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ORIGINAL ARTICLE

Dust ion acoustic instability with q-distribution in nonextensive statistics

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Abstract The instability of dust ion acoustic waves (DIAWs) driven by ions and electrons with different drift velocities in an unmagnetized, collisionless, isotropic dusty plasma was investigated. The electrons, ions and dust particles are assumed to be the generalized q-nonextensive distributions. The spectral indices of the q-distributions for the three plasma components are different from each other. Based on kinetic theory, the dispersion relation and the instability growth rate of DIAWs are obtained. It is found that the presence of the nonextensive distribution electrons and ions significantly modify the domain of the instability growth rate, as well as the ion-electron density ratio (ρ) and drifting-thermal velocity ratio (u_{i0}/v_{Te}). In reverse, the index of dust grains has nearly no any effect on the instability growth rate. Furthermore, the effects of these parameters on the growth rate have also been discussed in detail.

Keywords Dusty plasma · Instability · Nonextensive statistics

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1 Introduction

A dusty plasma is a normal electron-ion plasma with an additional highly charged component of small (micron to submicron sized) charged particles of solid matter (dust grains). Plasmas and dust are a couple of the ubiquitous elements of our universe, their occurrence in planetary ring, cometary tails, interstellar medium, asteroid zones, and lower part of earth's ionosphere and magnetosphere (Horanyi and Mendis 1985; Goertz 1989; Verheest 1996) make dusty plasma research increasingly important. The study of dusty plasmas also has a broad range of applications in industry and microelectronics (Kersten et al. 2001).

Because of the interaction between dust particles and plasmas, they often introduce the intriguing and surprising results in astrophysical and space environments as well as in laboratory plasmas (Shukla and Mamun 2002). The consideration of charged dust grains in plasma does not only modify the existing plasma-wave spectra, but also introduces a number of new novel eigenmodes, such as, dust-acoustic mode (Rao et al. 1990), dust ion-acoustic mode (Shukla and Silin 1992), dust cyclotron mode (Shukla and Rahman 1998), dust drift mode (Mamun et al. 1999), etc. Rao et al. (1990) have first reported theoretically the existence of extremely low phase velocity (in comparison with the electron and ion thermal velocities) dust-acoustic waves in an unmagnetized dusty plasma whose constituents are an inertial charged dust fluid and Boltzmann distributed ions and electrons. Among the various new wave modes, the DIAW which is the object of this study is the simplest example of a dusty plasma wave in the wave motion. The phase speed of the DIAW is much smaller (larger) than the electron (ion) thermal velocity, and the DIAW relies on a physical mechanism quite analogous to that of the ion acoustic wave (IAW), in which inertialess electrons provide the restoring