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ORIGINAL ARTICLE

K-dV and Burgers' equations on DA waves with strongly coupled dusty plasma

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Abstract A rigorous theoretical investigation has been made on the nonlinear structures, mainly, dust-acoustic (DA) solitary and shock waves propagating in a strongly coupled dusty plasma consisting of strongly coupled correlated positively and negatively charged inertial cold dust fluid, weakly correlated inertialess Maxwellian electron and ion fluids. The presence of arbitrary (negative and positive) charged dust grains in such a plasma system causes the presence opposite potentials (positive and negative) DA solitary and shock structures and significantly modify it's basic features. The results obtained from this analysis can be employed in understanding the nature of plasma waves both in laboratory and space plasma system.

Keywords Strongly coupled dusty plasma · DA solitary and shock wave · K-dV and Burgers' equations · Presence of opposite potentials

1 Introduction

The discovered dust-acoustic (DA) waves of Rao et al. (1990) and then generalized for arbitrary amplitude by Mamun et al. (1996) and Mamun (1999) have also been rigorously investigated by many authors for different dusty plasma situations theoretically (Shukla and Mamun 2001; Mamun and Shukla 2001; Asrafi et al. 2010) during past two decades. However, all of these works on nonlinear DA waves (Rahman et al. 2008; Mamun and Shukla 2009a, 2009b) are based on the most commonly used dusty plasma model that assumes negatively charged dust. There are some important charging processes by which dust grains become positively charged (Rosenberg et al. 1999). The principal mechanisms by which dust grains become positively charged are photoemission in the presence of a flux of ultraviolet photons (Rosenberg and Mendis 1995), thermionic emission induced by the radiative heating (Rosenberg and Mendis 1995), secondary emission of electrons from the surface of the dust grains (Mendis and Horanyi 1990; Mendis and Rosenberg 1994).

Recently, motivated by these theoretical predictions and satellite/experimental observations (D'Angelo 2001; Mamun and Shukla 2002; Shukla 2004), a large number of authors (Mamun 2008a, 2008b; El-Shewy et al. 2011; Elwakil et al. 2013) have considered a dusty plasma with dust of opposite potential, and have investigated linear (D'Angelo 2001; Shahmansouri and Alinejad 2013a, 2013b; Alinejad 2011) and nonlinear (Shukla 2004; Shukla and Rosenberg 2005) DA waves. However, all of these studies are limited to weekly coupled dusty plasmas (El-Awady and Djebli 2012; El-Labany et al. 2012a, 2012b; Kundu et al. 2012) and are valid as long as $\Gamma \ll 1$ [$\Gamma = (q_d^2/a_d T_d)\exp(-a_d/\lambda_D)$, the coupling parameter, q_d is the dust grain charge, a_d is the inter-grain distance, T_d is the dust temperature in units of the Boltzmann constant, and λ_D is the dusty plasma Debye radius].

It is now well known that because of high dust charge and low dust temperature most of the space and laboratory dusty plasmas are not weakly coupled ($\Gamma \ll 1$) but are strongly coupled $\Gamma \geq 1$ (Ikezi 1986; El-Awady and Djebli 2012; El-Labany et al. 2012c). This strongly coupled dusty plasma (Shukla and Eliasson 2009; Kundu et al. 2012) regime has

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