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ORIGINAL ARTICLE

Arbitrary amplitude ion-acoustic solitons in two-electron temperature warm ion plasma

S.K. Jain · M.K. Mishra

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Abstract The large amplitude Ion-acoustic solitons in collisionless plasma consisting of warm adiabatic ions, isothermal positrons and two-temperature distribution of electrons are investigated. Using pseudo-potential approach, an energy integral equation for the system has been derived which encompasses complete nonlinearity for the plasma system. The existence region of the solitons is analyzed numerically. It is found that for selected set of plasma parameters, both rarefactive and compressive solitons exist in the electron-positron-ion (EPI) plasma. It is also found that due to finite positron concentration both subsonic and supersonic rarefactive soliton exist in EPI plasma. An increase in finite ion temperature ratio decreases the amplitude of the rarefactive solitons. In the case of small amplitude, it is found that there exist supersonic compressive as well as rarefactive solitons simultaneously. The amplitude of the solitons decreases with increase in ion temperature ratio (σ), however an increase in positron concentration (α) and temperature ratio of positron to electrons (γ) increases the amplitude of the solitons. Effect of various plasma parameters on the characteristics of the solitons are discussed in detail. The results of the investigation may be helpful to understand the nonlinear structures in auroral plasma, pulsars and magnetospheric astrophysical environment as well as laboratory plasmas.

S.K. Jain (✉) · M.K. Mishra
Department of Physics, University of Rajasthan, Jaipur 302004, India
e-mail: surendrajain0110@gmail.com

Present address:
S.K. Jain
Government P.G. College, Dholpur, Rajasthan, India

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1 Introduction

Nonlinear wave propagation in electron-positron (e-p) plasma has been a subject of significant importance for researchers (Tsytovich and Wharton 1978; Berman et al. 1985; Tajima and Taniuti 1990; Shukla and Stenflo 1993), mainly because of the natural pair production in high energy processes occurring in many astrophysical environment such as active galactic nuclei (Miller and Witta 1987), pulsar magnetosphere (Goldreich and Julian 1969; Michel 1982), solar atmosphere (Tandverg-Husen and Emslie 1988), fireballs producing γ-ray bursts (Piran 1999), in inertial confinement fusion scheme using ultra-intense LASER (Liang et al. 1998) as well as in the understanding of the early universe (Misner et al. 1973; Rees 1983). Positrons are created in the interstellar medium when the atoms interact by the cosmic ray nuclei (Moskalenko and Strong 1998; Adrani et al. 2009). Positrons have also been observed in the joint European Torus (Gill 1993) and JT-60U (Yoshino et al. 1999). Electron–positron (e-p) plasma is characterized as fully ionized gases, consisting of electrons and positrons having charges of opposite polarity and possesses equal mass. Recently, Positrons have also been produced in tokamaks due to collisions of runaway electrons with plasma ions or thermal electrons (Helander and Ward 2003). The e-p plasmas have also been created in the Laboratory (Surko et al. 1989; Liang et al. 1998). Greaves et al. (1994) have reported that advances in the positron trapping technique has led to the room temperature plasma with sufficient long life time. Because of long lifetime of the