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ORIGINAL ARTICLE

Obliquely propagating ion-acoustic waves in a magnetized electron-positron-ion plasma with trapped electrons

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Abstract A theoretical investigation is carried out for understanding the basic features of oblique propagation of linear and nonlinear ion-acoustic waves subjected to an external magnetic field in an electron-positron-ion plasma which consists of a cold magnetized ion fluid, Boltzmann distributed positron, and electrons obeying a trapped distribution. In the linear regime, two dispersion curves are obtained. It is shown that the positron concentration causes the both modes to propagate with smaller phase velocities. Then, owing to the presence of resonant electrons, the modified Korteweg-de Vries equation describing the nonlinear dynamics of small but finite amplitude ion-acoustic waves is derived. It is found that the effects of external magnetic field (obliqueness), trapped electrons, positron concentration and temperature ratio significantly modify the basic features of solitary waves.

Keywords Trapped electron · Positron concentration · Solitary wave · Magnetic field

In recent years, the study of nonlinear propagation of electrostatic excitations in field free and magnetized electron-positron-ion (e-p-i) plasmas attracted significant attention among researchers (Popel et al. 1995; Salahuddin et al. 2002; Abdelsalam et al. 2008; Han et al. 2008; Mahmood et al. 2003; Mahmood and Akhtar 2008; Mahmood and Ur-Rehman 2009; Sabry 2009; Shatashvili et al. 1997; Alinejad et al. 2006; Alinejad 2009; Mishra et al. 2007; Tiwari et al. 2007; Tiwari 2008; Tribeche and Boukhalfa 2011; Pakzad and Javidan 2011; Ghosh and Bharathram 2011). Such a plasma can observe in the inner region of accretion discs in the vicinity of black holes (Lee et al. 2005), in magnetosphere of neutron stars (Michel 1982; Goldreich and Julian 1969), in active galactive cores (Miller and Witta 1987) and even in solar flare plasma (Kozlovsky et al. 2004). Moreover, e-p-i plasma is a particular case of ambiplasma which is a quasineutral space plasma containing electrons, positrons, protons and antiprotons (Alfven 1965). Three components e-p-i plasmas can also be created in the laboratory plasma. It is well known that propagation of a short relativistically strong laser pulse in matter can be accompanied by the formation of e-p-i plasmas due to photo production of pairs during photon scattering by nuclei, etc. (Berezhiani et al. 1992; Liang et al. 1998). Another example is related to plasma in tokamak and other magnetic confinement systems (Surko and Murphy 1990). In laboratory plasma, over a wide range of parameters the positron life time or annihilation of electrons and positrons, is relatively unimportant (Greaves et al. 1994). At low temperatures of the order of 1 eV and electron density of 10^{12} cm^{-3}, the observed positron annihilation time is greater than 1 second, which is much larger than the characteristic time scale for the ion-acoustic wave (Surko and Murphy 1990).

In contrast to the usual plasma with electrons and positive ions, the nonlinear wave phenomena in plasmas having positrons behave differently. Presence of positron component in conventional e-i plasma reduces the number density of ions and restoring force on electron fluid and hence the characteristics of linear waves as well as that of nonlinear structures are found to change considerably. Nonlinear wave

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