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ORIGINAL ARTICLE

Nonextensive dust acoustic solitary and shock waves in nonplanar geometry

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Abstract The properties of cylindrical and spherical dust acoustic (DA) solitary and shock waves in an unmagnetized electron depleted dusty plasma consisting of inertial dust fluid and ions featuring Tsallis statistics are investigated by employing the reductive perturbation technique. A Korteweg-de Vries Burgers (KdVB) equation is derived and its numerical solution is obtained. The effects of ion nonextensivity and dust kinematic viscosity on the basic features of DA solitary and shock waves are discussed in nonplanar geometry. It is found that nonextensive nonplanar DA waves behave quite differently from their one-dimensional planar counterpart.

Keywords Dust acoustic waves · Nonplanar geometry

1 Introduction

During the last two decades, there has been a phenomenal growth in research activities in dusty plasmas as highlighted in several reviews (Mendis and Rosenberg 1994; Verheest 1996; Shukla 2001) and books (Verheest 2000; Shukla and Mamun 2002). It is well known that when dust grains are introduced into electron-ion plasma the response of the latter changes significantly. In contrast to the usual two component plasma, it has been observed that the nonlinear waves in plasmas having an additional dust component behave differently. Such mixtures of electrons, ions, and charged grains are common in different parts of our solar system, namely, in planetary rings, in circumsolar dust grains, in the interplanetary medium, in cometary comae and tails, in asteroid zones, in earth's ionosphere and magnetosphere, and in interstellar molecular clouds. Beside these, dust particles have been observed in low temperature plasmas, like those used in plasma processing and plasma crystal. A dusty plasma distinguishes itself from ordinary plasmas in various ways. Unique and novel features of dusty plasmas when compared with the usual electron-ion plasmas are the existence of a new, ultra-low frequency regime for wave propagation and the highly charging of the grains which can fluctuate due to the collection of plasma currents onto the dust surface. It has been found both theoretically and experimentally that the presence of these extremely massive and highly charged dust grains in a plasma can modify the behavior of the usual waves and instabilities. On the other hand, it has been shown that the dust charge dynamics introduces new eigenmodes, such as, dust-acoustic (DA) mode (Rao et al. 1990), dust ion-acoustic (DIA) mode (Shukla and Silin 1992), dust Bernstein-Greene-Kruskal (DBGK) modes (Tribeche et al. 2002)… etc. The most well studied of such modes is the so-called "Dust Acoustic Wave" (DAW) which arises due to the restoring force provided by the plasma thermal pressure (electrons and ions) while the inertia is due to the dust mass. The Tsallis q-entropy and the ensuing generalized statistics have been employed with some success in plasma physics (Du 2004; Liyan and Du 2008; Liu and Goree 2008; Liu et al. 2009; Liu and Du 2009; Tribeche et al. 2010; Amour and Tribeche 2010; Ait Gougam and Tribeche 2011; Bains et al. 2011; Pakzad and Tribeche 2011; Abdelsalam et al. 2011; El-Awady and Moslem 2011; Bacha and Tribeche

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