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Adiabatic dust-acoustic solitons

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Abstract

We investigate the existence of adiabatic dust-acoustic solitons in a dusty plasma consisting of adiabatic dust particles along with Boltzmann distributed electrons and ions. It is shown that the presence of adiabatic dust particles decreases the magnitude of the soliton amplitude. © 1997 Published by Elsevier Science B.V.

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In the last several years, there has been much interest in the field of dusty plasmas which exhibit a number of low-frequency phenomena [1,2]. Rao et al. [3] presented the theory of dust-acoustic waves in an unmagnetized dusty plasma consisting of Boltzmann distributed electrons and ions, and negatively charged dust particles where the dynamics of the dust component is governed by the fluid equations. Laboratory experiments [4–7] have confirmed the existence of the dust-acoustic waves and its non-linear features. Mamun et al. [8] reported that only negative potential structures associated with non-linear dust-acoustic waves can exist in a two component plasma of ions and dust particles. Recently, Shchekinov [9] studied the dust-acoustic solitons in two component plasmas with ions adiabatically heated by the compressive wave. It was shown that such ions lead to an increase (decrease) of the width (amplitude) of the solitons. Vidhya Lakshma et al. [10] carried out the kinetic as well as fluid analysis of non-linear dust-acoustic waves in a dusty plasma. Kinetic and fluid models lead to essentially the same results in the limit of dust thermal speed being much smaller than the dust acoustic speed.

For typical values of the parameters relevant to the recent experiments [4–7], the dust-acoustic waves are found to exist in the extremely low-frequency range, typically about a few Hz. Accordingly, for such frequency regimes, the electron and the ion number densities can be assumed to be governed by the respective Boltzmann distributions where the dust fluid should be described by an adiabatic equation of state. In this Letter, we study the linear as well as non-linear dust-acoustic waves by self-consistently using the full adiabatic equation of state. The differences between the results of the present model and those obtained by using the usual γ-model, namely, $\nabla P_d = \gamma_d T_d \nabla n_d$ (P_d, T_d and n_d are the pressure, temperature and density of the dust particles respectively) are pointed out.

We consider a three component dusty plasma consisting of electrons, ions and dust particles. For very low-frequency modes such as the dust-acoustic waves,

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