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ORIGINAL ARTICLE

Head-on collision of electron acoustic solitary waves in a plasma with nonextensive hot electrons

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Abstract The head-on collision between two electron-acoustic solitary waves (EASWs) in an unmagnetized plasma is investigated, including a cold electrons fluid, hot electrons, obeying a nonextensive distribution and stationary ions. By using the extended Poincaré-Lighthill–Kuo (PLK) perturbation method, the analytical phase shifts following the head-on collision are derived. The effects of the ratio of the number density of hot electrons to the number density of cold electrons α, and the nonextensive parameter q on the phase shifts are studied. It is found that q and the hot-to-cold electron density ratio significantly modify the phase shifts.

Keywords Electron-acoustic solitary waves · E–i plasma · Korteweg–de Vries equation · Nonextensive electrons · Head-on collision · Phase shifts

1 Introduction

Electron acoustic modes can exist in a plasma having two electron components, hot and cold. These are electrostatic waves of high frequency (in comparison with the ion plasma frequency), propagating at a phase speed which lies between the hot and cool electron thermal velocities. On such a fast (high frequency) dynamical scale, the positive ions may safely be assumed to form a uniform stationary charge background simply providing charge neutrality, yet playing no essential role in the dynamics. The cool electrons provide the inertia necessary to maintain the electrostatic oscillations, while the restoring force comes from the hot electron pressure. Electron-acoustic waves occur in laboratory experiments (Henry and Treguier 1972; Ikezawa and Nakamura 1981) and space plasmas, e.g., in the Earth's bow shock (Thomsen et al. 1983; Feldman et al. 1983; Bale et al. 1998) and in the auroral magnetosphere (Lin et al. 1984). They are associated with broadband electrostatic noise (BEN), a common high-frequency background activity, regularly observed by satellite missions in the plasma sheet boundary layer (PSBL) (Matsumoto et al. 1994b; Cattell et al. 1999; Kakad et al. 2009). BEN emission includes a series of isolated bipolar pulses, within a frequency range from ∼10 Hz up to the local electron plasma frequency (∼10 kHz) (Matsumoto et al. 1994b). This clearly suggests that BEN is related to electron dynamics rather than to the ions (Matsumoto et al. 1994b; Kakad et al. 2009). High time resolution observations have shown that the BEN consists of small scale, large amplitude magnetic field aligned electric field structures. Electric field amplitude can reach up to 100 mV/m in dayside auroral zone and more in auroral kilometric radiation (AKR) source region. Such large values of electric fields suggest that the nonlinear effects have a bearing in the generation of BEN. Electrostatic solitary structures have been observed in the auroral acceleration region (Temerin et al. 1982; Bostrom et al. 1982; Dubouloz et al. 1991a, 1991b; Mozer et al. 1997), in Earth's high altitude polar magnetosphere

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