Astrophys Space Sci (2012) 338:287–294
DOI 10.1007/s10509-011-0950-0

ORIGINAL ARTICLE

# Electron acoustic solitary waves in a plasma with nonthermal electrons featuring Tsallis distribution

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Received: 10 November 2011 / Accepted: 30 November 2011 / Published online: 5 January 2012


**Abstract** The problem of solitary electron acoustic (EA) wave propagation in a plasma with nonthermal hot electrons featuring the Tsallis distribution is addressed. A physically meaningful nonextensive nonthermal velocity distribution is outlined. It is shown that the effect of the nonthermal electron nonextensivity on EA waves can be quite important. Interestingly, we found that the phase speed of the linear EA mode increases as the entropic index $q$ decreases. This enhancement is weak for $q > 1$, and significant for $q < 1$. For a given nonthermal state, the minimum value of the allowable Mach numbers is lowered as the nonextensive nature of the electrons becomes important. This critical limit is shifted towards higher values as the nonthermal character of the plasma is increased. Moreover, our plasma model supports rarefactive EA solitary waves the main quantities of which depend sensitively on $q$. This dependency (for $q > 1$) becomes less noticeable as the nonthermal parameter decreases. Nevertheless, decreasing $\alpha$ yields for $q < 0$ a different result, a trend which may be attributed to the functional form of the nonthermal nonextensive distribution. Our study (which is not aimed at putting the ad hoc Cairns distribution onto a more rigorous foundation) suggests that a background electron nonextensivity may influence the EA solitons.

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**Keywords** Electron acoustic waves · Soliton · Nonthermal electrons · Tsallis distribution · Nonextensive plasmas

## 1 Introduction

The nonlinear evolution of electron-acoustic (EA) mode is one of the important subject in space plasma physics. The idea of EA mode had been conceived by Fried and Gould (1961) during numerical solutions of the linear Vlasov dispersion equation in an unmagnetized, homogeneous plasma. Besides the well-known Langmuir and ion-acoustic waves, they noticed the existence of a heavily damped acoustic- like solution of the dispersion equation. It was later shown that with two species of electrons with widely disparate temperatures, referred to as hot and cold electrons with immobile ions, one indeed obtains a weakly damped EA mode (Watanabe and Taniuti 1977), which has different properties than Langmuir and ion-acoustic waves.

Several theoretical studies have been done on EA waves. Since plasmas with two electrons temperatures occur in both laboratory experimental (Defler and Simonen 1969; Henery and Treumann 1972) and space plasmas (Dubouloz et al. 1991; Pottelette et al. 1999), Gary and Tokar (1985) performed a parameter survey and found conditions for the existence of the EA waves. The EA mode plays an important role in these environments. In the earth's bow shock, particularly in the upstream region, the EA waves have been suggested as a possible source of broadband electrostatic noise (BEN). They are also of potential importance in interpreting BEN observed in cusp of terrestrial magnetospace in auroral region and in geomagnetic tail (Berthomier et al. 2000; Tokar and Gray 1984; Schriver and Ashour-Abdalla 1989; Dubouloz et al. 1991; Pottelette et al. 1999). The EA mode has also been used to explain wave emissions in different