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ORIGINAL ARTICLE

Head-on collision of ion-acoustic solitary waves in magnetized plasmas with nonextensive electrons and positrons

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Abstract This article presents the first study of the head-on collision of two ion-acoustic solitary waves (IASWs) in magnetized plasmas with nonextensive electrons and positrons using the extended Poincaré-Lighthill-Kuo (PLK) method. The effects of the ion gyro-frequency to ion plasma frequency ratio, the positron to ion number density ratio, the electrons temperature to positrons temperature ratio, and the nonextensive parameter q on the phase shifts are investigated. It is shown that these factors significantly modify the phase shifts.

Keywords Nonextensive electrons and positorns · Magnetized plasma · Ion-acoustic solitary waves · Head-on collision · Phase shifts

1 Introduction

During the last few decades, the investigation of linear and nonlinear propagation of ion acoustic waves in plasmas has attracted significant attention among authors (Popel et al. 1995; Mahmood et al. 2003; Alinejad et al. 2006; Mishra et al. 2007; Mahmood and Akhtar 2008; Sabry 2009; El-Awady et al. 2010; Pakzad 2011; Sahu 2012). Sagdeev investigated the basic features of ion-acoustic solitary waves (IASWs) in the frame work of the pseudopotential technique (Sagdeev 1966). The first experimental observation of ion-acoustic solitons has been made by Ikezi et al. (1970). Subsequently, the IASWs theory was extended to study the effects of finite ion temperature (Tappert 1972; Tagare 1973) and the effects due to a trapped electron population (Schamel 1972, 1973) and high order nonlinearity (Watanabe 1978). Moreover, a number of authors have studied the dynamics of IASWs in the frame work of nonplanar geometry (Sahu and Roychoudhury 2005; Sahu 2011). These studies on IASWs in unmagnetized or magnetized plasmas have concentrated mainly on Maxwellian distribution of electrons or Cairns type distributions. As is well known, Maxwellian distribution in Boltzmann-Gibbs statistics is believed valid universally for the macroscopic ergodic equilibrium systems. However, for the systems with the long-range interactions, such as plasma and gravitational systems, where the non-equilibrium stationary states exist, Maxwellian distribution might be inadequate for the description of the systems. For example, various observations of fast ions and electrons in space environments indicate that these particles can have velocity distributions that deviate from the Maxwellian behavior (Asbridge et al. 1968; Divine and Garrett 1983; Krimigis et al. 1983; Lundlin et al. 1989; Futaana et al. 2003). A new statistical approach (Renyi 1955), namely nonextensive statistics or Tsallis statistics based on the derivation of BG statistics (Tsallis 1988), is proposed to the study the cases where Maxwellian distribution is considered inappropriate. The generalization of the BG statistics was first recognized by Renyi (1955), and subsequently proposed by Tsallis (1988), where the entropic index q, characterized the degree of nonextensivity of considered system ($q \to 1$ corresponds to the standard, extensive, BG statistics). Nonextensive statistics was successfully applied to a number of astrophysics and cosmological scenarios, which

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