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ORIGINAL ARTICLE

Dust-acoustic solitary waves in a magnetized dusty plasmas with nonthermal ions and two-temperature nonextensive electrons

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Abstract A rigorous theoretical investigation has been made on the obliquely propagating dust-acoustic (DA) waves in a magnetized dusty plasmas consisting of distinct temperature q-distributed electrons with distinct strength of nonextensivities, nonthermal ions and negatively charged mobile dust grains, and analyzed by deriving the Zakharov-Kuznetsov equation. It is found that the characteristics and the properties of the DA solitary waves (DASWs) are significantly modified by the external magnetic field, relative temperature ratio of ions, relative number densities of electrons as well as ions, the nonextensivity of electrons, nonthermality of ions and the obliqueness of the system. The possible implications of the results obtained from this analysis in space and laboratory dusty plasmas are briefly addressed.

Keywords Nonlinear · Magnetized dusty plasma · Two distinct temperatures · Nonextensivity · Nonthermality

1 Introduction

Dust-acoustic waves in dusty plasmas are a fascinating example which show the existence of solitons in the different planetary atmospheres. These particular plasma media which attract growing interest are nothing but the complex (dusty) plasmas (Marif and Djebli 2012). Rao et al. (1990), at first, theoretically found the evidence of the existence of extremely low phase velocity dust-acoustic (DA) waves in an unmagnetized dusty plasma. After five years, Barkan et al. (1995) experimentally studied the DA waves and verified the theoretical prediction of Rao et al. (1990).

There are so many evidences of the existence of energetic particles in space, particularly in the astrophysical plasma environments (Haque 2013; Masood and Ahmad 2012a). The measurements of the distribution functions of these particles have revealed the fact that they are extremely nonthermal (Goldman et al. 1999; Tasnim et al. 2013). It is logical to assume that the electrons are nonextensively distributed and the ions are nonthermally distributed which can contribute much to the nonlinear waves and structures (Davidson 1972) in space. Satellite and spacecraft observations (Feldman et al. 1983; Lundin et al. 1989; Futaana et al. 2003) have also confirmed the existence of such distributions of electrons and ions.

In the recent past, many efforts have been made regarding the nonextensive generalization of the Boltzmann Gibbs Shannon (BGS) entropy, which was first recognized by Renyi (1955) and then by Tsallis (1988). A large number of experimental and theoretical observations shown that the BGS formalism can not describe the systems including long range interactions and memory effects. However, Tsallis (1988) proposed a new entropy which was employed successfully in plasma physics together with the generalized statistics (Silva et al. 1999; Leubner 2004; Du 2004; Liu et al. 2009; Tribeche et al. 2010; Tribeche and Djebarni 2010). Depending on the nonextensive parameter q, the generalized entropy of the system as a whole can be greater than the sum of the entropies of the parts of it if $q < 1$

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