

Ion-acoustic double layers in magnetized positive-negative ion plasmas with nonthermal electrons

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Abstract The nonlinear ion-acoustic double layers (IADLs) in a warm magnetoplasma with positive-negative ions and nonthermal electrons are investigated. For this purpose, the hydrodynamic equations for the positive-negative ions, non-thermal electron density distribution, and the Poisson equation are used to derive a modified Zakharov–Kuznetsov

(MZK) equation, in the small amplitude regime. It is found that compressive and rarefactive IADLs strongly depend on the mass and density ratios of the negative-to-positive ions as well as the nonthermal electron parameter. Also, it is shown that there are one critical value for the density ratio of the negative-to-positive ions (ν), the ratio between unperturbed electron-to-positive ion density (μ), and the nonthermal electron parameter (β), which decide the existence of positive and negative IADLs. The present study is applied to examine the small amplitude nonlinear IADL excitations for the (H^+ , O_2^-) and (H^+ , H^-) plasmas, where they are found in the D- and F-regions of the Earth's ionosphere. This investigation should be helpful in understanding the salient features of the nonlinear IADLs in either space or laboratory plasmas where two distinct groups of ions and non-Boltzmann distributed electrons are present.

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1 Introduction

For more than four decades, negative ion plasmas attracted attention due to their importance both in laboratory experiments and in space plasma observations (Massey 1976; Jacquinot et al. 1977; Bacal and Hamilton 1979; Gottscho and Gaebe 1986; Swider 1988; Portnyagin et al. 1991; Chaizy et al. 1991; Shibayama et al. 1996; Nakamura et al. 2001; Ichiki et al. 2002; Coates et al. 2007; El-Labany et al. 2010; El-Taibany et al. 2011; Sahu 2011). Negative ion plasma is a plasma that contains both negative and positive ion species as well as electrons. This type of plasma has a great importance to various fields of plasma science