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Dust-Acoustic Periodic Waves with Trapped Ions and Nonthermal Electrons in a Magnetized Dusty Plasma in Astrophysical Conditions: Tangential Excitations

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Abstract

It has been attempted to obliquely propagate three-dimensional Dust-Acoustic Periodic Travelling Waves (DAPTWs) in a magnetized dusty plasma made up of trapped ions, nonthermal fast electrons, and negatively charged inertial dust particles. The dynamic behaviours of DAPTWs in the current dusty plasma model are controlled by a Schamel equation. Bifurcation analysis of the Hamiltonian system is used to look into the existence of Dust Acoustic Solitary Waves (DASWs) and DAPTWs. The Sagdeev potential and phase portrait structures show that small-amplitude DAPTW solutions exist in the nonlinear realm. The effects of intrinsic physical parameters on the characteristics of DAPTWs are numerically simulated. These parameters include the strength of the static magnetic field, the obliqueness of propagation, the thermal pressure of charged dust grains, the electron to dust density ratio, the nonthermality of fast electrons and the parameter of trapped ions. The results show, in particular, that as the numerical values of the trapping parameter are decreased, the amplitude of DAPTWs decreases. It's interesting to note that the numerical outcomes of the theoretical simulations can be utilised to emphasize the physical properties of DAPTWs in astrophysical contexts like the magnetosphere, auroral area, and heliospheric environments

Keywords: The bifurcation theory, Recurring waves in the dust, Rapid nonthermal electrons

Introduction

An intriguing nonlinear phenomena is the trapping of electrons and ions in a dusty plasma. In this case, the dusty plasma model's electrostatic wave potential restricts some charged particles (i.e., electrons and ions) in a specific area, forcing them to bounce back and forth. It is generally known that in a dusty plasma system, the inertia is given by the bulk of the dust grains, but the restoring force is produced by the pressures of the inertia less ions and electrons. Due to the flow of plasma currents to their surfaces, negative charged dusty plasmas often predominate. Therefore, depending on the laboratory and space plasma environment under consideration, the trapping process causes the electron and ion species to depart from Maxwellian distribution and follow non-thermal distribution functions. The Schamel distribution function is one of the most prevalent non-thermal distribution functions that describes the trapping process of the electron and ion species in numerous laboratory and space plasmas. In general, numerous researchers have examined how trapped ions affect nonlinear waves for various plasma models. The focus of this work will be the effects of trapped ions, nonthermal electrons, the intensity of the external static magne-

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-tic field, and the obliqueness of propagation on the physical behaviours of DAPTWs in dusty plasma. The mathematical model for a magnetized dusty plasma made up of trapped ions, negatively charged inertial dust particles, and nonthermal fast electrons. Furthermore, the dynamics of nonlinear waves propagating in the current plasma are governed by the Schamel equation, which is a Korteweg-De-Vries (KdV) type equation. Additionally, several data from space and laboratories point to the presence of very energetic electrons that do not follow the Boltzmann distribution. Instead, a nonthermal distribution is used to describe the electron energy distribution, which usually has more intricate geometries and extended tails. The first effort to use a nonthermal distribution to characterize the energetic electrons detected by the FREJA satellite. Later, the presence of nonthermal electrons in a variety of astrophysical systems, including plasmas in the auroral zone, solar wind, magnetosphere, and interstellar medium. ASPERA on the Photos 2 spacecraft has also captured the departure of energetic electrons from Mars' upper ionosphere. On nonplanar spherical and cylindrical DIASWs, the effects of electron nonthermal distribution and dust charge number density are examined. They have looked at the nonlinear properties of DAWs in magnetized dusty plasma, including negative charge dust fluid, vortex-like ions distribution, and nonthermal fast electrons. It is observed that the effects of the nonthermality of the electrons distribution and the geometry factor significantly modify the features of the DIASWs. They showed that the excitation of DAWs disappears below a crucial amount of the fraction of energetic electrons. The bifurcation theory has emerged as one of the most intriguing and well-known methods for examining the dynamical behaviours of plasma systems in recent years. In this regard, the physical characteristics of propagating nonlinear dust acoustic waves in plasma have been widely studied using the bifurcation analysis of the phase picture for the system's Hamiltonian. Significant applications of this study may be found in many plasma settings. For instance, super thermal electrons have been used to study the bifurcation analysis of nonlinear ion acoustic travelling waves in a multicomponent magneto plasma. This work will focus on the effects of trapped ions, nonthermal electrons, the intensity of the external static magnetic field, and the obliqueness of propagation on the physical behaviours of DAPTWs in dusty plasma. The structure of this essay is as follows: The mathematical model for a magnetized dusty plasma made up of trapped ions, nonthermal fast electrons, and negatively charged inertial dust particles is described. Additionally, the Schamel equation is developed, which controls the dynamics of nonlinear waves propagating in the current plasma. To investigate the idea, the Sagdeev potential and bifurcation analysis are devised.

Conclusion

In the current study, we investigated the amplitude modulation of electrostatic waves using the nonlinear field equations of an unmagnetized collision less hot dusty plasma in the presence of nonthermal electrons and trapped ions. The updated nonlinear Schrödinger equation is found using the reductive perturbation approach. It is noted that only brilliant solitons, not dark ones, may be generated using the given evolution equation.