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ORIGINAL ARTICLE

Nonlinear ion acoustic waveforms for Kadomstev–Petviashvili equation

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Abstract The reductive perturbation method has been employed to derive the Kadomstev–Petviashvili equation for small but finite amplitude electrostatic ion-acoustic waves. An algebraic method with computerized symbolic computation is applied in obtaining a series of solutions of the Kadomstev–Petviashvili equation. Numerical studies have been made using plasma parameters reveals different waveforms such as bell-shaped solitary pulses, rational pulses and others with singularity at finite points which called blowup solutions in addition to the propagation of explosive pulses. The result of the present investigation may be applicable to some plasma environments, such as ionosphere plasma.

Keywords Ion-acoustic waves · Reductive perturbation · Symbolic computations · Explosive solutions

1 Introduction

The study of electrostatic ion-acoustic solitary waves (IASWs) in plasmas has received considerable attention because of its vital role in understanding the nonlinear features of localized electrostatic disturbances. Experiments on ion-acoustic waves were studied in Q-machines and double plasma devices (Tran 1979; Nakamura 1982; Longren 1979, 1983, 1998). The Viking spacecraft (Boström 1992) and FREJA satellite (Dovner et al. 1994) observations in the magnetosphere show the existence of ion-acoustic solitary pulses. The range of ion-acoustic waves for the parameters of the lower magnetospheric source region of AKR and dense ionospheric plasma consist of nonlinear ion-acoustic features. The most probable of those features are ion-acoustic solitons (Pottelette et al. 2003; Buti 1980; Reddy and Lakhina 1991; Reddy et al. 1992). Theoretical investigations of nonlinear propagation of electrostatic disturbances have received a considerable attention and have been focused by many authors (Pakzad 2009; El-Shewy et al. 2010; Kalita and Barman 2010; El-Labany et al. 2012a, 2012b, 2012c; Tasnim and Mannan 2012; Sahu 2012; Chawla and Mishra 2013). The fully nonlinear properties and modulation instability of the envelope ion-acoustic solitary waves in plasma with positive-negative ions and non-thermal electrons have been discussed (Sabry et al. 2009; El-Wakil et al. 2010). The effect of non-thermality of electrons on the motion and shape of ion-acoustic solitary waves in warm collisionless plasma with non-thermal distribution of electrons has recently been studied (Abdelwahed and El-Shewy 2012). Shahmansouri (2012) has studied the nonlinear propagation of ion acoustic soliton waves in electron-ion plasmas including cool ions, excess suprathermal ions and kappa distributed electrons. The influence of superthermal and trapped electrons on oblique propagation of ion-acoustic waves in magnetized electron-ion plasma was investigated by Sabry et al. (2012). El-Wakil et al. (2011b, 2012) investigated the problem of time fractional KdV equation for a system of collisionless plasma consisting of a mixture of

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