Astrophys Space Sci (2012) 342:105–111
DOI 10.1007/s10509-012-1159-6

ORIGINAL ARTICLE

Dust acoustic waves in a collisional strongly coupled dusty plasmas

E.I. El-Awady · M. Djebli

Received: 18 April 2012 / Accepted: 22 June 2012 / Published online: 5 July 2012

Abstract Progress in understanding the nonlinear features of dust-acoustic waves (DAWs) which accompany a collisional strongly and weakly coupled unmagnetized dusty plasma with Boltzmann distributed electrons, ions and negatively charged dust grains is presented. By using a hydrodynamic model, the Korteweg–de Vries-Burgers (KdV-Burgers) equation is derived. The existence regions of the solitary pulses are defined precisely. Furthermore, numerical calculations reveal that, due to collisions, the DAWs damp waves and the damping rate of the waves depends mainly on the collision frequency. The collisions are found to significantly change the basic properties of the DAWs. The effects of electron-to-ion concentration ratio, and ion-to-electron temperature ratio have important roles in the behavior of the DAWs. The results may have relevance in space and laboratory dusty plasmas.

Keywords Shock · Soliton · Coupling

1 Introduction

Investigations relating to nonlinear wave propagation in dusty plasmas have seen an explosive growth in recent years motivated to a large extent by the novelty of the dusty plasma medium as well as by its potential diverse applications in space plasmas, astrophysical phenomena, and laboratory experiments on dusty plasmas (Shukla and Mamun 2002; Verheest 2000; Ganguli et al. 2002; Hollenstein 2000). The massive and highly charged dust grains blockade the plasma with a variety of effects including a host of collective modes and associated instabilities that are not found in the usual two component electron-ion plasmas. One of these modes is the low frequency dust-acoustic wave (DAW). The existence of DAWs in an unmagnetized dusty plasma was reported theoretically first by Rao et al. (1990) and was conclusively verified in a recent laboratory experiment (Barkan et al. 1995). Extensive work has been devoted to the study of DAWs in unmagnetized dusty plasmas (Shukla 2000; Mamun et al. 1996).

In dusty plasmas, the collisions between particles play an important role for the propagation of nonlinear acoustic waves. It was found that the effects of collisions between charged particles and neutrals could significantly affect the properties of the waves (Piper and Goree 1996). Furthermore, it has also been estimated that under some experimental conditions (Piper and Goree 1996), the dust-neutral collisional mean free paths may be comparable or even shorter than the typical wavelengths of the excited waves. Therefore, to study these waves in dusty plasma with a significant background neutrals pressure, the use of the collisionless plasma limit is unjustified. Recently, there have been some publications studying the properties of DAWs in collisional dusty plasmas. For example, Wierling et al. (2000) modified the dispersion relation of DAWs in the presence of dust neutral collisions. Mahanta and Goswami (2001) used the usual fluid model to study the behavior of unmagnetized dusty plasma near a conducting boundary with dust-neutral collisional effect.

E.I. El-Awady (✉)
Department of Physics, Faculty of Science, Port Said University, Port Said, Egypt
e-mail: eielawady@hotmail.com

E.I. El-Awady
e-mail: eielawady@yahoo.com

M. Djebli
Faculty of Physics, Theoretical Physics Laboratory, USTHB, B.P. 32, Bab Ezzouar, 16023 Algiers, Algeria
e-mail: mdjebli@usthb.dz