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ORIGINAL ARTICLE

Nonextensive collisioneless dust-acoustic shock waves in a charge varying dusty plasma

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Abstract Nonlinear dust-acoustic (DA) shock waves are addressed in a nonextensive dusty plasma exhibiting self-consistent nonadiabatic charge variation. Our results reveal that the amplitude, strength and nature of the DA shock waves are extremely sensitive to the degree of ion nonextensivity. Significant differences in the potential function occur for very small changes in the value of the nonextensive parameter. Stronger is the ions correlation, more important is the charge variation induced nonlinear wave damping.

Keywords Dusty plasmas · Dust acoustic waves · Shock waves · Anomalous damping · Nonadiabatic charge variation · Nonextensive theory

1 Introduction

Nonlinear phenomena in dusty plasma attracted much attention during the last two decades. A dusty plasma is a three component plasma consisting of electrons, ions, and very massive solid grains. Dusty plasma coexist in a wide variety of cosmic and laboratory environments. It is ubiquitous in different parts of our solar system, namely, in planetary rings, in the interplanetary medium, in cometary comae and tails, in asteroid zones, in the Earth's ionosphere and magnetosphere, in interstellar molecular clouds (Verheest 2000; Shukla and Mamun 2002)…etc. Beside these, dust particles have been observed in low temperature plasmas, like those used in plasma processing and plasma crystal. 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. Dust grains become charged due to different processes, such as collection of charged particles from the surrounding plasma, photoionization, secondary electron emission, sputtering by energetic ions, etc. There has been a great deal of interest in understanding different types of collective processes in dusty plasmas (Goertz 1989; Mendis and Rosenberg 1994; Horanyi 1996; Lin and Zhang 2007; Mamun and Cairns 2009; Mamun and Shukla 2009; Mamun et al. 2009; Pakzad 2009, 2010; Alinejad 2010, 2011a, 2011b, 2011c; El-Labany et al. 2010; Shalaby et al. 2010; Barman and Talukdar 2011; Eslami et al. 2011; Mayout and Tribeche 2011; Tribeche and Benzekka 2011). It has been shown both theoretically and experimentally that the presence of extremely massive and highly charged dust grains in a plasma can either modify the behavior of the usual waves and instabilities or introduce new eigenmodes. The most well studied of such modes is the so-called "Dust Acoustic Wave" (DAW) (Rao et al. 1990) 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. However, in a real dusty plasma, the dust charge may fluctuate becoming therefore a new dynamical variable, and the electron behavior can be strongly modified by external or self-consistent plasma fields.

Over the last two decades, a great deal of attention has been devoted to the nonextensive generalization of the Boltzmann–Gibbs–Shannon (BGS) entropy, first recognized by Renyi (1955) and subsequently proposed by Tsallis (1988). Owing to an increasing amount of experimental and theoretical evidence showing that the BGS formalism fails to describe systems with long range interactions

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