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ORIGINAL ARTICLE

# Large amplitude dust ion-acoustic solitary waves in a plasma in the presence of positrons

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**Abstract** Properties of propagation of large amplitude dust ion-acoustic solitary waves and double layers are investigated in electron-positron-ion plasma with highly charged negative dust. Sagdeev pseudopotential method has been used to derive the energy balance equation. The expression for the critical Mach number (lower/upper limit) for the existence of solitary structures has also been derived. The Sagdeev pseudopotential is a function of numbers of physical parameters such as ion temperature ($\sigma$), positron density ($\delta_p$), dust density ($\delta_d$) and electron to positron temperature ratio ($\beta$). These parameters significantly influence the properties of the solitary structures and double layers. Further it is found that both polarity (compressive and rarefactive) solitons and negative potential double layers are observed.

**Keywords** Dust ion-acoustic wave · Positrons · Double layers · Solitons · Dust concentration

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## 1 Introduction

Over the last many years, the study of linear and nonlinear properties of solitary waves in multicomponent plasmas is an important area of research. Among nonlinear structures, the ion-acoustic solitons (*IASs*) which arise due to delicate balance of nonlinearity and dispersion, represent the most important aspect of nonlinear phenomena in modern plasma research.

Electron-positron-ion (*e-p-i*) plasmas are believed to occur in magnetospheres of neutron stars (Michel 1982), in the inner region of accretion disks in the vicinity of black holes (Lee et al. 2005), in solar flare plasmas (Hansen and Emslie 1988), active galactic cores (Begelman et al. 1984; Miller and Witta 1987), supernova remnants (Piran 1999) and semiconductor plasmas (Shukla et al. 1986). A series of plasma experiments, e.g., laser-matter interaction (Salamin et al. 2006), in tokamak and other magnetic confinement systems (Surko and Murphy 1990) and beam-plasma experiments (Greaves and Surko 1995) confirm the formation of *e-p-i* plasmas. For the last four decades, a large number of investigations have been reported in understanding the formation of arbitrary amplitude ion-acoustic solitary waves, double layers and envelope excitations in *e-p-i* plasmas (Popel et al. 1995; Salahuddin et al. 2002; Mahmood et al. 2003; Ali et al. 2007; Bains et al. 2010; Haque et al. 2011; Haque 2012). Popel et al. (1995) studied the nonlinear dynamics of ion-acoustic waves in an *e-p-i* plasma and observed the existence of positive potential ion-acoustic solitons. A variation in positron concentration in a plasma has a significant effect on the modification of solitary structures. Ali et al. (2007) investigated the linear and nonlinear properties of quantum ion-acoustic waves (*QIAWs*) in three-component plasmas composed of electrons, positrons and ions. They have observed that the potential well profiles