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ORIGINAL ARTICLE

Nonextensive dust acoustic waves in a charge varying dusty plasma

Mustapha Bacha · Mouloud Tribeche

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Abstract Our recent analysis on nonlinear nonextensive dust-acoustic waves (DA) [Amour and Tribeche in Phys. Plasmas 17:063702, 2010] is extended to include self-consistent nonadiabatic grain charge fluctuation. The appropriate nonextensive electron charging current is rederived based on the orbit-limited motion theory. Our results reveal that the amplitude, strength and nature of the nonlinear DA waves (solitons and shocks) are extremely sensitive to the degree of ion nonextensivity. Stronger is the electron correlation, more important is the charge variation induced nonlinear wave damping. The anomalous dissipation effects may prevail over that dispersion as the electrons evolve far away from their Maxwellian equilibrium. Our investigation may be of wide relevance to astronomers and space scientists working on interstellar dusty plasmas where nonthermal distributions are turning out to be a very common and characteristic feature.

Keywords Dust acoustic waves · Nonadiabatic dust charge fluctuation · Tsallis entropy · Nonextensivity · Solitary waves · Noncollisional shock waves · Anomalous damping

1 Introduction

Study of nonlinear as well as linear phenomena in dusty plasma attracted much attention during the last two decades. The dusty plasma is actually 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; Alinejad 2010; Alinejad 2011a, 2011b, 2011c; Barman and Talukdar 2011; El-Labany et al. 2010; Eslami et al. 2011; Mayout and Tribeche 2011; Pakzad 2009; Pakzad 2010; Rahman et al. 2011; Shalaby et al. 2010; 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

M. Bacha · M. Tribeche (✉)
Plasma Physics Group, Theoretical Physics Laboratory,
Faculty of Sciences-Physics, University of Bab-Ezzouar,
USTHB, B.P. 32, El Alia, Algiers 16111, Algeria
e-mail: mouloudtribeche@yahoo.fr