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ORIGINAL ARTICLE

Effect of electron nonextensivity on oblique propagation of arbitrary ion acoustic waves in a magnetized plasma

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Abstract The combined effects of the obliqueness and nonextensive electrons are incorporated in the study of ion acoustic (IA) waves in a magnetized plasma. The propagation properties of two possible modes (in the linear regime) are investigated. It is found that the electron nonextensivity decreases the phase velocities of both two modes. Also obliqueness leads to increase of separation between two modes. The nonlinear evolution of IA solitary waves is governed by an energy-like equation. The influence of electron nonextensivity, obliqueness and electron population on the existence domain of solitary waves and the soliton characteristics are examined. It is shown that the existence domain of the IA soliton and its profile is significantly depended on the deviation of electrons from thermodynamic equilibrium and obliqueness. Interestingly, the present model supports compressive as well as rarefactive IA solitary waves. Our finding should elucidate the nonlinear electrostatic structures that propagate in astrophysical and cosmological plasma scenarios where nonextensive and magnetized plasma can exist; like instellar plasma stellar polytropes, solar neutrino problem, peculiar velocities of galaxy clusters, dark-matter halos, protoneutron stars, hadronic matter, quark-gluon plasma, and magnetosphere, etc.

Keywords Ion-acoustic waves · Nonextensive electrons · Solitary waves

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1 Introduction

Ion acoustic (IA) waves as one of the basic waves in plasma have been studied in the last several decades both theoretically and experimentally (Sagdeev 1966; Ikezi et al. 1970; Baboolal et al. 1990; Bharuthram and Shukla 1992; Popel et al. 1995; Mamun and Shukla 2001; Hellberg and Mace 2002; Tribeche et al. 2010). Sagdeev (1966) used a mechanical analogy approach to study the nonlinear theory of these waves. Then Ikezi et al. (1970) observed IA solitons in laboratory. Subsequently, the nonlinear IA wave theory has been developed in the cases of two electron populations (Baboolal et al. 1990; Baluku and Hellberg 2012), multi-ion plasma compositions (Bharuthram and Shukla 1992; McKenzie et al. 2004, 2005; Verheest et al. 2005), electron-positron-ion (e-p-i) plasma (Popel et al. 1995; Alinejad and Mamun 2011; Ghosh and Bharuthram 2011), non-Maxwellian components plasma (Pakzad 2009, 2011; Baluku and Hellberg 2012; Shahmansouri 2012), geometry effects (Maxon and Viecelli 1974a, 1974b; Sahu and Roychoudhury 2003, 2005; Ghosh et al. 2012), degenerate particles (Hass 2011), a finite ion temperature (Tagare 1973; Tappert 1972), high order nonlinearity (Watanabe 1978), and relativistic effects (Tribeche and Boukhalfa 2011; Sahu 2011), etc.

Observations of astrophysical plasmas indicate that external magnetic field in space and astrophysical plasmas plays a vital role in linear and nonlinear plasma dynamics, as well as it affects the stability condition of plasma waves. Ion acoustic wave can be propagated in magnetized as well as unmagnetized plasmas. Yu et al. (1980) extended the Sagdeev approach to study the IA waves in a magnetized plasma. Furthermore, the IA solitary waves have been discussed in magnetized plasma by a number of authors (Lee and Kan 1981; Kalita and Bujarbarua 1983; Bhatnagar and Sharma 1984;