*) solitary waves. Positive as well as negative polarity solitons exist. Since singularity exists for $A = 0$ so we have also derived modified Korteweg de Vries (*mKdV*) equation to study the solitonic solution for critical values of physical parameters (q, f, σ). The nonextensivity of electrons (via q) and density ratio of electrons and ions (via f) and temperature ratio (σ) significantly influence the characteristics of ion acoustic solitary structures.

Keywords Solitons · Two temperature electrons · Nonextensivity · Non-Maxwellian · Ion acoustic · mKdV

1 Introduction

For the last few decades, extensive theoretical and experimental investigations have been reported to study the propagation of ion acoustic (*IA*) solitary waves in a multicomponent plasmas (Asano et al. 1969; Washimi and Taniuti 1966; Ikezi and Lonngren 1972; Taylor et al. 1972; Ikezi 1973; Tran 1979). Washimi and Taniuti (1966) first used the reductive perturbation method to derive the well known *KdV* equation and investigated the small amplitude ion acoustic waves in an unmagnetized plasma consisting of cold ions and hot and isothermal electrons. In the early days of the research of solitary structures, most of the investigations were confined to single electron temperature for different plasma models. The observations of the voyager PLS (Barbosa and Kurth 1993; Sittler et al. 1983) and Cassini CAPS (Young 2005) have shown the existence of both cool and hot electrons populations (non-Maxwellian) in Saturn's Magnetosphere.

Many laboratory as well as geophysical plasmas have witnessed the propagation of ion acoustic waves with hot and relatively cold electrons (Ghosh et al. 1996). Some examples are high intensity laser irradiated plasma (Estabrook and Kruer 1978), hot cathode discharges and space plasmas such as solar corona, Earth's auroral zone, and the Van Allen radiation belt. A large number of investigations to study the characteristics of ion acoustic solitary waves in two temperature electrons plasmas have been during the last three decades (Jones et al. 1975; Goswami and Buti 1976; Buti 1980; Nishihara and Tajiri 1981; Sayal et al. 1993; Rice et al. 1993). In order to model the experimental observations on ion acoustic waves, two temperature electrons plasmas were treated as two fluids by researchers (Jones et al. 1975). Goswami and Buti (1976) studied the solution of a two temperature electrons plasma using a *KdV* equation. Nishihara and Tajiri (1981) considered *e-i* plasma with Maxwellian cool and hot electrons to show the normal and anomalous regions of propagation of waves. They showed that there exist both types of solitons (rarefactive and compressive).

To account for full nonlinearity of plasma, a large number of investigations have been reported in the literature.

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