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ORIGINAL ARTICLE

Dust ion acoustic travelling waves in the framework of a modified Kadomtsev-Petviashvili equation in a magnetized dusty plasma with superthermal electrons

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Abstract For the critical values of the parameters q and V, the work (Samanta et al. in Phys. Plasma 20:022111, 2013b) is unable to describe the nonlinear wave features in magnetized dusty plasma with superthermal electrons. To describe the nonlinear wave features for critical values of the parameters q and V, we extend the work (Samanta et al. in Phys. Plasma 20:022111, 2013b). To extend the work, we derive the modified Kadomtsev-Petviashvili (MKP) equation for dust ion acoustic waves in a magnetized dusty plasma with q-nonextensive velocity distributed electrons by considering higher order coefficients of ϵ. By applying the bifurcation theory of planar dynamical systems to this MKP equation, the existence of solitary wave solutions of both types rarefactive and compressive, periodic travelling wave solutions and kink and anti-kink wave solutions is proved. Three exact solutions of these above waves are determined. The present study could be helpful for understanding the nonlinear travelling waves propagating in mercury, solar wind, Saturn and in magnetosphere of the Earth.

Keywords Dusty plasma · Solitary wave · Periodic wave · Kink and anti-kink waves

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1 Introduction

Dusty plasmas occur in different astrophysical bodies such as cometary tails, asteroid zones, planetary rings, interstellar medium, nebulas, magnetosphere of the Earth and in the radial structure of Saturn's rings (Goertz 1989; Horanyi 1996; Mendis and Rosenberg 1994; Northrop and Bringham 1990). Also it has remarkable applications in low temperature physics (radio frequency), plasma discharge (Chu et al. 1994a) and in fabrication of many modern materials such as semi conductors, optical fibres and dusty crystals (Chu et al. 1994b; Thomas et al. 1994; Hayashi and Tachibana 1994) etc. It has been found that dust charge dynamics in dusty plasma modifies the existing plasma wave features and introduces different types of new wave modes theoretically and experimentally (Barkan et al. 1997). For examples, dust ion acoustic (DIA) mode (Shukla and Slin 1992; Merlino et al. 1998), dust acoustic (DA) mode (Rao et al. 1990; Mamun 1999), dust-drift mode (Shukla et al. 1992), dust lattice (DL) mode (Melandso 1996) and Shukla-Varma mode (Shukla and Varma 1993), etc.

Duan (2001) investigated DAWS in an unmagnetized plasma within the framework of a Kadomtsev-Petviashvili (KP) equation. He made a comparison between his results and the results obtained by Mamun and Shukla (2002) and shown that the magnetized dusty plasma and the unmagnetized dusty plasma are different mainly in case of two-dimensional long wavelength perturbations. Chatterjee et al. (2008) considered the anisotropic ion pressure to study the properties of large amplitude solitary waves and double layer in a dusty magnetoplasma applying Sagdeev's potential. Saha and Chatterjee (2009) also investigated oblique propagation of large amplitude DIA solitary waves in a magnetized dusty plasma. Chatterjee et al. (2001) also studied the head on collision of dust ion acoustic soliton in quantum

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