Astrophys Space Sci (2012) 337:261–267
DOI 10.1007/s10509-011-0831-6

ORIGINAL ARTICLE

Electrostatic solitary structures in a four-component adiabatic dusty plasma

S. Tasnim · A. Mannan · A.A. Mamun

Received: 6 May 2011 / Accepted: 8 August 2011 / Published online: 9 September 2011

Abstract A theoretical investigation has been made of propagating electrostatic waves in a four-component adiabatic dusty plasma, whose constituents are adiabatic electrons, adiabatic ions, adiabatic positively and as well as negatively charged warm dust. The basic features of the solitary structures in such a four-component adiabatic dusty plasma are studied by the reductive perturbation method. It is found that the presence of the positive dust component does not only significantly modify the basic properties of the solitary waves, but also causes the existence of the positive solitary potential structures, which is an interesting feature shown in an adiabatic dusty plasma with the dust of opposite polarity. It is also observed that the basic properties (polarity, speed, amplitude and width) of the DA SWs are significantly modified by the effects of adiabaticity ($\gamma > 1$) of electrons, ions, negatively as well as positively charged warm dust. The present investigation can be of relevance to the electrostatic solitary structures observed in various dusty space plasma environments (viz. cometary tails, upper mesosphere, Jupiter's magnetosphere, etc.).

Keywords Dusty plasma · Four component dusty plasma · Adiabatic dusty plasma · The solitary waves · Reductive perturbation method

Electronic supplementary material The online version of this article (doi:10.1007/s10509-011-0831-6) contains supplementary material, which is available to authorized users.

S. Tasnim (✉)
Department of Natural Science, Stamford University Bangladesh, Siddeswari, Dhaka 1217, Bangladesh
e-mail: susmitaphy@yahoo.com

A. Mannan · A.A. Mamun
Department of Physics, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh

1 Introduction

Recently, there has been a great deal of interest in the physics of charged dust (which are ubiquitous in plasmas) in understanding the electrostatic density perturbations and solitary structures that are observed in different regions of space, viz. mesosphere, cometary tails, planetary rings, planetary magnetospheres, interplanetary space, interstellar media, etc. (Goertz 1989; Mendis and Rosenberg 1994; Horányi 1996; Verheest 2000; Shukla and Mamun 2002). The electrostatic density perturbations and solitary potential structures observed in such different regions of space have been theoretically studied by a large number of authors (Rao et al. 1990; Bharuthram and Shukla 1992; Ma and Liu 1997; Gupta et al. 2001; Mamun 1998, 1999; Mamun and Shukla 2001; Moslem 2003; Xue 2004). Rao et al. (1990) first predicted theoretically the existence of extremely low phase velocity (in comparison with the electron and ion thermal velocities) dust acoustic (DA) waves, where the dust particle mass provides the inertia and the thermal pressures of the electrons and ions give rise to the restoring force. Rao et al. (1990) have studied these dust-acoustic solitary waves by using the reductive perturbation method which is only valid for small but finite amplitude limit. Mamun (1999) has then generalized the work of Rao et al. (1990) by employing the pseudo-potential approach to study the arbitrary amplitude DA solitary waves. It has been observed that the basic features of the DA solitary waves are significantly modified by the effects of the dust charge fluctuation (Ma and Liu 1997; Gupta et al. 2001), vortexlike ion distribution (Mamun 1998), nonplanar geometry (Mamun and Shukla 2001), and dust-neutral collisions (Moslem 2003), interaction between two DA solitary waves (Xue 2004), etc. However, all of these are based on a commonly used dusty plasma model that assumes electrons, ions, and negatively charged