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ORIGINAL ARTICLE

Dust-acoustic solitary waves and double layers with two temperature ions in a nonextensive dusty plasma

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Abstract Small amplitude dust-acoustic solitary waves in an unmagnetized dusty plasma consisting of electrons and two temperature ions obeying the q-nonextensive distribution are investigated. Employing reductive perturbation method, the Korteweg-de Vries (KdV) equation is derived. From the solitonic solutions of KdV equation, the influence of nonextensivity of electrons as well as ions and dust concentration on the amplitude and width of dust-acoustic solitary waves has been studied. It is observed that both positive and negative potential dust acoustic solitary waves occur in this case. The modified KdV (mKdV) equation is derived in order to examine the solitonic solutions for the critical plasma parameters for which KdV theory fails. The parametric regimes for the existence of mKdV solitons and double layers (DLs) have also been determined. Positive potential double layers are found to occur in the present study.

Keywords Dust-acoustic solitary waves · Nonextensive distribution · Double layers · Dusty · mKdV

1 Introduction

The linear and nonlinear propagation of electrostatic waves in dusty plasmas which occur in both space and laboratory environments have received a considerable attention for the last many years (Shukla and Mamun 2002; Merlino and Goree 2004; Ishihara 2007). Researchers have been showing great interest in nonlinear structures because they offer deep physical insight underlying the nonlinear phenomena. The nonlinearity in plasma contributes to localization of waves, leading to different types of interesting coherent nonlinear wave structures such as solitons, shock waves, vortices and double layers. Most of the space and astrophysical environments show the presence of dust particles. Dust particles are often of micron to submicron size, with masses in the range of 10^6 to 10^{12} proton masses. Dust particles are usually found to have negative charge (possibly as large as $\sim 10^4$ electron charges), depending on the environment where they occur. On the other hand, smaller dust grains may be found to be positively charged. Because of high charge and large mass of the grain particulates compared to those of ions, new time and space scales come into play, giving rise to either new or modified waves in dusty plasmas (Rao et al. 1990; Shukla and Silin 1992; Kaw and Sen 1998; Rao 1999; Tribeche et al. 2000). Dust acoustic wave (DAW) is one of the low frequency mode that occurs in dusty plasmas, where the dust particle mass provides the inertia and the pressures of the inertialess electrons and ions provide the restoring force. In recent years, a great deal of attention has been paid to study properties of collective waves in dusty plasmas in astrophysical and space plasma environments e.g., in planetary rings, comets, the Earth's ionosphere, interstellar molecular clouds, circumstellar disks, etc. (Horanyi and Mendis 1985, 1986; Verheest 1996; Goertz 1992). At earlier stage, studies in dusty plasma were based on the theoretical prediction of the existence of dust-acoustic waves (DAWs) by Rao et al. (1990), which were later confirmed by several experimental groups (Barkan et al. 1995; Pieper and Goree 1996; Prabhuram and Goree 1996). Mamun et al. (1996) showed that a dusty plasmas with ions following Boltzmann distribution possess only negative solitons associated with DAWs. The coexistence of both dust

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